Where did you go wrong? 
Errors, partial errors, and the nature of human 
information processing 

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Abstract 

Human performance is seldom perfect, and even when an overt response is correct it may be accompanied by partial-error activity that does not achieve the level of a complete incorrect response. Partial errors can be detected in measures of the lateralized readiness potential, of the electromyogram, and of response force. Correct responses accompanied by partial errors tend to have slower reaction times than “clean” correct responses (because of response competition), and condition differences in reaction time can, on some occasions, be explained in terms of differences in the incidence of partial errors. In two-choice reaction time tasks, partial errors are more frequent when the imperative stimulus contains information that favors both responses, than when it contains information that favors only one response. The non-random nature of partial errors supports the inference that partial information about the stimulus is used to guide responses. A similar inference is supported by the observation that, in hybrid choice Go/No-go tasks, the kinds of partial errors that follow a No-go stimulus represent activation of the response that would have been correct had the stimulus been a Go stimulus. Finally, we note that the human processing system is capable of monitoring its own behavior and of initiating remedial actions if necessary. The activity of an error-detection system, as revealed by measures of the error-related negativity, is related to the degree to which responses are slowed after errors. 

1. Introduction 

In this paper, we will discuss an approach to the study of human information processing that features measures of errors, and, importantly, measures of partial

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errors as a significant source of data. In particular, the measures can provide insights into both the dynamics and the architecture of the human cognitive system.

There is nothing particularly new about being interested in errors. For example, the work by Wicklegren (1977) on the speed-accuracy tradeoff, the analysis by Schweickert (1985) of the separable effects on speed and accuracy, Meyer and colleagues' work on speed-accuracy decomposition (Meyer et al., 1988a), and Logan's studies of stopping (e.g., Logan and Cowan, 1984), all feature error probability and/or error reaction time (RT) as critical dependent variables. What is different about our approach (see also Mulder et al., 1993) is the emphasis on partial errors, error tendencies that do not result in a full-fledged incorrect response. Analysis of these partial errors reveals that things may be going wrong with the system, even when its final output, the overt behavioral response, is correct.

Why are partial errors important? First, the way in which a correct response is executed may be affected by the presence of subthreshold incorrect motor activity associated with partial errors. Thus, correct responses accompanied by partial errors are not the same as "clean", pure correct responses, and we can use this distinction as a basis for decomposing correct RT distributions. Second, the incidence, timing and nature of partial errors, all depend on experimental conditions. This observation can be used to justify the inference that partial information transmission occurs in the processing system. Finally, the processing system notices partial errors (and complete errors) and adjusts its behavior accordingly. Performance after an error depends on what happens as the error is being made. These points will be considered below. But first we will provide a brief overview of the measurement of partial errors.

2. Partial errors and their measurement

Consider the traditional two-choice RT task in which subjects must execute either a left- or a right-hand response as a function of an imperative stimulus. Suppose, for example, that the subject is required to execute a right-hand response when the letter S appears on the screen and a left-hand response to the letter H. The response required is depression of one of two buttons — and a response is registered when the button is depressed to a set criterion and a switch is closed. Of course, the measure of interest is primarily the time between the presentation of the stimulus and switch closure, or the RT.

In this kind of task, errors are traditionally defined as complete button presses with the incorrect hand (e.g., a left-hand button press to the letter S: see left column of Fig. 1). It is, of course, quite possible for the subject to make a movement with the wrong hand without pressing the button completely, or to activate muscles associated with the incorrect response without actually moving, or to begin to select the incorrect response, without even activating any muscles. These are what we call "partial errors" — that is, signs of incorrect response activation
that are not associated with the kind of overt movement that satisfies the criterion to be registered as an incorrect response.

When buttons are used as response devices, as is the case in many studies in mental chronometry, manifestations of response activation that are insufficient to cause a switch closure will go unnoticed. In our research, we have used a different response device, the zero-displacement dynamometer, to detect movements that may not result in this kind of switch closure. Subjects register their responses by squeezing dynamometers, and an overt response is registered only when a criterion force level is exceeded (see middle column of Fig. 1). In most of our research, this criterion is 25% of the maximum force. Because the dynamometer provides a continuous measure of force, we can detect responses that fall short of the criterion. Such a situation is shown in Fig. 1 (right column upper panel). Here we see a squeeze with the correct hand that exceeds the force criterion and a squeeze with the incorrect hand that falls short. For us, of course, this is a partial-error trial – while for the traditional view it is a correct trial.

