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THE ROLE OF TASK COMPLEXITY IN PK: A REVIEW

By J. E. KENNEDY

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ABSTRACT: The investigation of the role of task complexity is an attempt to understand how information is processed in PK. Various topics that may provide insight into this aspect of PK include: the number of objects influenced simultaneously, the paradoxical hypotheses of majority-vote experiments, the role of ESP in PK, the information contents of differing a priori probabilities, the number of opportunities for PK to operate on a system, and the possible mechanisms for static PK effects.

A review of the literature suggests that PK is, at least to some extent, a goal-oriented process, but also that it is limited by the information content of a priori probabilities. Experiments with differing probabilities of a hit and experiments with majority-vote procedures offer the most direct means to empirically investigate models for the information processing aspects of PK.

There are several reasons for investigating the role of task complexity in the PK process. The importance of discovering the range of systems that PK can influence is particularly crucial when one considers the popular concept that PK is a "goal-oriented" process. As Schmidt (1974b) described the situation, "it may be more appropriate to see PK as a goal-oriented principle, one that aims successfully at a final event, no matter how intricate the intermediate steps" (p. 190). This hypothesis assumes that PK operates when there is motivation for a particular event and that the PK effect does not depend on the complexity of the mechanism that must be influenced to produce that outcome.

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Some of the more severe consequences of the concept of goal-oriented psi become apparent when the topic of psi-mediated experimenter effects is discussed (Kennedy & Taddonio, 1976; White, 1976). Is there a difference between the subject who thinks "I'm going to throw the die and get a six," and the experimenter who thinks, "I'm going to carry out an experiment and get a significant result." Both are focusing on the outcome of a random process. The primary difference between the two situations is that carrying out an experiment is a more complex task than throwing a die. If complexity is not a limiting factor, an entire experiment may be viewed as one PK event for the experimenter, and possibly it may not be meaningful to investigate psi on a trial-by-trial level, or any level other than in terms of the specific "goals" held by the experimenter. The radical implications of this concept clearly require careful consideration of the underlying assumptions. This paper reviews the role of task complexity in PK.

The term *complexity*, as it is used here, needs to be clarified. Most research in parapsychology has investigated psychological variables such as attitude, motivation, personality, mood, states of consciousness, intention, etc. The topic of task complexity does not directly involve these variables; rather, *this paper will discuss the characteristics and limitations of PK that are somehow related to the amount of information utilized in accomplishing the task.* In the quantitative, mathematical use of the word, information refers to the reduction of uncertainty. The amount of information depends on the amount of uncertainty; for example, to paranormally produce a hit on a trial with an a priori probability of 1/10 requires more information than for a trial with a probability of 1/2. In this context, information is closely related to probability and can be used as a method to compare results mathematically (Schmidt, 1970; Beloff & Bate, 1971) and to represent models of psi (Cadoret, 1961).

Task complexity, however, involves more than just probability. It includes explicit or implicit models for the detailed operation of psi. Thus, although the probability of a hit may be the same for both blind PK (in which the subject tries to make a random outcome match an unknown target) and regular PK tasks, blind PK is considered more complex because the subject presumably must identify the target before producing the appropriate result. Here it becomes apparent that the standard for measuring complexity is to compare the psi task with a process that would duplicate the result by technical, sensorimotor means. Thus, blind PK, for example, is assumed to involve (1) obtaining the information of the target identity (analogous to a sensory process), and (2) inducing the appropriate outcome. Psi may or may not follow information processing steps similar to sensory systems. The literature relevant to developing proper models for the information processing aspects of PK will be reviewed here.

Very few experiments have been carried out to directly investigate task complexity. The indications derived from experimental work are based primarily on studies designed for other purposes, and uncontrolled psychological variables (expectancy, preference, etc.) severely complicate the interpretation of these studies. It is hoped that general trends found in diverse types of experiments may allow insight into the PK process and pinpoint specific hypotheses of future investigations.

This survey is greatly simplified by the existence of excellent general reviews of the experimental PK literature by L. E. Rhine (1972) and more recently by Stanford (1977b). Much of the present paper will be summarizing, commenting on, and extending topics discussed by Stanford. Christopher Scott (1961) has provided a remarkably incisive discussion of methodology for investigating various models of psi. Much of the stimulus for the present work came from Scott's paper.

NUMBER OF OBJECTS INFLUENCED SIMULTANEOUSLY

The Role of Physical Parameters

Simultaneously influencing more than one object would appear to be a more complex task than influencing only one object. Before discussing the number of objects simultaneously influenced, the role of physical parameters of size, density, and material of objects should be briefly summarized. Besides being a confounding variable in the discussion of the number of objects, the amount of mass could be also viewed as providing more objects (i.e., molecules) to influence.

Previous reviews of the relevant experimental literature have suggested that there is little evidence indicating differences in results due intrinsically to size, density, or material of the influenced objects and that psychological variables seem to overshadow these physical ones (J. B. Rhine, 1947; L. E. Rhine, 1972). While the notably inconsistent findings with regard to these physical factors certainly suggest psychological interpretations such as preference or expectancy effects, Stanford (1977b) has pointed out that the absence of clear evidence could also be attributed to the lack of properly designed studies. It is not surprising that ad hoc explanations of preference or expectancy can be applied to these studies since, for the most part, no attempts were made to control for these factors. A study by Cox (1971) in which the subjects and experimenters were blind to the use of two densities of dice is a notable exception; the deviations for both types of dice were about equal in magnitude though opposite in direction.

The absence of consistent findings in the existing literature does suggest that the physical parameters of size, mass, and material are not more important than psychological factors such as preference or ' expectancy. However, much further evidence will be needed before these physical properties and their associated parameters of energy and force can safely be considered negligible factors. Another aspect of the role of mass will be discussed later.

The Number of Dice Influenced

The possibility that more than one die per release could be influenced was one of the first questions to be investigated regarding physical properties of PK. Numerous studies obtained significant results when many (up to 96) dice were released simultaneously. (For reviews, see L. E. Rhine, 1972; Stanford, 1977b.) However, Nash (1955) reviewed the relevant experiments and concluded: "As yet, there appears to be no evidence of a PK effect on more than one die per trial" (p. 9). Likewise, in his review, Stanford (1977b) stated: "There is no compelling basis so far to conclude that more than one die is influenced on a single throw, although 'no compelling basis' does not mean that it does not or cannot happen" (p. 364). As Nash (1955) pointed out, before one can conclude that more than one die per release was influenced, the scoring rate must be higher than could be obtained by affecting only one die per release.[1] Unfortunately, the relevant experiments either do not have the required scoring rate or else are not applicable because of uncontrolled dice bias.

[1] Although this argument seems clear in principle, working out the details leads to somewhat circular reasoning. In order to prove that more than one die was influenced per trial, the total number of dice influenced by PK must be estimated. This estimation requires assumptions of a model for PK operation—which is, in fact, the very question under investigation. Nash uses the deviation (Dev) as the estimated number of trials influenced by PK; others may feel that Dev/(l-P) is more appropriate (e.g., see Foster, 1940). In either case it is not clear to the reviewer that a negative deviation could be handled properly.

Experiments with combination targets (e.g., high-dice, low-dice, doubles) would also seem to provide evidence that more than one die was influenced simultaneously. Here Nash (1955) suggested that the subject may influence only one die to match the chance outcome of the other die. L. E. Rhine (1972, p. 152) considered such situations to be possible examples of blind PK, presumably involving a mechanism similar to that proposed by Nash.

