Long Term Recency Effects In Recalling Previous Answers

M.W. Lansdale
Systems Psychology Department
ITT Europe *

ABSTRACT

Successive tests of the same memory often appear to change it, either by consolidation of a correct response, or an increased probability of repeating errors. This raises the question as to whether the act of attempted recall modifies existing memory traces or creates new ones. Experimental work in this area is complicated by difficulties (a) in isolating what the interactions between successive trials actually reflect, and (b) determining exactly when such interactions have taken place.

A methodology is described in which these difficulties can be overcome within the domain of a specific experimental paradigm: the repeated cueing (RTTT) method used by Jones (1974). Analysis provides three significant findings. Firstly, attempts at recall produce an engram which is normally unavailable after a small number of subsequent trials. Secondly, in a small number of cases these traces may survive for at least the duration of the experiment. Finally, analysis of subject's confidence ratings indicates that subjects are able to distinguish between recalls of stimuli and previous answers, implying an addition to, rather than a corruption of, existing memory.

INTRODUCTION

Many of the techniques we use for studying memory require that the recall be tested more than once. However, it is becoming increasingly likely that repeated tests do not leave memory unchanged for later trials: evidence is accumulating to suggest that attempts at recognition or recall can themselves give rise to traces which may compete for recall with the original memory (e.g. Kay, 1955), or in some way alter the probability of recall (Izawa, 1970).

This has a number of important consequences. Firstly it represents a source of interference in experimental data which could lead to misleading inferences. Tests of all-or-none recall, for example, look at the consistencies in recall of a stimulus from one trial to the next. However, if the subject is merely recalling his previous responses, then all-or-none patterns in recall will predominate and may not represent the state of memory for the original stimulus. Inter-response interactions are therefore of theoretical interest in their own right.

Secondly, from an applied point of view, the interrogation of memory is of everyday importance in society; law being the most obvious case. Here it is important that the accuracy of recall is preserved as far as possible. The work of Loftus and others (e.g. Loftus, Miller & Burns, 1978) has supported the belief that the use of misinformation or leading questions can corrupt a witness' recall. Legal protocol has evolved to avoid this as far as possible, but since the repeated questioning of a witness' memory is unavoidable (not least by the witness himself), it is still important to know and understand how memory maybe changed by attempts at recall.

One difficulty in the experimental study of this process is that in most experiments the recalls of previous responses are indistinguishable from guesses or recalls of the original stimulus. This is because a single response only is required, as in paired associate experiments (e.g. see Izawa 1970). Such experiments give little information as to the interactions between responses.

The aim of this research is to study the recall of previous answers in an experiment in which this distinction can be made operationally. This experiment turns on the repeated cueing of multicomponent stimuli after the manner devised by Jones (1974) to test his Fragmentation Hypothesis. Although this is not central to the study of sequential effects in memory, it nevertheless provides the basis for studying them in this case. Since this is a relatively new idea, it is therefore useful to summarise Jones' work briefly before describing the current research in more detail.

The Fragmentation Hypothesis states that memory of a stimulus (such as a picture) is equivalent to a fragment of the original stimulus (in practice a subset of its attributes), structured in such a way that recall of the entire fragment occurs in an all-or-none manner when and only when the cue for recall is contained in the fragment. The critical test of this hypothesis depends on the repeated cueing of a multicomponent memory by each of the stimulus attributes in turn without providing any feedback of results. If the hypothesis holds, the patterns of recall should unambiguously correspond to one or another of the possible fragmentations of the stimulus.

Two experiments by Lansdale (1979) showed that this unusually precise hypothesis holds very well. The first of these is of interest here. The stimuli used were scenes of a billiard table in which three dimensions were defined: a white object (O) on the side of the table, a random pattern of red balls (P), and a coloured ball (C). Nine alternative values of each attribute were used and the stimulus set consisted of an orthogonal set of nine such pictures. With each attribute value being used once as cue, the data from each presentation set consists of a sequence of nine stimulus combinations of C, P and O values followed by 27 test trial combinations, in which one of C, P, or O is given as cue and the other two are the subject's responses. A hypothetical sequence of stimuli and responses is given in Figure 1, with those elements of the response corresponding to identifiable fragments underlined.