We should emphasize that the use of dynamometers rather than buttons as response devices does not appear to influence the way in which the processing system deals with the task. We compared buttons and dynamometers with respect to the traditional measures of RT and accuracy in a task involving manipulations of different kinds of stimulus–response compatibilities (Otten and Coles, 1994). While squeeze responses were significantly slower than button presses, there were no significant interactions between response device and any of the other independent variables for measures of RT. Furthermore, there were no significant main effects or interactions for accuracy.

We can also detect partial errors by looking at the activity of the physiological systems that are involved in response execution. The squeeze responses we require of our subjects are controlled by the forearm flexor muscles and we measure the activity of these muscles to detect a weaker form of partial error. Fig. 1 (right column: middle panel) shows a case where the correct response is executed – there is a criterion squeeze and associated EMG activity on the correct side – but there is also EMG activity on the incorrect side. For us this is a partial-error trial – but again for the traditional view, it is a correct trial.

Finally, consideration of the neural systems that control motor responses has led us and several other investigators to an even more sensitive measure of response activation, the Lateralized Readiness Potential, or LRP. We have known for some time that one can detect movement-related brain activity from electrodes placed on the scalp. For example, Kornhuber and Deecke (1965) demonstrated that voluntary movements of the hand are associated with a negative potential at the scalp and that this negativity reaches a maximum at around the time of the movement. The negativity is largest over those parts of the brain where such movements are presumably controlled. Thus, when subjects prepare to make movements of the right-hand, the negative potential is largest over the left motor cortex; for left-hand movements, the opposite asymmetry is observed.

We reasoned that the asymmetry in these movement-related potentials, or the lateralized readiness potential (or LRP), could be used to infer when subjects
Fig. 1. Schematic representation of correct responses, errors, and partial errors for the stimulus letter S that required a left-hand response. Left column: Correct (upper) and Incorrect (lower) responses with buttons as response devices. Center column: Correct (upper) and Incorrect (lower) responses with dynamometers as response devices. Right column: Partial errors detectable as partial squeezes (upper), partial EMG activity (middle), and LRPs (lower). See text for further explanation.
preferentially activate the left- or the right-hand response. For example, a partial error could be detected when the asymmetry suggests that the left-hand response is activated when the right-hand response is correct. This situation is shown in Fig. 1 (right column: bottom panel). Here we see that the subject has made a correct response. There is EMG and criterion squeeze activity on the correct side, and there is an associated asymmetry indicating activation of the right-hand response with more negativity on the left side of the scalp. However, there is an earlier asymmetry suggesting that the left-hand response was primed first, with more negativity over the right side of scalp. This is a partial error.

Of course, the left-hand is not always responsible for making errors. So on each trial, we compute the measure of asymmetry with respect to the response hand that is correct for that trial. We do this separately for all trials where the left-hand response is correct and for all trials where the right-hand response is correct. Then we average these two measures of asymmetry. In so doing, we eliminate all those asymmetries that are unrelated to the side of the movement from our final measure of the LRP. As a result, deflections of the trace in the negative (upward) direction reflect activation of the correct response, while deflections in the positive (downward) direction reflect activation of the incorrect response.

To summarize this section of the paper: By measuring the force output of the response device, along with the two psychophysiological measures, we can detect partial errors - erroneous activity that is not necessarily associated with a criterion error response. In fact, in the examples we have reviewed, the subject always made the correct response. He or she always squeezed the correct dynamometer to the criterion level of force, and without the measures of partial errors, these trials would all have been viewed as equivalent, correct-response trials.

3. Partial errors, response dynamics and the distribution of correct reaction times

The presence of partial-error activity on trials where subjects produce the correct, criterion response appears to have an effect on the way the correct response is executed. This is evident when we look at the dynamics of correct response activation on partial-error trials. As a result, the characteristics of the RT distributions for correct trials vary as a function of the presence of partial-error activity.

To examine the dynamics of correct response execution in relation to partial-error activity, Coles et al. (1985) classified each individual trial in terms of the degree of error present. The paradigm involved the Eriksen flankers task (e.g., Eriksen and Eriksen, 1974), in which the subject must respond with the left- or right-hand as a function of the center, target letter in a 5-letter visual array. The target letter could be either H or S and the noise letters surrounding the target (the flankers) were either the same as the target (compatible arrays – HHHHH, SSSSS) or the letter associated with the other response (incompatible arrays – SSHSS or HHSSH). The “degree of error” was defined in terms of the presence of electromyographic (EMG) and sub-threshold squeeze activity for the side associated with the incorrect-response hand. Thus, there were correct-response trials
where there was no evidence of incorrect response activity, trials where there was electromyographic activity on the incorrect side (partial-EMG errors), and trials where there was partial-squeeze activity on the incorrect side (partial-squeeze errors).