The simultaneous high- and low-aim experiment carried out by Humphrey (1947) deserves comment since it is often used as an example of a complex PK task involving more than one die per throw. In testing herself, Humphrey threw six white and six red dice simultaneously from the same cup. On each throw she wanted one 'color of dice to come with the one-face (high-aim) and the other color to avoid the one-face (low-aim). The primary analysis, comparing the number of one's that came up in the high-aim and low-aim conditions, gave $p < .01$ (one-tailed). To see if the PK effect simultaneously influenced the high- and low-aim dice, the number of throws in which the dice came out in the expected direction (i.e, two or more one's on high-aim dice and at the same time no one's on low-aim dice) were compared with the number of times the dice came out opposite to the expectation. This analysis gave $p < .015$ (one-tailed) for all the data and $p < .01$ (one-tailed) for a selected subset of the data. Humphrey interpreted this analysis as indicating that the high- and low-aim results were produced simultaneously. This interpretation, however, assumed that PK operated in both the high- and low-aim conditions. Given the possibility of dice bias and the design of the experiment, one cannot conclude that PK occurred in either condition alone, only that there was a difference between conditions. Since the high-aim condition gave only a *CR* — .70 (assuming no dice bias) while the low-aim result gave *CR* = 2.78, the PK effect may have occurred only in the low-aim dice. If this happened, the number of times the dice would be expected to come out in the favored direction would be very close to that actually found by Humphrey. The analysis of a simultaneous effect merely reaffirms the primary finding of a difference between conditions without giving evidence that two effects occurred simultaneously.[2]

Even if one could obtain experimental evidence that more than one die per release was influenced by PK, the results would still be

[2] Humphrey also computed an erroneous correlation in this paper (p. 170). Following the structure of the record sheet, she pooled the data into a six-by-six matrix and then correlated the six row totals with the six column totals. The row and column totals are obviously not independent.

difficult to interpret. To explain the lack of a conspicuous relationship to physical parameters, Nash (1955) suggested that "PK is effective only when the die is in an unstable equilibrium, i.e., poised on one of its edges or corners" (p. 8). Although the general concept of a small influence occurring at a critical instant had been mentioned previously (Cox, 1951; J. B. Rhine, 1951; Pratt, 1951), the idea that this could explain the absence of effects due to mass had apparently not been discussed before. If PK operates only at instances of instability, then PK may possibly influence only one object at a time but sequentially switch which object is being influenced; thus, more than one die could be influenced on each release but only one die would be influenced at any point in time. This ambiguity in the term *simultaneous* is made more plausible by high-speed RNG studies indicating that PK can influence events of only 1/300 sec. (Schmidt, 1973) or possibly even 1/1000 sec. (Bierman & Houtkooper, 1975) duration. Not only is there an absence of evidence showing that more than one object is influenced simultaneously, but also it may be very difficult to acquire any conclusive evidence.[3]

MAJORITY-VOTE STUDIES

Experiments using majority-vote (MV) procedures provide one of the most enlightening methods for investigating the complexity question. The paradoxical nature of the hypotheses that would seem to apply to MV studies may be introduced by discussing a specific experiment carried out by Schmidt (1974).

On a binary PK task, Schmidt's subjects were given visual feedback on the outcome of an electronic RNG decision. Their task was to make the hit light come on ($P_{hit} = 1/2$). The hit-miss decision was made by one of two different RNG systems and a prerecorded random sequence determined which was in effect on any trial. Some subjects knew that two different RNG's were being used, but no subject knew which RNG was in use on any given trial.

In one RNG system, called the "simple" RNG, the hit-miss decision was based on one event from a nuclear decay RNG. The other RNG was "complex" and its decision was based on the MV of 100

[3] For completeness, it should be noted that Walker (1975) has applied his quantum theory of psi phenomena to some of Forwald's placement PK experiments, producing remarkable agreement with the data. Based on his calculations and some *tentative assumptions,* Walker suggests for placement PK "control of two (or more) cubes on each release would be as rare as a perfect run through one (or more) [ESP] decks" (p. 34).

individual events from a high-speed noise diode RNG; i.e., feedback for the trial depended on 100 RNG events. Schmidt wanted to see if one RNG system was "easier" to influence than the other. Ignoring the factors of the different types and speeds of the RNG's, three hypotheses, each leading to different predictions, are possible:

A. The "more complex" hypothesis. The MV condition is more complex since more PK "effort" would be needed to influence the larger number of individual RNG events. The added RNG events would dilute the PK effect and the MV condition should give less significant results than the single-event condition.

B. The "majority-vote" hypothesis. In the majority-vote condition, PK has more opportunities to operate and thus a more significant effect is expected. If the PK effect on the individual RNG events is the same in both the single-event and MV conditions, the MV scoring rate should be larger, according to the normal laws of probability (Thouless, 1960; Scott, 1960; Schmidt, 1973).

C. The "independent-of-complexity" hypothesis. Following the concept of goal-oriented psi, the actual workings of the RNG system should not matter. If the goal is the outcome of a majority vote, then PK will operate directly on that outcome independently of what leads to it. With this hypothesis, equal scoring rates should occur in both the single event and majority-vote conditions.

Before reviewing the results of Schmidt's and other experiments, several concepts should be discussed. As noted by Thouless (1960) and Scott (1960), according to probability theory MV results are expected to show a higher scoring rate (i.e., signal enhancement), but lower statistical significance (larger p value) than one would find by an analysis of the single events that comprise the MV. This decrease in significance occurs because the MV, in effect, has a reduced number of trials which is not offset by the increased scoring rate. If the results deviate significantly from the pattern of higher scoring rate/lower significance, the phenomenon is not following the normal probability laws of MV. In Schmidt's experiment described above, the MV condition had 100 times more trials than the single event condition, so both a higher scoring rate and increased significance would be expected.

The role of feedback may be an important factor for establishing "goals" in experiments. Typically, the subject's goal is to receive feedback of a hit. It is possible, however, that the goal may encompass more than one unit of feedback; thus the subject may receive feedback for each trial but focus on the outcome of the run, majority vote, session, or even experiment. Alternatively, the subject may not receive feedback for the individual trials. The recent "observational" theories of psi, borrowing ideas from quantum mechanics, postulate that PK affects an event only at the time of and because of "observation" (feedback) of the outcome (Walker, 1974, 1975; de Beaure-gard, 1975; Schmidt, 1975). The biasing of the outcome is generally considered to be goal-oriented in that it is independent of the details of the random process leading to the outcome. If feedback does play a crucial role in PK, at least three majority-vote situations can be distinguished. 1. When no feedback is given for the individual events in a MV, as in Schmidt's experiment described above, the goal-oriented principle may lead to the same rates of feedback occurrence in the MV condition and the separate single event condition.[4] 2. If feedback is given for each event in the MV and the subject is focusing on each event (i.e., the subject takes each event as a goal), the results should follow the normal probability laws for MV, i.e., increased scoring rate, lower significance. 3. If feedback is given for each event in the MV, but the subject is focusing on the outcome of the MV, the situation is more complicated and does not lead to obvious predictions.[5]

While this discussion provides an idea of factors that need to be investigated, different assumptions, such as eliminating the crucial role of "observation," may lead to quite different predictions.

The results of the relevant experimental literature are summarized in Table 1. For the pilot and confirmation experiments pooled in the Schmidt (1974a) study, the single-event condition had a scoring rate of 55.93%. According to the "more complex" hypothesis (A), a scoring rate of about 50.5% would be expected in

[4] According to observational models, recording the individual events comprising the MV for later observations would complicate matters; the actual magnitudes of the MV could then be determined by the person who later observed them.