Figure 1: Relationships between stimuli and responses.

		Cue Value				Link
	1		Pink	P7	Book	
S	2		Brown	P6	Clock	
T	3		Light blue	P9	Bottle	
I	4		Yellow	P8	Cup	
M	5		Black	P1	Vase	
U	6		Green	P2	Mug	
L	7		White	P4	Brush	CP
I	8		Orange	P3	Newspaper	
	9		Dark Blue	P5	Gloves	CPO
R	1	P2	Green	P2	Vase	
E	2	Bottle	Black	P4	Bottle	CPO
S	3	Black	Black	P4	Bottle	
P	4	P7	White	P7	Vase	PO
O	5	Orange	Orange	P4	Bottle	CPO
N	6	Cup	Yellow	P8	Cup	
S	7	Green	Green	P2	Vase	
E	8	P9	Black	P9	Book	
S	9	Vase	Black	P9	Base	

It can be seen how in this type of data recall of previous responses can be recognised. They will appear as congruences between response combinations (e.g. between trials 2 and 3 or trials 1 and 7) over and above that normally expected by correct recall or chance repetition of errors. The possible effect of recalling previous errors is apparent if one considers the possibility that the subject guesses 'green' correctly to the cue "P2" at trial 1 and then repeats this response at trial 7. The patterns of 'recall' indicate that cue "P2" elicits recall of "green" and vice-versa, from which it would be inferred incorrectly that a [CP] memory fragment exists. Clearly repetition can therefore misrepresent the data in suggesting an all-or-none memory where no memory need exist or need not be all-or-none in reality.

From this brief discussion of the experimental technique, it can be seen that the means exist to investigate the possible effects of answer repetition more deeply; and that this also has great significance for the validity of the repeated-cueing of memory. To do this, it is first necessary to show that it occurs significantly more often than would normally be expected by chance, and to this end a sequential analysis, described in the next section was carried out.

SEQUENTIAL ANALYSIS

In investigating repetitions of previous answers in these data there are two questions to be resolved:

(i) How does one define a response as a recall of a previous answer?

(ii) How does one show that this is more than just a chance event?

Defining Previous Answers

As Figure 1 illustrates, the recall of any response combination at another trial manifests itself as a congruence between response values. However, simple congruence does not necessarily indicate a direct relationship between trials, and ambiguities can occur. Consider the following sequence of responses:

Trial Number	Response Attribute Values			Congruence to Later Trial n
i	C_j	P_j	O_j	CO
k	C_j	P_k	O_j	CPO
l	C_j	P_k	O_j	CPO
m	C_j	P_k	O_m	CP
n	C_j	P_k	O_j	

The hypothetical engram which is tapped at trial n can apparently have come from one of four sources. It is, however, important to identify a single most likely source of repetition in order to establish the chance level of its being repeated at any one trial. To do this one must make two assumptions:

(i) Given two possible sources with the same amount of congruence, e.g. trial k and trial l, there is no information that the later of the two is not itself a repetition of the earlier trial. In these cases the most likely source is taken to be the earliest trial in which the response combination in question appeared.

(ii) When one possible source gives a greater match with the trial in question than another, that is taken to be the more likely source.

Taking these points, the sequential analysis can work through individual sets of data and identify the most likely source of each response by searching all previous responses and the stimuli for the earliest combination with which the response has the greatest congruence. This can produce a complex array of relationships within responses and between responses and stimuli, as shown in Figure 1.