When we looked at the RTs for the correct response as a function of the degree of partial error, two phenomena were evident. First, the RT associated with the correct response increased as the degree of error increased. Second, the process of correct-response execution appeared to be disrupted, especially when there were partial squeeze errors. This disruption was evident in an increase in the interval between the onset of electromyographic activity and of squeeze activity for both correct and incorrect response sides. This "mutual" disruption is consistent with the idea of response competition proposed by Eriksen and Schultz (1979).

We and others (e.g., Smid et al., 1990; Smid, 1993) have observed similar kinds of effects in a number of other experiments. For example, a recent study conducted by Fournier and others in our lab (Fournier et al., 1994) examined response competition effects in a variant of the Eriksen task that involved both letters and various symbols, like arrowheads and slanted lines. This study also revealed another kind of disruption in the dynamics of the correct squeeze response itself. In particular, the time between squeeze onset and squeeze peak is (slightly) longer for those trials where there is a squeeze on the incorrect side. These data are also consistent with the idea that, when two responses are activated in this kind of task, they compete with each other and this results in their mutual disruption.

In the preceding examples, we have noted how the mean response latency for correct responses accompanied by partial errors is longer than that for "clean" correct responses (i.e., those that are not accompanied by partial errors). Of course, if partial errors are not measured, the latencies of all these correct responses would contribute to the estimate of correct-response latency. Thus, the parent distribution of RTs for all correct response trials can be regarded as a mixture of the distribution of RTs for trials with clean correct responses and the distribution of RTs for trials where the correct response is accompanied by a partial error.

Several other investigators have been interested in parsing correct RT distributions into component distributions. For example, in their varied priming procedure, Meyer and colleagues (Meyer et al., 1985) determined whether the distribution of RTs for a partially primed condition could be accounted for in terms of a mixture of the distributions for unprimed and completely primed conditions. Estimates of the characteristic component distributions were derived by running subjects in separate unprimed and completely primed conditions. In contrast, according to our procedure, the basis for parsing the distribution is derived from the individual trial data themselves, rather than from some ancillary conditions. In particular, we can separate out partial-error trials from clean, no-error trials. In so doing, we are effectively distinguishing among trials on the basis of evidence of peripheral response competition.

Fig. 2 shows various correct RT distributions for a subject in the Fournier et al. experiment. The upper panel shows separate distributions for three different types
Fig. 2. Cumulative RT distributions for the data for one subject from Fournier et al. (in preparation). Upper panel: distributions for three different types of trials; clean correct trials (N), trials on which there were partial EMG errors (E), and trials where there were partial-squeeze errors (S). Lower panel: distributions for compatible and incompatible conditions for all correct trials (N+E+S) and for only clean correct trials (N).

of trials: completely clean correct trials (N), trials on which there were partial EMG errors (E), and trials where there were partial-squeeze errors (S). Not surprisingly, the differences between clean and partial-error trials, in the dynamics of correct-response execution, are associated with differences in the characteristics of the correct RT distributions.

Of course, unless one measures partial errors, the trials we have classified as N, E and S would be regarded as equivalent, and the distribution of "correct" RTs would include all three trial types. The degree to which this distribution will deviate from the distribution of exclusively clean, correct trials will depend on the proportions of partial-error trials that are included in the overall correct RT distribution. Thus, the distribution of RTs for all correct trials will be differentially affected as a function of the incidence of partial-error trials, and a measure, like mean correct RT, will increase as a function of the number of partial errors that are mixed in with the completely clean trials. By measuring partial errors, we can
determine whether a particular difference between conditions in mean RTs should be attributed to a factor like response competition or to other factors (or to both). This is accomplished by determining whether the conditions differ in the incidence of partial errors and then computing mean RTs for clean trials and for the different kinds of partial-error trials. The effect of other factors can be evaluated by analyzing experimental effects on the distributions for what we have called "completely clean" trials. However, as we shall see, there may be response-competition effects that occur at more central levels than are revealed in the EMG and squeeze measures.

4. Partial errors and partial information transmission

We will now consider the use of measures of partial errors as a basis for inferring partial information transmission. We shall focus on two kinds of paradigms: the Eriksen flankers task, and a Go/No-go task. A comprehensive review of data from other paradigms is provided in a recent chapter by Coles et al. (1995), as well as in earlier reviews by Coles et al. (1991) and Smid (1993; see also Smid et al., 1992).