[5] This situation is similar to "run-score targeting" discussed by Walker (1976). Here the scores in the majority-vote condition may be less significant or the same as the results for a *separate condition with each trial as a goal.* The outcome will depend on how efficiently the subject uses his psi information, and Walker tentatively suggests that naive subjects may randomly select a "mode" (or efficiency) of psi operation. It is not clear to this review^ whether the relationship between MV scores and the *single trials comprising the MV* _,nould follow the pattern expected by probability theory. Walker also derives an expression indicating that under certain conditions similar to run-score targeting with *continuous* feedback (observation), the psi effect could be greatly enhanced in comparison with other conditions. However, as yet this possibility has not been given the detailed evaluation needed to see to what extent it applies to experimental situations.

the MV condition.[6] The "majority-vote" hypothesis (B) leads to an expected scoring rate of about 90% (reviewer's calculations). The scoring rate in the MV condition was lower than that in the single-event condition, but the difference was not significant. The absence of a significant difference supports the "independent-of-complexity" hypothesis (C) and apparently is the result Schmidt expected. The MV scoring rate is significantly different from that predicted by either hypothesis A or B.

It should be noted that this study used different RNG events in the single-event and MV conditions. The distribution of single-event scores for the majority votes is unknown. All the other studies reviewed here report the single-event results of those events actually used in the MV.

Schmidt (1973) also reported MV analyses of a pilot and confirmation in another binary RNG-PK experiment. The pilot used a "slow" RNG (30 trials/sec.) and the confirmation used the slow RNG on some runs and a "fast" RNG (300 trials/sec.) on other runs. The subjects' task was to influence each RNG event; feedback, though merging with that from other trials, was received for each event. A run consisted of 100 trials with the slow RNG or 1,000 trials with the fast. Schmidt reported a MV analysis by evaluating the number of runs with more hits than misses. As seen in Table 1, the results fell in line with the normal probability laws of MV; i.e., higher scoring rates but lower C/?'s. Apparently, this is the result Schmidt expected in this situation. The fact that the *CR* for the pooled result is greater in the MV condition is due to the large number of trials and lower scoring rate with the fast RNG; this dilutes the single-event results proportionately more than the MV results since 10 times more trials go into the fast RNG-MV than go into the MV for the slow RNG.

Five reports of majority-vote PK experiments conducted over a period of several years have been summarized by Cox (1974, p. 68). All experiments utilized PK machines built by Cox, and he was ex-

[6] One can estimate the expected scoring rate assuming that approximately the same number of individual RNG events were influenced in both the single-event and MV conditions. If the number of trials influenced is Dev/(l-P) (easily derived, e.g., see Foster, 1940), then about 262 of the 2,210 (or 11.85%) of the single-event trials were influenced by PK. One would then expect about 249 of the 2,105 MV trials to have one event influenced. However, if one event is selected by PK, the other 99 RNG events in the MV would be randomly distributed, leading to an expected scoring rate of only 54.33% on the trials influenced by PK (discarding ties of 50/100). Combining this scoring rate with the chance scores (50.00%) on the non-PK trials gives an expected overall scoring rate of 50.5% on the MV trials.

Table 1
COMPARISON OF SINGLE-EVENT AND MAJORITY-VOTE RESULTS

Author	Apparatus	Series or Condition	Single Event			Majority Vote			Subjects
			Trials	% Hits	*CR*	Trials	% Hits	*CR*	
Schmidt, 1974[a]	2 Electronic RNG's	Pilot	515	58.06	3.61	496	51.21	.49	39
		Confirm.	1,695	55.28	4.32	1,609	53.76	2.99	(Schmidt, lab staff
		Total	2,210	55.93	5.55	2,105	53.16	2.89	& visitors)
Schmidt, 1973	Electronic RNG. Fast & Slow Speeds	Pilot/Slow	20,000	51.42	4.02	183	62.84	3.40	14
		Conf./Slow	40,000	51.62	6.48	373	66.22	6.21	(Schmidt &
		Conf./Fast	400,000	50.37	4.71	389	60.15	3.95	selected
		Total	460,000	50.53	7.14	945	63.07	8.00	subjects)
Cox, 1962[b,c]	5-tier balls machine		12,482	51.3	2.94	190	60.0	2.68	33 (Volunteers)
Cox, 1965[c,d]	Hexstat balls machine		185,500	50.0	.43	518	57.0	3.14	
Morris, 1965[c,e]	Hexstat balls machine		113,295	50.2	1.50	416	56.2	2.48	(High-school & col. stud.'s)
Cox, 1966[c]	3 x 45 balls machine		69,448	50.2	1.10	445	56.2	2.57	
Cox, 1974[c,f]	32-channel balls machine	Series 4	11,052	50.0	.02	239	54.8	1.42	1
		Series 8	12,020	50.3	.55	237	52.3	.65	(Res. ass't)
		Series 12	10,434	50.7	1.36	233	57.1	2.10	
		Total	33,506	50.3	1.11	709	54.7	2.48	
Bierman & Houtkooper, 1975 & 1978[g]	Electronic RNG/visible trials	MV on intervals	675,241	50.11	1.86	6,160	51.55	2.42	14 (Volunteers)
		MV on runs	675,241	50.11	1.86	140	61.87	2.71	
Bierman & Houtkooper, 1978	Same as above. Totals for 9 other series	MV on intervals	5,731,264	50.02	1.17	13,000	50.38	.86	78 (Volunteers & selected subjects)
		MV on runs	5,731,264	50.02	1.17	510	53.43	1.51	
Heseltine, 1977	RNG was electronics interfaced with subject's EEG	Series 1, high-tone target	35,200	50.04	.16			n.s.	16 (Young adult volunteers)
		Series 1, low-tone target	22,240	50.83	2.47			n.s.	
		Series 2, low-tone target	169,600	50.43	3.53			n.s.	

[a] The scoring rate of the individual trials comprising the MV was not recorded.
The difference between the single-event and MV scoring rates in the pilot study gives $p < .05$, two-tailed, by a chi-square analysis. For the confirmatory study and the pooled data, the difference is not significant with either a chi-square or t test.
[b] The MV analysis was carried out "years later."
[c] Reported in Cox (1974, p. 66).
[d] This and the following studies by Cox were testing his "cumulative" hypothesis.
[e] This study was carried out as a confirmation of Cox (1965).
[f] The task in these series was blind PK.
[g] Subjects received feedback for the outcome of an "interval" which consisted of several RNG events. Several intervals made a run.

perimenter in all but one experiment. The description of the various machines and the experimental procedure will not be gone into here; suffice it to say that all machines involved placement of a large number of balls into chutes; all used P_{hit} of 1/2; and, other than a few sections of the first experiment (Cox, 1962), the subjects could observe the balls falling.

As shown in Table 1, the first report followed the probability laws of MV nicely, as might be expected if the subject took each event as his goal. However, in opposition to probability theory, the next four reports consistently found larger *CR's* for the MV analysis than for the single-event results. Unfortunately, the statistical significance of these anomalies cannot be calculated since the majority votes involved a varying number of events (balls) and therefore the expected scoring rate cannot be reliably estimated.