Identifying Chance Levels Of Repetition

Figure 1 is typical of all subjects' response sequences in showing not merely congruences between stimuli and responses, as would be expected if the subject had any memory at all, but also between one response and another. Clearly some of these will occur by chance, and the statistical test of the significance of this process depends upon determining the chance level.

Since the total number of stimulus attribute values is finite, it follows that the chance levels of repetition at any one trial are a function of the number of different permutations of attribute values that have already occurred in the subject's response sequence. Thus, for example, the chance level, Q(CO), for a repetition of a combination of C and O attributes is given by:

$$Q(CO) = \frac{\text{no. of different previously occurring trial combinations of C \& O}}{\text{no. of possible different combinations of C \& O values}}$$

Since the denominator is constant, Q(CO) increases gradually throughout the response sequence, as might be expected. Similar calculations can be made for other types of repetition.

Summarising the previous section, the sequential analysis can be seen as a chronological scan of response sequences from individual subjects. At each response the probability of each kind of repetition can be calculated, and the observed number of repetitions counted. It can be shown that over the entire response set the statistical significance of each type of repetition k (where k = CPO, CP, CO or PO) over the 27 trials is given by a X^2 statistic by the equation:

$$X^2_1 = \frac{\left(\left| OBS - \sum_1^{27} Q(k) \right| - \frac{1}{2} \right)^2}{\sum_1^{27} \left((Q(k)(1 - Q(k)) \right)}$$

Where OBS is the observed number of repetitions of that type and incorporating the correction for continuity. As a result, the sequential analysis gives a value of X^2 for each subject and for each type of answer repetitions.

The result of this is a clear and very strong trend for the repetition of complete combinations ($X^2 = 1236.5$, 27 df $p < \cdot0001$), with all but one subject showing significant levels of this type of repetition. Less clear is the position for repetitions of smaller combinations. A small number of subjects seem to show significant frequencies of CO-repetition, although the total value of X^2 is very much less than that for CPO-repetition ($X^2 = 51.6$, 27 df $p < \cdot01$). There is also a *suppression* of repetitions of CP combinations by some subjects (overall $X^2 = 49.1$, 27 df $p < \cdot01$). In view of the confused and minor role of CO-repetitions, the remainder of the analysis concentrates upon the highly significant effect of the repetition of entire CPO combinations.

TIME COURSE OF THE REPETITION EFFECT

Figure 1 shows at trials 2 and 3 a repetition of one trial on the next. Casual observation of many such response sequences shows this to be a very frequent occurrence, and it is an interesting question whether the repetition of answers only occurs between close or adjacent trials as a short-term effect.

One property of repetitions of complete answers is that they cannot occur unless one of the components of the original response combination subsequently appears as a cue. Put another way, any occurrence of the attribute values of a response combination appearing later as cues can be taken as an *opportunity* to reproduce that combination. By the semi-random nature of the subject's responses, these opportunities will fall at different separations (in trials) from the original response. For example, in Figure 1, trial 1 could be repeated 6 and again 8 trials later, whilst trial 2 is repeatable one trial later. Of all the opportunities for repetition at any separation, a certain proportion will be successful, and the ratio of successful repetitions to opportunities gives an estimate of the probability of repetition at that value of separation.

A temporal analysis was carried out in the following way. Every response combination that was not itself a completely correct response (in which case repetitions are indistinguishable from recalls of the original memory) was taken as a potential source of repetition. Each subsequent trial where one of its components appeared as cue was counted as an opportunity to repeat that combination, the intervening interval being measured in terms of the number of trials separating the two trials. In calculating the proportions of trials on which a previous response combination was repeated, the distinction was made between responses in which there was no underlying fragment and these in which a CP, CO or PO fragment existed. With only one guess included in the latter class of response combinations, the chance probability of subsequent matchings is an order of magnitude higher than in the no-fragment condition , where two guesses have to be made. For brevity, the results of CP, CO and PO fragment responses are presented together and subsequently referred to as S1 repetitions, whilst the no-fragment responses are referred to as S2 repetitions. The proportions of repetitions are plotted in Figures 2 and 3 respectively.