In the Eriksen flankers task, RT is slower, and responses are less accurate for incompatible versus compatible arrays. Analysis of the incidence of partial errors for this task revealed that partial-squeeze errors also occurred more often when the array was incompatible (Coles et al., 1985) — that is, when there was evidence in the stimulus that called for the incorrect response. As we noted in the previous section, correct responses accompanied by partial-squeeze errors are slower than "clean" correct responses. When we considered this fact, together with the greater incidence of partial-squeeze errors for incompatible than for compatible arrays, Coles et al. (1985) were able to account for about 10 ms of the 47 ms difference in mean correct RT between compatible and incompatible arrays.

To provide a more detailed illustration of the contribution of partial errors to the compatibility effect, we applied the parsing procedure described earlier to the RT data from Fournier et al. (in preparation). In the lower panel of Fig. 2, we see differences between compatible and incompatible conditions for clean correct trials (N) and for all correct trials (N + E + S) for one subject. Note that the effect of removing the partial-error trials is larger for the incompatible condition and that, as a result, the effect of the compatibility of the array on mean RT is smaller after the effect of response competition has been removed. Of course, we still need to account for the remaining difference. The next set of data to be discussed, relating to the LRP, implicate a more central form of response-related processing as one potential factor.

In Fig. 3, upper panel, we see the averaged waveforms for the two compatibility conditions (data are from Gratton et al., 1988). These waveforms are based on clean correct trials, for which no partial EMG or squeeze activity was present. The incompatible arrays are associated with a "dip" (from 150–250 ms) indicating initial activation of the incorrect response on these trials. Thus, even when there is
no evidence of incorrect activity at the level of the musculature, we still find an influence of array compatibility on the response system (see also Smid et al., 1990).

What do all these data mean? The greater incidence of S trials and the dip in the LRP when the array is incompatible, suggest that partial information about the array is being transmitted to the response system while the array is being processed. This partial information appears to concern the letters in the array without regard to their location, while complete processing of the array yields information about the identity of the letter at the target location. When the array is incompatible, partial information will be dominated by the letter associated with the incorrect response, and it is the transmission of this information that leads to the partial activation of the incorrect response. It is important to note that both incorrect and correct responses are activated on the same trials, that the incorrect response activity tends to occur before correct response activation, and, of course, that the incidence of these partial-error trials is influenced by the compatibility of the array. It is these three observations that together support the inference of partial information transmission in the Eriksen task.

A rather different set of observations are seen in the hybrid choice Go/No-go task used by Miller and Hackley (1992). For example, in their Experiment 2, subjects had to execute a left- or right-hand response or withhold a response as a
function of the identity and size of a letter stimulus. For example, right- and left-hand responses were required for larger S and T stimuli, respectively, while no response was required if the letters were small. Letter size was deliberately adjusted so that information about letter identity would be available before letter size. The critical question concerned the nature of the response on No-go trials and its relation to the response on Go trials. As can be seen in the lower panel of Fig. 3, there was a partial LRP on No-go trials indicating that the response associated with the letter's identity was partially activated. On the basis of this observation and those derived from other related experiments, Miller and Hackley concluded that information about letter identity was passed to the response system before information about letter size was available – that is, there was partial information transmission. Note that, in this case, the presence of the partial LRP on No-go trials, the fact that the onset of the partial LRP was the same as the complete LRP on Go trials, and the fact that the partial LRP signified partial activation of the response signalled by letter identity, together provided a basis for inferring that partial information transmission occurred.

As we have noted elsewhere (Coles et al., 1995: p. 112), it is one thing to demonstrate that partial information transmission can occur, but quite another to specify how “partial” is the information, or, in Miller's terms (e.g., Miller, 1988), to specify the grain size of the information. For example, in the Eriksen task, is information passed on in two chunks, one related to the processing of the letters without regard to their locations and one related to the processing of the central target letter? Or is the evidence passed on continuously, gradually changing from location-independent to location-dependent information? Similarly, in the hybrid Go/No-go task, is information about letter identity and letter size passed on in two chunks – or is it passed continuously? The smooth form of the average LRP is suggestive of continuous transmission. However, the shape of the average LRP may not accurately represent the form of the underlying process. As with the speed-accuracy trade-off phenomenon, one can obtain these smooth kinds of functions, suggestive of a continuous underlying process, by averaging a two-stage discrete process that is jittered in time (e.g., Meyer et al., 1988b: p. 29).