During the last four studies, Cox was interested in his "cumulative" hypothesis, which held that MV procedures "will increase PK yield by giving PK many opportunities per trial in which to function instead of just one opportunity as with most previous work" (Cox, 1965, p. 300). The results of these four studies are, of course, in line with this hypothesis. It is crucial to the interpretation of these findings to know Cox's expectation on the first experiment, the only one that follows the normal pattern. When asked by this reviewer if he had the "cumulative" hypothesis in mind during the 1962 experiment, Cox replied that he had not, and, in fact, the MV analysis was carried out years later. It appears that when Cox's interest focused on the individual trial, the most significant results occurred in the individual trial analysis; and when his focus was on the outcome of a MV, the most significant results occurred in the majority vote.

A complicated PK experiment using a high-speed electronic RNG was reported by Bierman and Houtkooper (1975). The authors were attempting a simultaneous investigation of many variables, which included rate of RNG, length of run, type of feedback display, role of feedback, and retroactive PK effects. Only those aspects of direct relevance to this review will be discussed here.

On the computerized task, individual RNG events (P_{hit} = 1/2) were summed to give a score for the "interval." The number of events in each interval varied (because of different time lengths and RNG rates) from about 5 to 430 RNG events. The subject received visual feedback on the magnitude and direction of the interval scores. Several intervals (either 20 or 30) combined to form a run, and the authors carried out a MV analysis by evaluating the number of runs with more hits than misses. The experiment also compared "visible" and "invisible" RNG events; the subjects were given feedback on the visible trials while the invisible events were stored for later use. The results for the invisible trials were not significant and, for simplicity, only the visible trials will be discussed here.

The subject's task was to influence the interval scores. The experimenters expected the run-MV results to be more significant than the results for the individual trials (Bierman, 1978) and in the original report, the results for the intervals were not given. As in Cox's work, the experimental results showed a tendency for larger significance with the MV analysis (see Table 1). In line with the experimenter's expectation, the MV analysis at the run level (i.e., number of runs with more trials that were hits than misses) was more significant than the results for individual trials. The MV analysis at the interval level (i.e., number of intervals with more trials that were hits than misses) was more significant than the trial result but less significant than the run-MV (Bierman & Houtkooper, 1978). The totals for nine other series showed a similar trend toward higher significance in the run-MV conditions than for the intervals or trials (Bierman & Houtkooper, 1978).

Heseltine (1977) used subjects' EEC recordings interfaced with a high-frequency oscillator as an RNG (P_{hit} = 1/2) in a PK study. A computer sampled the RNG decisions, carried out a MV on the individual events about every three seconds, and gave the subject feedback on the majority-vote outcome. Series 1 used a high or low tone as the target, but only produced significant results with the low tone. In Series 2 only the low tone was used. Since the subjects presumably focused on the outcome of the MV, Cox's findings might indicate that the greater significance would be focused there. However, the maximum significance actually occurred at the single-event level. Heseltine's primary interest was the investigation of the relationship between EEC activity and RNG operations. Since the EEG analysis was carried out on individual RNG events, the *experimenter* may have focused on them. Given the blatant possibility of psi-mediated experimenter effects in PK studies (Kennedy & Taddonio, 1976) and the consistency with which the experimenter's expectancies have been fulfilled in the MV-PK studies discussed above, an experimenter-effect interpretation would certainly seem possible when the maximum significance occurs in connection with his special interest.[7]

In summary, the majority-vote procedure *per se* seems neither to increase task complexity nor allow more opportunities for PK to enter; rather, as discussed relative to observational theories, the details of feedback and desired outcomes seem important. Schmidt's two studies fit in nicely with these concepts and are complemented by the indication that significance levels tend to be highest with the particular analysis, be it MV or single event, of interest to the experimenter.

Besides deviating from the pattern expected by probability theory, the experiments finding enhanced significance with the MV analysis suggest that PK is operating efficiently. As Cox (1974) noted with regard to his work " . . . a relatively large percentage of majority-vote hits were produced by a differential of only one or two balls. A small differential contributes little to the overall ball count, but does of course contribute to the majority-vote results to the same extent as a large differential" (p. 67). This efficiency effect, if confirmed, is one of the few methods of providing direct evidence for Stanford's hypothesis that a psi effect "tends to be accomplished in the most economical way possible" (Stanford, 1974, p. 46). However, as shown by the Schmidt (1973) study, combining MV outcomes composed of differing numbers of trials can lead to increased significance for reasons that may not be related to efficiency. Since all the studies showing increased significance combined MV outcomes of markedly different numbers of trials, the efficiency interpretation needs further clarification. Also, the studies using electronic RNG's were confounded by different RNG rates. The results are further confounded by experimenter effects, since increased significance occurred only when that specific effect was desired by the experimenter.

THE ROLE OF ESP IN PK

The interrelationship of ESP and PK has been discussed for

[7] As noted earlier, if feedback is given only for the outcome of the MV, the actual individual events may be *constrained* by the MV results but determined in detail by the circumstances under which they are observed directly. Also, the idea that PK effects occur when the outcome is "observed" or "comes into consciousness" may involve more than simply sensory feedback. In criticizing observational theories, Bohm and Hiley (1976) comment: "Observers themselves become active only when they interpret the results of their experiments" (p. 176).

many years. The similarities of psychological factors and performance patterns led to the hypothesis that ESP and PK are closely related (J. B. Rhine & L. E. Rhine, 1943) and are, perhaps, two aspects of one basic process (Thouless & Wiesner, 1946; J. B. Rhine, 1947). The Rhines (J. B. Rhine, 1945, 1947; J. B. Rhine & L. E. Rhine, 1943) proposed a further intertwined relationship by suggesting that the PK process *requires* ESP for its operation. As J. B. Rhine (1947) put it:

> When the subject influences the dice he has to follow them in some intelligent way to exert whatever causative action is responsible for the results. Naturally he has to do this exerting at the right point of space and the right instant of time. The essential mental action on the rolling cube takes place somewhere in its course before it comes to rest, and even if the subject attempted to focus visually on the rolling dice, the roll is invariably too rapid for the necessary knowledge to be gained in that way. Sight is not swift enough; reaction time is too slow; and the possible role of sensory perception is thus ruled out. Nowhere is it better ruled out than in the rapid, violent bounding of the dice down the long wire mesh cages in the machine throwing tests. Yet it must be assumed that there is some guiding knowledge of the die as it is being influenced by the subject's mental action. In the nature of the case the awareness must be extrasensorially obtained. ESP is, therefore, an essential part of PK. (pp. 128-129)

While the American literature made little comment on the idea of ESP monitoring, it did not sit well with British thinkers (Broad, 1946-1949; Tyrrell, 1946-1949; Price, 1948; Mundle, 1949-1952). The objections, as summarized by Mundle, were:

> We rarely find Rhine using an a priori argument, but he does so in order to justify this conclusion. . . . Rhine's conclusion is reached by an argument from analogy, and the analogy is not a strong one. He is assuming that PK must be analogous to normal voluntary action in which we interfere with environmental objects, in so far as both must be guided by perception of some kind; and since normal sense-perception cannot supply the data by which PK could be intelligently guided, he concludes that the data must be supplied by ESP. But since PK is so strikingly different from normal voluntary action in some respects (notably in not using the efferent nervous system), can we argue that PK *must* resemble it in another respect—in being a perceptually guided process, in being an intelligent response to information? (p. 73)

In essence, the critics were not saying the ESP monitoring model was wrong, but rather, that it was an untested hypothesis. Empirical data on the PK-ESP relationship were clearly needed.