Both plots show high probabilities of repetition at low separations, decreasing rapidly with increasing separation to some stable level. Given that the average time between trials was some 20 to 30 seconds, this result is comparable in timescale to the long-term recency effects reviewed by Baddeley (1976, p 181).

Another interesting aspect of this data is that whilst the S2 plot appears to decay to a chance level, that for S1 repetitions remains significantly above chance. Taking the data from separation 5 and above as representative of the stable portions of the curves, this can be confirmed statistically: X^2 for S1 = 28.19, (13 df $p<0{\cdot}25$), while X^2 for S2 = 15·28, (18 df n.s.). This indicates that the mnemonic representation of S2 answers has becomes unavailable after a small number of trials, while some of the S1 answers remain effective for the duration of the experimental session.

Figure 2: Probability of recalling S1 response combinations as a function of the number of intervening trials

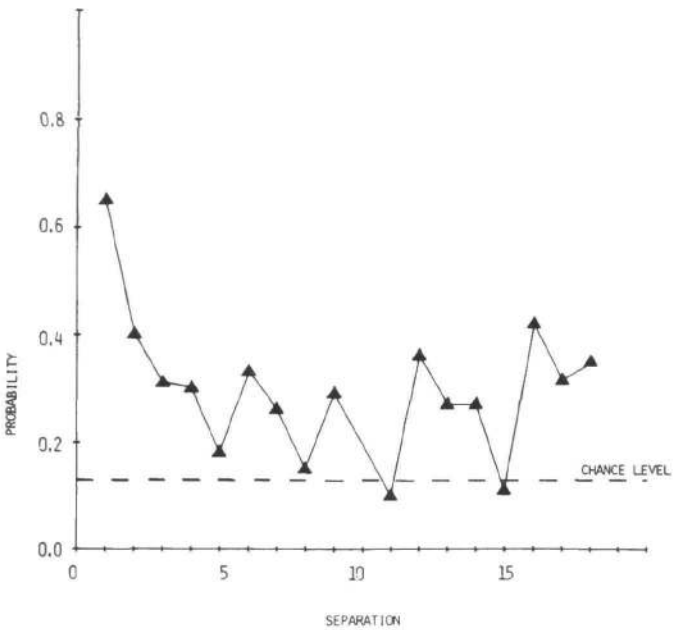
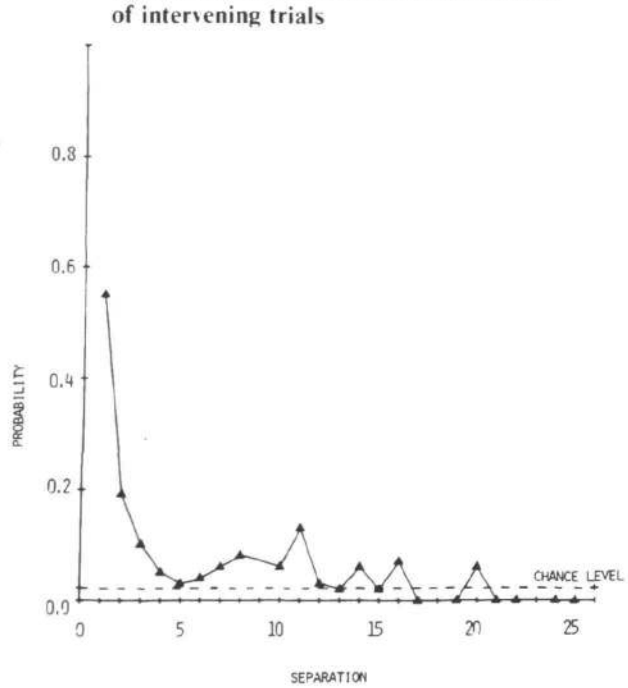


Figure 3: Probability of repeating S2 response combinations as a function of the number of intervening trials



CONFIDENCE JUDGEMENTS

In this experiment, subjects were asked to give, in addition to their responses, a confidence rating for each attribute value given as a response. These ratings were requested in one of five categories, from 1 "SURE" to 5 = "RANDOM GUESS".