In considering these kinds of psychophysiological data, Sanders (1993) has made an interesting distinction between the nominal stimulus and the functional stimulus in the kinds of tasks that have been used. He claims that “nominal” stimuli may be composed of multiple functional stimuli. For example, in the Eriksen task, the flanking letters and the target letter are multiple attributes of the nominal five-letter array stimulus. Similarly, letter identity and letter size are multiple attributes of the letter stimuli used in the hybrid choice Go/No-go task. According to this view, then, the psychophysiological data described in this section are consistent with a model that proposes completely discrete transmission of information about each functional stimulus. However, such a model would have to assume that stages of processing have variable, rather than constant, output. Otherwise, the subjects would make errors for every incompatible trial for the Eriksen task and every No-go trial of the Miller and Hackley task (see also Smid, 1993).

From this perspective, the psychophysiological approach could provide a method
of defining the relationship between the nominal stimulus and the functional stimulus (see also Coles et al., 1995). Whenever partial information transmission is suggested by the partial-error data, the nominal stimulus would contain, by definition, more than one functional stimulus. Of course, as far as the analysis of the discrete/continuous issue is concerned, we need to have an independent method of defining, a priori, whether a nominal stimulus comprises more than one functional stimulus. Otherwise we have a serious circularity problem.

In this regard, it is important to note that even in cases where stimuli appear to be so elemental or simple that the nominal and functional stimulus are the same, there are some psychophysiological data that suggest that partial information transmission may occur. Smid et al. (1991) observed partial response activation effects in an Eriksen-like visual search task even when the noise letters had no experimentally defined responses. In this case, standard incompatibility effects were observed when the noise letters shared features with the incorrect response. To account for these data, Smid et al. proposed that partial information about letter-shape features was transmitted, and thus that the nominal letter stimulus operated as if its features constitute multiple functional stimuli. However, partial information transmission about the features of letters does not always occur. For example, Miller and Hackley (1992, Experiment 4) failed to find evidence that partial information about letter size was transmitted in their hybrid choice, Go/No-go paradigm. As we have argued elsewhere (Coles et al., 1995), there appears to be considerable flexibility in the degree to which partial information is used to prime responses (e.g., Gratton et al., 1992) and partial information may sometimes be available but not be used (e.g., Smid et al., 1992; see also Smid and Mulder, 1995, this volume). This flexibility may reflect variability in how the subject defines the functional stimulus, which in turn will lead to variability both in the occurrence of partial information transmission and in the grain size of the information transmitted. Future studies of the determinants of this flexibility, and of its limits, will be aided by observations of the incidence and timing of partial errors.

5. The significance of errors for the subject

In the previous section, we showed how measures of partial errors can be used to make inferences about partial information transmission. Of course, the person using the measures and making inferences is the experimenter or theoretician who is trying to understand how the information processing system works. However, the occurrence of partial (and complete) errors is used to make other kinds of important inferences. These are "inferences" made by the subject about his or her own behavior. It appears that the human information processing system monitors its own behavior, and that the way in which the system responds to an error is related to its future performance. The meta-point here is that, as students of human information processing, we should pay attention to errors because our subjects are certainly paying attention to them.
Since the work of Pat Rabbitt in the 1960s (for review, see Rabbitt, 1981) we have known that subjects slow down after they make errors. Rabbitt interpreted these results in terms of error-detection and error-compensation processes that are involved in monitoring the system and initiating remedial actions if necessary.

Recently, we (e.g., Gehring et al., 1993) and Falkenstein and his colleagues (e.g., Falkenstein et al., 1990) have identified a brain potential component that appears to be related to this kind of error-monitoring process. When subjects make errors in choice RT tasks, a distinctive negative deflection can be observed in the event-related brain potential trace. The deflection (referred to by us as the "error-related negativity" or the ERN) begins at around the time of the erroneous response and peaks shortly thereafter. We have also observed the same component when subjects fail to withhold their response in a Go/No-go task (Scheffers et al., in press; see also, Falkenstein et al., 1995). These data indicate that, indeed, a neural process is engaged when subjects make errors in these kinds of cognitive tasks. In fact, Dehaene et al. (1994) have recently obtained data that suggest that the process may be implemented in the anterior cingulate cortex or supplementary motor area, confirming speculations made by Gehring et al. (1993) on the basis of what is known about the functions of these structures.