The classic paradigm for investigating the relationship between ESP and PK is blind PK (Osis, 1953). This topic has been adequately reviewed elsewhere (L. E. Rhine, 1972; Stanford, 1977b) and may be summarized here by saying that PK has been shown to occur when the subjects did not know the target through sensory means and that the scoring rate in blind PK is not noticeably lower than in the normal PK condition. The added data processing burden of the ESP task appears to be readily absorbed by PK. As Osis (1953) noted, this finding suggests "that under the conditions given, ESP and PK acted according to a one-step process. . . . The results show that there must be a close relationship between ESP and PK and that they may be aspects of a single psi operation" (p. 308).

ESP acquisition of information would also seem to be a factor when considering the subject's knowledge of the RNG mechanism. One might presume that the RNG mechanism would have to be understood before the system could be influenced. Stanford (1977b) points out, however, that "the PK literature is replete with examples of success at PK tasks in which subjects are lacking many sorts of information which would 'reasonably' seem to be required for success" (p. 339). If the knowledge about the RNG mechanism does not come through normal means, then it would presumably have to be acquired by ESP. A subject who knows little about the RNG would have to gain more information through ESP; i.e., the task would be more complex. Stanford summarizes the relevant literature by stating that "the magnitude of the effect observed does not appear to depend upon giving the subject knowledge of the technicalities of what is required for a favorable outcome" (p. 341). The matter is not as clear as one would like, however; experimenter effects may confound the results of the relevant studies, since the experimenter's knowledge of the system would be constant.

It appears from the data that PK does not depend on knowledge of the target or knowledge of the RNG mechanism. If ESP acquisition of information is a part of the PK process, it is apparently not an observable part since the strength of the PK effect does not seem to depend on the amount of information that must be collected. Further, the fact that PK appears to be a "one-step" process may indicate that it is not appropriate to conceptually distinguish an ESP component.

Various authors have attempted to move away from what Stanford (1977a) has called the "cybernetic" (ESP monitoring) view of PK. Mundle (1949-1952) discussed a suggestion by Price:

> Professor Price has suggested that we may be wrong in thinking of PK as a perceptually guided process, and that perhaps the appropriate

> conceptual model is that of *idea-motor action.* The sort of occurrences which Price presumably had in mind were cases where the thought of a bodily movement, *e.g.,* yawning or stretching a limb, issues automatically into the corresponding behaviour, provided that it is not inhibited by some other idea. Does anyone believe that the idea of yawning can only issue into a yawn if it is guided by information regarding the physical changes in the brain which precede or accompany yawning? Surely we do not want to attribute to the unconscious mind of every child a knowledge of physiology far exceeding that attained by physiologists merely because it usually yawns when it thinks of yawning! Now the point of assimilating PK and ideo-motor action is that it suggests that, in PK, an idea may be realizing itself in an external physical event without being guided by information about the physical mechanisms which precede or accompany the event in question, (p. 73)

This approach can be seen to be a forerunner of the concept of goal-oriented PK and of most recent models for PK. "Observational" theories (Walker, 1974, 1975; Schmidt, 1975), Stanford's "confor-mance behavior" ideas (1977a, 1977b), and the renewed interest in Jung's idea of synchronicity (Koestler, 1972; Hardy, Harvie, & Koestler, 1973; Bender, 1977; Gatlin, 1977) are all moving away from cybernetic models.

PROBABILITY OF A HIT FACTOR

Although PK does not seem to depend on acquisition of information about the mechanism of the RNG system, it may depend on another aspect of information processing, the a priori probability of getting the desired outcome. As mentioned in the introduction, successes with different probabilities of a hit involve different amounts of information; a correct guess with a P_{hit} of 1/10 resolves more uncertainty than with a P_{hit} of 1/2. The usefulness of employing differing probabilities of a hit for investigating the psi process was noted early by Thouless (1935) with regard to high- versus low-aim ESP tests. Scott (1961) has provided the conceptual and mathematical basis for the general application of differing probabilities and related methods to investigate models of information processing in psi. Although he suggested several hypothetical models, Scott's emphasis was on methodology for discovering mathematical models to describe the psi process rather than offering specific hypotheses for testing.

Walker (1977) has recently proposed the use of varying probabilities of a hit to distinguish among several specific models for PK operation. He used the mathematical formalism of Schmidt (1975) since his primary purpose was to develop a method for comparing Walker's quantum theory with Schmidt's mathematical model.[8] Figure 1 plots the relationships between statistical significance level *(CR)* and P_{hit} for five different models, based primarily on equations provided by Walker (1977). The curves are calculated for a hypothetical example of 20,000 trials with the "psi strength" for the different models standardized to CR = 3.0 for $P_{hit} = 1/2$; that is, if a subject gives a CR of 3.0 for $P = 1/2$, the graph shows what CR is expected for other probabilities according to the different models. The use of a standardized psi strength implies that the psychological conditions are uniform. Although different examples could be given, the general shape of the curves, the most important feature depicted in the graph, would remain the same. The various models represented in Figure 1 are described briefly below.

Walker's Quantum Theory

Walker's theory is unique in that the significance *(CR)* remains constant independent of the P_{hit} on the task. According to this theory, the "amount" of psi is measured as information in the mathematical, quantitative sense and is thus directly related to the overall statistical significance. If one assumes a constant psi source, a constant significance level is expected.

Walker (1977) notes that this derivation is "appropriate to the case of probability biasing" (p. 55), which implies that there are situations for which it would not be valid. He does indicate (p. 57) that it is appropriate for electronic RNG's, the most practical instrument for testing the hypothesis. In general, if there is adequate divergence (discussed later) this formulation is also appropriate for die-face experiments (Walker, 1978). The independence of statistical significance from P_{hit} is based only on the information processing assumptions of Walker's theory; this mathematical representation does not directly involve his concepts of "hidden variables," "will," etc.

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[8] Schmidt used the parameter θ to describe the strength of a psi source, where $P'/Q' = \theta P/Q$, with

$P' = P_{hit}$ with psi influence,
$Q' = 1 - P'$,
$P = P_{hit}$ without psi influence, and
$Q = 1 - P$.

This gives $P' = \dfrac{P\theta}{Q + P\theta}$.

Schmidt's model assumes θ is constant. Other models can be formulated in this format by making θ a variable, e.g., a function of P_{hit}. If θ can be estimated, the expected scoring rate can be found.