The question at issue here is whether subjects could tell the difference between genuine recalls of stimuli and recalls of previous (erroneous) answers. The ability to do so implies that memory for previous answers are additional to existing memory and distinguishable from it. A sensitive test is to look at the confidence levels of successful repetitions of S1 responses, which contain one correct recall and one guess, in comparison to non-repeated S1 responses. There are two useful comparisons here: (a) between the original and repeated S1 combinations, and (b) between the correct and error elements of a repeated S1 combination. The confidence levels used for the S1 responses were therefore broken down in three ways:

1) whether the response in question was correct or a guess.

2) whether the trial combination was a repetition of a previous trial or not

3) in the case of successful repetitions, whether the separation between the trials is greater than 4 trials or not, making a comparison between long term and short term repetitions which may possibly have different properties.

Within original response combinations there is, as one might expect, a significant difference in confidence for correct responses (average 1.96) as opposed to guessed responses (average 3.48), with $X^2 = 40{\cdot}3$, 4 df $p<0{\cdot}001$. Comparison of the guesses in the repeated trials with the original guesses shows no significant differences in confidence levels in either long or short term repetitions ($X^2 = 9{\cdot}83$, 8 df). Neither do the comparisons of correct responses show any differences ($X^2 = 2{\cdot}32$, 8 df). It can therefore be concluded that when a subject repeats a previous S1 combination, he knows which element has been correctly recalled and which is a repetition of a previous guess. The memory of the original response combination must therefore be additional to that of the stimulus.

DISCUSSION

To summarize the results of this analysis: in a sequence of memory trials subjects have available memory traces of previous answers which are commonly used as responses later in the sequence. These traces normally remain available only for a small number of trials, representing a duration of up to 100 seconds, but some appear to survive for much longer periods of time. Subjects seem to be aware of the distinction between recall of these traces and recall of the original stimuli.

This analysis has a clear methodological implication: successive tests of the same memory, particularly over short intervals, will not be independant of one another. Experiments in which the observations rely upon comparison of recall on several different trials must therefore take this into account. Numerous examples can be given where doubt arises as to the validity of the conclusions in the light of this result.

What is particularly compelling about this effect is its strength and replicability across subjects, (given that no experimental instructions were made to repeat answers), and its timecourse.. This corresponds well with previous work in which long term recency effects were an explicit object of study. Such effects seem difficult to explain by reference to fixed capacity stores (Waugh and Norman, 1965), or differential encoding methods (Craik and Lockhart 1972), particularly in the latter case in the light of the incidental nature of recall in this case, in which case one would not expect subjects to adopt specific strategies of encoding.

A plausible model of these long term recency effects has been proposed by Hitch et al(1980). In their view, recency effects can be explained by a strategy of retrieval based upon temporal discrimination. Items can be retrieved from memory by their temporal position in the past only while it is discriminable from the temporal position of other, related items. Long term recency effects can therefore occur when, as in these experiments, the to-be-recalled items are spaced relatively widely in time and are therefore discriminable for longer periods.

Given that the subjects were required to guess, and that memory traces for previous appropriate guesses were available, it is not particularly surprising that subjects should use them. Speculation as to why subjects should choose to repeat previous guesses is therefore not worthwhile. Whatever the subject's reasons for repeating responses, in the process of doing so he deprives the experimenter of a certain amount of information, and potentially adds some misinformation about the state of his memory. The import of this research is chiefly a methodological one: it reinforces the long held view that the experimental psychologist should be aware that the task the subjects carry out may not be quite the one he intended.

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