The ERN is related to a number of aspects of the subject's behavior that together can be conceptualized as representing remedial actions following errors (Gehring et al., 1993). These include the force of the error response, the probability that it will be followed immediately by a correct response on the same trial, as well as the degree to which responses are slowed on the trial subsequent to the error. It appears that the ERN represents some kind of error signal that is generated as a result of a mismatch between representations of the actual response and the correct response (Bernstein et al., in press). Remedial actions are triggered when the error-signal is generated.

In Fig. 4, we show data concerning the relationship between the size of the ERN on error trials and the RT on the next trial for which the response was

![Fig. 4. The relationship between the ERN on error trials and RT on the next correct trial in a choice reaction time task. Mean RTs on error trials and on correct trials following correct trials are also shown (data from Gehring, 1992; and Gehring et al., 1993).](image)
correct. Note first that the mean RT on the trial following an error was not significantly different from the mean RT on trials following a correct response. Therefore, we did not replicate the finding of Rabbitt and Vyas (1970) who showed that correct RTs following errors were slower than "ordinary" correct RTs. However, since error RTs were shorter than correct RTs, the RT on the correct trial after an error does indicate that some slowing has taken place. As Gehring (1992) argued, the kind of slowing reported by Rabbitt is actually non-optimal – it represents more slowing than would be necessary to ensure a correct response. Viewed from this perspective, the slowing seen in our data is certainly more optimal. In any case, what is interesting is that the size of the ERN on the error trial is related to the degree of slowing on the subsequent trial. The larger the ERN, the slower the subsequent RT.

These effects were replicated in a slightly different experiment that involved a hybrid Choice/Go-No-go task (Scheffers et al., in press). In this task, the stimuli had two attributes: one, the direction of an arrow to the left or right, indicated the response hand to be used; the other, the orientation of a rectangle, within which the arrow occurred, indicated whether or not a response was to be made. In this task, it is possible for subjects to make two kinds of errors: errors of choice (using the wrong hand to respond on a Go trial) and errors of action (responding on a No-go trial). In this case, we observed a relationship between the ERN on error trials (both choice and action) and the onset of electromyographic activity associated with the correct response on the next Go trial. The response latency on the correct Go trial was longer when the ERN on the preceding trial was large than when it was small.

Together, these data suggest that the processing system uses information about errors to guide its behavior. The data are important for two reasons. First, because they reveal (again) that RTs are influenced by error activity – although, in this case, the RTs in question are those for trials following error trials. Correct trials following large ERN error trials have long RTs. Thus, the distribution of correct RTs will be differentially affected as a function of the incidence of these kinds of error trials, even though the RTs for the error trials themselves are excluded. Second, the data underscore the fact that, if we are to achieve a complete understanding of human information processing, we would do well to follow our subjects' example and pay attention to errors and partial errors.

6. Conclusions

As we have seen, measures of partial errors can be used to parse RT distributions, to specify the locus of experimental effects on the cognitive system, and to make inferences about the nature of information transmission. The data we have reviewed are also relevant to more general issues in the modelling of human information processing.

In the context of the two-choice reaction time paradigms reviewed here, two classes of models have been dominant (see Townsend and Ashby, 1983, for
review): the two-counter model in which evidence in favor of each of the two choices is accumulated separately in two counters, and the single counter, random-walk, model in which evidence in favor of one choice is taken as evidence against the other choice. In each model, a response is released when the evidence-accumulation function exceeds some threshold. While detailed consideration of the relative merits of these models is beyond the scope of this paper, it is clear that information derived from the measurement of partial errors can be used to explore these models. In particular, if there is transmission of at least some form of partial information between stimulus evaluation and response activation systems, then measurement of the activation of response systems should provide some indication of the process of evidence accumulation. Our observations that correct responses can be accompanied by different degrees of partial errors (evident in EMG and partial squeeze measures) suggests that a two-counter model may provide a more satisfying account of the psychophysiological data. However, it is also important to note that derivation of one psychophysiological measure, the lateralized readiness potential, requires that the nominal activation functions for the two responses be subtracted. As a result, the LRP measure behaves more like the random walk function that is characteristic of single-counter models.

Finally, we should emphasize again that partial-error measures can provide a basis for decomposing RT distributions. The measures could be integrated with the more common procedures used by modelers of reaction times, such as speed-accuracy decomposition (Meyer et al., 1988a) or deconvolution (Ratcliff and Murdoch, 1976). Although more research is needed to evaluate the relationships among the more traditional procedures and those based on partial errors, it seems clear that such an integrated approach is likely to prove beneficial (e.g., De Jong et al., 1990).

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