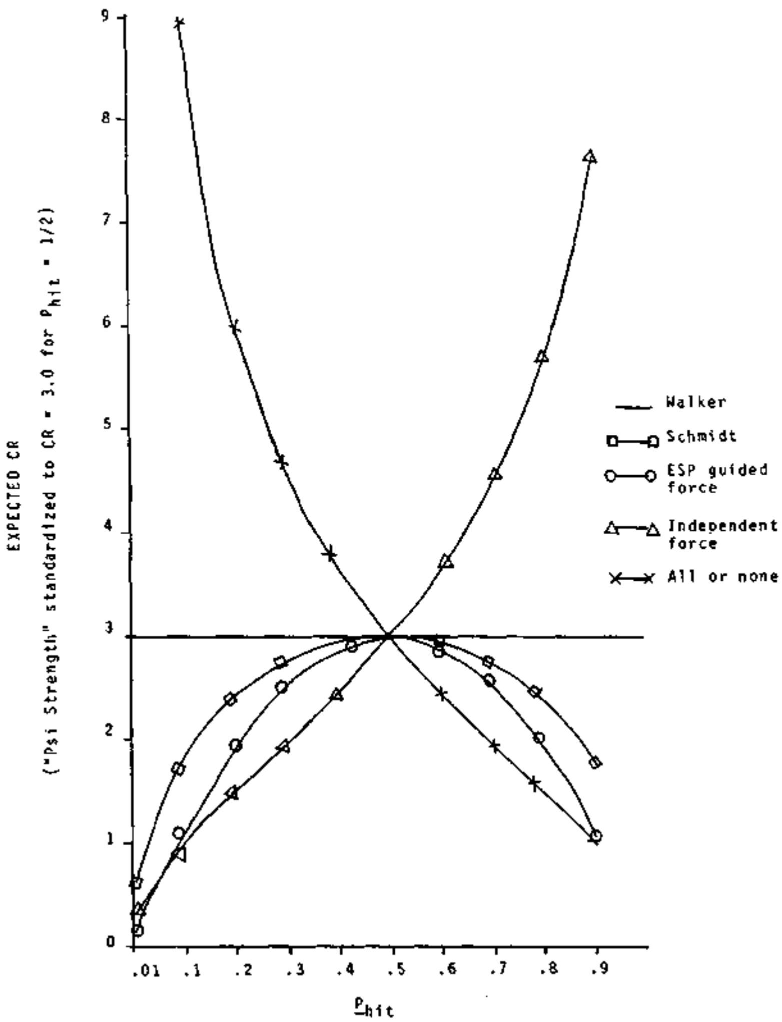

FIGURE 1. Expected *CR* vs. P_{hit} for various models of PK (hypothetical case of 20,000 trials). The expected scoring rates and corresponding *CR*'s were found by using

$$P' = \frac{P\theta}{Q + P\theta}$$

where θ takes the following forms. (The constant, K, has different values in each model.)

(Walker)	$\theta = (1 + K\sqrt{Q/P}) \ / \ (1 - K\sqrt{P/Q} = 1 + K/\sqrt{PQ},$
(Schmidt)	$\theta = K,$
(ESP guided force)	$\theta = 1 + K\sqrt{PQ},$
(Independent force)	$\theta = 1 + K/Q,$
(All or none)	$\theta = 1 + K/P.$

Schmidt's Mathematical Model

This model was based on a few simple a priori assumptions about the psi process. It was not meant to be a complete theory but rather just a means to formulate and test certain assumptions. The model predicts a maximum significance for P_{hit} = 1/2 with an approximately symmetrical dropping-off on either side of the maximum. If the P_{hit} and P_{miss} are reversed, the significance will be approximately the same (see Figure 1).

PK Force Guided by ESP

The hypothesis that PK operates by applying force or energy directly to a system[9] is difficult to formulate precisely for macroscopic systems such as dice. However, Walker (1977) has recently described the characteristics such an effect would produce upon RNG's based on nuclear processes—for example, radioactive decay. (It is not clear if this equation will apply to RNG's using noise diodes or to dice.) For one case he assumes the force is guided by ESP which operates at a low level as found in experimental work. Also, the ESP is assumed to process data in a manner that follows the basic equations of information theory. The relationship between *CR* and P_{hit} has the same shape as Schmidt's model, and apparently the two would be difficult to distinguish empirically.

Independent PK Force

Walker (1977) also derived the characteristics of a PK effect upon a nuclear RNG if the information for guiding the application of the force is assumed to come through paranormal means that are not restricted by the assumption that ESP operates at the low level found in experimental work. The expected CR is not symmetric around P_{hit} = 1/2 but increases dramatically as the P_{hit} increases. If P_{hit} and P_{miss} are exchanged, very different results should be found.

All-or-None Hypothesis

The idea that psi produces very strong effects when it operates but only works on a few trials is an intuitively appealing model that has been frequently implied when interpreting results. The derivation

[9] In Walker's quantum theory, the psi effect does not appear as a force; rather, it enters through the probability (i.e., information) aspects of quantum mechanical state selection. Schmidt's mathematical model is purely descriptive and makes no assumptions about the mechanism for producing effects.

used here[10] assumes that PK operates on a fixed proportion of the trials independent of P_{hit}. The expected *CR* versus P_{hit} curve is the mirror image of the previous case. The strong negative relationship clearly is a readily testable prediction.

Only one study has directly looked at the role of the P_{hit} (Schmidt, 1976). PK trials with P_{hit} = 1/8 and P_{hit} = 7/8 were randomly mixed so that subjects did not know which was occurring on any trial. Unfortunately, the results were not significant and only suggested, if anything, a differential effect between the two types of trials (for P_{hit} = 1/8, *CR* = 1.74; for P_{hit} = 7/8, *CR* = -1.26). While this is the only study that has approached the question directly, other experiments carried out for different purposes may provide relevant data. Given the problem of experimenter effects, it is the reviewer's opinion that such "after the fact" evidence, although indirect, plays a role in answering questions.

Low-aim conditions (in which the subject attempts to avoid a particular target) essentially exchange P_{hit} with P_{miss} from high-aim tasks, thus giving different P_{hits} for the two conditions. The reviewer found only two studies reporting high- and low-aim findings that can be applied here. On a blind PK task using a die to guess cards (P_{hit} = 1/5), Forwald (1963) found a *CR* = 3.63 on high-aim trials (P_{hit} = 1/5) and a *CR* = 1.89 on low-aim (P_{hit} = 4/5, same number of trials). Using an RNG (P_{hit} = 1/4) in a test presented as precognition, but with PK being an equally plausible interpretation, Schmidt (1969) found a stronger effect on low-aim (*CR* = 4.41) than on high-aim (*CR* = 3.76, more trials than in low-aim) for one subject who worked in both

[10] The equation for this case was derived by the reviewer. If X hits occur by PK in N trials independent of P_{hit}, then

$$P' = \frac{(N-X)P + X}{N}, \quad Q' = \frac{(N-X)Q}{N},$$

$$P'/Q' = \theta P/Q = \frac{\frac{(N-X)P+X}{N}}{\frac{(N-X)Q}{N}} = P/Q \; \frac{(N-X)+X/P}{(N-X)}, \text{ and}$$

$$\theta = 1 + \frac{X/P}{N-X}.$$

If X is a fixed proportion of N, then

$$X = X'N, \text{ and } \theta = 1 + \frac{X'/P}{1-X'} = 1 + K/P.$$

conditions. Of course, in these studies the psychological conditions for the different P_{hit} cannot be considered the same.

The value of this discussion lies in providing background for future work attacking the problem directly. Automated experiments that randomly mix trials with several different probabilities of a hit (e.g., 1/10, 1/2, and 9/10) should help identify which model, if any, of those discussed here is most appropriate.

NUMBER OF OPPORTUNITIES FOR PK TO ENTER

The number of opportunities for PK to enter is related to the a priori probability of a successful outcome and the number of objects influenced simultaneously, and the topic reappears several other times throughout the discussion of task complexity. As Stanford (1977b) summarized the matter, "One of the most important suggestions of a physical kind which emerges from the PK literature is that changes in the state of a physical system (including its movement) may in some sense be opportunities for PK influence to occur and that the number as well as the existence of such opportunities may be important" (p. 369).

This idea is closely related to the "divergent process" concept discussed by Walker (1975) in his recent quantum mechanical theory of psi phenomena. Walker postulates that divergent processes, processes in which quantum uncertainties lead to macroscopic effects (e.g., a rolling die), are susceptible to PK influence.[11] *Increasing the number of collisions or impacts results in more divergence and thus, more potential for PK influence.* Walker's theory assumes that the uncertainties on the microscopic level lead to macroscopic effects within the limits allowed by the uncertainty principle. A more divergent process has a wider range of possible outcomes within the deterministic limits, so the desired result is more likely to be within the range of probable outcomes. Thus, unless a die has an adequate number of impacts, the desired face may have a very low probability of coming up (the extreme case being a stationary die with zero impacts). Likewise, in placement PK an extreme outcome is more likely if there is a large number of impacts. In essence, the a priori probability of getting the desired outcome *(Phu)* may be small unless there is a large amount of divergence. In Walker's

[11] The use here of the term *divergence* should not be confused with the "divergence problem" which arises because the assumption of time independence of psi leads to the difficult position that persons in the future can influence past events (Schmidt, 1975; Walker, 1977; Hartwell, 1977; Houtkooper, 1977).

theory PK operates on the final observed outcome; each impact is not a separate place for a PK force to enter, but rather it adds an amount of uncertainty that makes the desired outcome more probable.[12]

In working out the details of his theory, Walker found that some effects due to physical parameters could be expected. For Forwald's (1959) placement PK experiments, Walker (1975) calculated the expected displacement for the different masses and moments of inertia of the various cubes and as noted above, found remarkable agreement with the experimental data. The amount of mass enters in two ways: it is a factor in determining the magnitude of microscopic uncertainties in position, momentum, etc., of the cubes, and it also affects the number of bounces that occur. Walker notes that "the result is not too sensitive to [the number of impacts] so long as it is sufficiently large" (p. 29).

The number of impacts, Walker proposed, could also explain the results of experiments comparing different numbers of dice per release. As previous reviewers have noted (J. B. Rhine, 1947; L. E. Rhine, 1972; Stanford, 1977b), the general trend of die-face experimental work has been for the scoring rates to be the same, or slightly higher, with more dice. Walker (1975, p. 35) attributes this trend to the fact that more objects per release result in more collisions and thus a more divergent process. The role of divergence envisioned by Walker does not necessarily lead to the conclusion that more than one die is being influenced per release; rather a stronger influence on one die is likely.

A die-face experiment by Forwald (1961) also could be interpreted as evidence for effects due to the number of collisions. In this experiment, results with two sizes of dice were compared on hard and soft surfaces. The overall scoring rate was significant. While all four conditions showed suggestive evidence for PK, the condition of the small dice on the hard surface produced most of the significance. This finding was replicated in a second experiment. Noting that the small dice on the hard surface produced many more bounces than the other condition, Forwald observed: "There is some justification for speculating that the outstanding results with the small dice on the hard surface were due to the larger number of rolls produced in this

[12] In some cases, the apparent number of opportunities for PK to operate can increase without increasing the amount of divergence. For example, a majority-vote procedure may have many instances of uncertainty, but the a priori probability of the MV outcomes remains the same whether the majority vote contains one or one thousand RNG decisions.

case" (p. 111). However, other interpretations are equally (and perhaps more) likely. The vast majority of the significance was due to the one-face targets. Since this was presumably a preference effect, it is certainly possible that the small-dice, hard-surface effect was also a preference effect—particularly since Forwald had a strong conviction that the physical properties of the apparatus were important.

The number of collisions was also discussed by Wilbur and Mangan (1956). They observed that "a consistent finding from the large amount of PK research, whether placement or throwing for specified die faces, is that PK has been observed to operate only on objects moving over a surface of interrupted motion. . . . Greater success with rough than with smooth surfaces, and with cubic than with spherical objects, therefore, might be anticipated; the latter, in fact, has proved to be a fairly consistent experimental finding" (p. 159). The authors note that studies by Cox (1951, 1954) and L. E. Rhine (1951) found better placement PK results with cubes than with spheres. However, these findings can be considered as only a weak indication since none of the differences were significant. Another study not discussed by Wilbur and Mangan may also be relevant. Although he never published it in full, J. B. Rhine (1947) mentions a die-face study carried out at Duke comparing dice with four different degrees of rounded corners. It was thought that if PK was a physical force, better results should be obtained with the rounded dice. Of course, in light of later thinking, better results might also be expected with the more divergent square dice. The scores with the two nearest-to-square dice combined were significant, as were the results with the two nearest-to-round dice combined. Both groups were about equally significant, indicating that the spherical degree of the dice was not important in this instance.

Wilbur and Mangan (1956, 1957) carried out three experiments varying the number of interruptions in a placement PK task by manipulating the roughness of the surface and size of sphere. The overall results were not significant and the primary evidence for PK occurred in the form of scoring declines. The presence of the declines was not systematically related to the number of interruptions. The (presumably) psychological factors leading to the declines apparently overshadowed the physical variables in the experiment.

After reviewing all PK studies using spheres, Stanford (1977b) noted that the studies have sometimes been successful and sometimes not. As a possible explanation, Stanford proposed, "Consideration of the physical circumstances suggests that the successful studies may have provided more opportunities for PK influence on the movement of balls. That is, successful studies have often provided for more definite and/or numerous interruptions in the path of rolling or falling spheres" (p. 368). In Walker's terminology, the results seem to be better with more divergent systems.

In work contrary to this point of view, Forwald (1964, 1977) reported experiments attempting to influence the path of a ball slowly rolling without interruption on a very slight incline. Attempts to influence a steel ball were unsuccessful, but significant results were reported with a small wooden sphere. Walker (1975, p. 21) has commented that the center of gravity of the wooden sphere is likely to be off center to an intolerable degree, given the slight incline of the surface (a slope of approximately 1 in 150 to 1 in 100). Recent control runs by Forwald (1977) indicated that the variability in the path of the wooden ball was, in fact, determined by the exact alignment of the sphere when released. Although this alignment of the sphere was not controlled in the experimental runs, Forwald favored the PK interpretation over unconscious manipulation of the initial conditions. However, given the overt possibility of producing the effect through sensory means, this work cannot be considered evidential.

To summarize, there is some consistency in the evidence indicating that a system with a large number of interruptions is conducive to PK influence. Most of the relevant experiments found either the same or a nonsignificant increase in scoring rate in the condition with more interruptions; few, if any, studies have found a decrease in scoring rate. Walker's suggestion that divergence is an important factor but that the value of increasing it becomes less important for systems with a large amount of divergence, seems very plausible in light of the present data. One might expect that most experiments would be carried out on systems with a large amount of divergence. It should be kept in mind, however, that as with most studies of physical parameters in PK, essentially all the experiments have been severely confounded by psychological factors that offer reasonable alternative interpretations.

STATIC PK

This reviewer is of the opinion that reports of poltergeist activity (for reviews, see Owen, 1964; Roll, 1976, 1977) and recent group table phenomena (Batcheldor, 1966; Brookes-Smith & Hunt, 1970) are of sufficient evidential value that static effects (such as movement or levitation of objects) cannot be ignored when considering the range of PK phenomena. Static PK effects have important implications for the topics of the number of objects influenced simultaneously, the P_{hit} factor, and the efficiency of PK operation.

The demarcation line between statistical and static PK is not sharp. For example, gross movement of a table would be considered static PK; but if the minute vibrations (due to traffic noise, etc.) were amplified and monitored with appropriate technology, producing slight paranormal movements of the table, manifested as fluctuations against this background noise, would not be an unreasonable statistical PK task. Likewise, if one influences a stationary die, it is static PK; if the die is rolling, it is statistical PK. When the die is not thrown very hard, the situation lies in between and the divergence factor discussed by Walker arises. The quantity that is different between static and statistical PK is called the signal-to-noise ratio by engineers. As Puthoff and Targ (1975) have observed, "Researchers in the area of psychokinesis appear to be plagued by results whose amplitudes have a signal-to-noise ratio near unity, regardless of the process or mechanism involved" (p. 139). That is, the PK effect is of about the same magnitude as the system noise. Static PK involves producing effects with signal-to-noise ratios much larger than 1.

Several investigators (Millar, 1975; Mattuck, 1975, 1977, 1978; Puthoff & Targ, 1975; Schmidt, 1973; Walker, 1975, 1977) have proposed that static PK effects are produced by an organization or coherence of the minute random fluctuations inherent in physical environments (e.g., thermal fluctuations). This coherence of system noise would produce a net effect instead of the usual random cancellations and has a remotely small but finite probability of occurrence by chance (i.e., a P_{hit} vanishingly small). By any standards, producing a static PK effect through this mechanism would have to be considered one of the most complex of all PK tasks. Mattuck (1975, 1977, 1978) and Walker (1975, 1977) have developed the "noise" idea to a mathematical level and have derived testable predictions. Two of the predictions will be discussed briefly.

First, Mattuck (1978) has pointed out that the magnitude of a PK effect should be directly related to the noise level, an idea not unrelated to the familiar topic of the number of opportunities for PK to operate. This hypothesis can be tested by experiments with controlled noise levels. However, there may be some supporting evidence already in the literature. Lambert (1955, 1956, 1959, 1960, 1964, 1976) has published a series of reports suggesting that poltergeist and related phenomena occur more frequently in areas and times of fluctuations in running ground water. He attributes the bulk of the alleged PK effects to misinterpretation of normal disturbances produced by ground water or similar sources. Numerous critics have pointed out, however, that the vibration levels induced by such mechanisms could not account for many of the alleged PK effects through normal means (Cornell & Gauld, 1961; Carrington & Fodor, 1955; Chesters, 1955; Carrington, 1956; Pearce-Higgins, 1956; Evans, 1976; Harrison, 1976; Zorab, 1976). This possible increased incidence of PK at times of enhanced physical vibration would be expected according to the noise theory of PK.

The second hypothesis to be discussed concerns the role of observation in static PK. As mentioned in the majority-vote section, Walker predicts that information can possibly be used with enhanced efficiency if there is continuous observation of the system's progress toward the desired outcome. Mattuck (1975) had previously derived this principle and used it to explain static PK phenomena. If one continuously observes a system, then tremendously efficient use of psi information is theoretically possible; the only limitation on the efficiency of PK operation—and presumably on the magnitude of the effect—is the rate at which the brain can process the appropriate information. These very high efficiencies would be needed to explain movements of stationary objects.

The published work on observational theories to date has treated static PK effects as plausible when the motion of an object is directly observed. However, numerous poltergeist effects have occurred without direct observation (e.g., Pratt & Roll, 1958; Roll & Pratt, 1971). Furthermore, in many cases, direct observation apparently has an inhibitory effect. In his comprehensive review, Roll (1977) found that "among the 105 cases involving movements of objects, visual fixation seemed to have had an inhibiting effect in 47 and to have had no effect in 43" (p. 397). It would seem that although the coherence-of-noise concept may be on the right track, the role of observation may need reevaluation when dealing with the static-PK effects.

Discussion

This survey of the literature has raised many questions and answered few. The primary value of this effort probably lies in suggesting specific hypotheses for testing and helping to place priorities on topics for experimental work. Certain topics, such as the role of ESP in PK and the number of objects influenced simultaneously, may not be appropriate questions in light of recent work. This does not mean that the concepts are incorrect, but rather that other topics are in more urgent need of investigation.

Investigation of psi effects using different a priori probabilities (i.e., P_{hit}) is one of the most direct means of exploring the information aspects of psi. Unfortunately, the meager amount of relevant experimental work allows only speculation about this important question. Walker's application of information theory to psi phenomena, which predicts constant statistical significance independent of P_{Mt}, is intuitively very appealing, but other models are possible. Chari (1975, 1976) has taken the position that information theory, as it is known today, while useful in certain situations, cannot adequately represent the full range of psi phenomena. Most of Chari's arguments are theoretical, however, and a testable alternative has not yet been proposed. It appears to this reviewer (who has only a superficial knowledge of information theory) that much further empirical evidence will be required before the abandonment of current information theory becomes compelling.

There is evidence that the information content of a priori probabilities is a limiting factor in PK. This view is supported by the evidence indicating that the amount of divergence is an important factor. The actual probability of a hit in a system that lacks adequate divergence would not be equal to that assumed in the statistical analysis (e.g., all faces of a balanced die are not equally probable unless the die is thrown with a large number of bounces). Thus, the divergence factor is important specifically because it relates to the P_{hit}. The fact that the amount of divergence appears to limit PK occurrence indicates that the P_{hit} is a limiting factor. Also, if the number of successful PK events were independent of a priori probability (i.e., if the "all-or-none" model was true), very significant results would be obtained on events with a small P_{hit}. Such a situation would surely have been noticed by now, particularly since it would seem to apply to static PK events which can be viewed as events with P_{hit} vanishingly small.

The majority-vote studies suggest that the goal-oriented process concept has a degree of validity. It is clear that the meaning and implications of the *terms feedback, observation* and *goal* are not fully grasped at present. Apparently these factors, along with the information aspects of a priori probabilities, provide limitations and structure for the PK process. More experimental work and greater conceptual clarity will be required before the details of these limitations and structure can be discerned. Majority-vote experiments with carefully controlled feedback and goal selection (particularly the goals and feedback of the experimenter) would seem to be a way to investigate this area directly. One can anticipate that the goal-oriented aspect and the probability factor will have a mutual interaction that will be difficult to analyze since different goals may have different a priori probabilities.

The idea that PK operates efficiently, as hinted by some of the majority-vote studies, is a very intriguing (and, at present, *speculative)* possibility. If it is true that a PK effect is manifested maximally in the specific outcome of interest and is less statistically significant with other less direct measures, the implications may go beyond the level of individual experiments. Most experimenters have a hierarchy of goals; the experimenter wants (1) the individual trials to be successful, (2) the individual subjects to be successful, (3) the experiment to be successful, (4) the line of research to be successful, and (5) his/her personal career to be successful. This situation may be analogous to the majority-vote studies; if the experimenter focuses on a successful experiment, this outcome could be achieved efficiently with a minimal effect on the trial level. Likewise, the goal of a successful line of research would be accomplished with less significant results on the level of experimental outcomes, not to mention the lower levels of individual subjects or individual trials. One could speculate that the decline in significance often found when replicating experiments (Taves & Dale, 1943; Kennedy & Taddonio, 1976) is due to the experimenters' shifting their goals to a higher level in the hierarchy (e.g., focusing more on the outcome of the line of research than on individual subjects). The majority-vote studies suggest that psi effects may occur on higher levels of a hierarchy (e.g., MV or experimental outcome) that would not be expected on the basis of the psi effects at the lower levels (e.g., individual trials). *These speculations raise the intriguing possibility that psi may not be as capricious as has been thought; perhaps we just have not been correctly identifying the goals that have been accomplished in a very efficient manner.*[13] The interaction of the differ-

[13] The experimental "error phenomena" (reviewed in White, 1976) may be related to the efficiency idea. Also, commenting on the characteristic PK manifestations in their laboratory, Puthoff and Targ (1975) note: "Psychokinetic phenomena often appear to be more the result of coincidence than the effect of a well-defined cause. . . . Unexpected but natural causes may be the effect of a series of causal links, outside the defined experimental boundaries but representing an unforeseen line of least resistance. At worst, such causal links may in fact be unobservable . . . but nevertheless act as instruments of the will" (pp. 139-140).

ent levels of goals within and between participants in an experiment would provide an interesting area for research.

For a proper perspective of the role of task complexity ESP should also be considered. This project is currently in progress.

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