Quarterly Journal of Experimental Psychology

ISSN: 0033-555X (Print) (Online) Journal homepage: http://www.tandfonline.com/loi/pqje19

# An adjacency effect in free recall

Arthur R. Jensen

**To cite this article:** Arthur R. Jensen (1965) An adjacency effect in free recall, Quarterly Journal of Experimental Psychology, 17:4, 315-322, DOI: 10.1080/17470216508416450

**To link to this article:** http://dx.doi.org/10.1080/17470216508416450

Published online: 07 Apr 2008.

Submit your article to this journal

Article views: 9

View related articles

Citing articles: 1 View citing articles

Full Terms & Conditions of access and use can be found at
http://www.tandfonline.com/action/journalInformation?journalCode=pqje20

**Download by:** [University of Washington Libraries] **Date:** 18 September 2017, At: 18:11

Downloaded by [University of Washington Libraries] at 18:11 18 September 2017

# AN ADJACENCY EFFECT IN FREE RECALL

BY

ARTHUR R. JENSEN

*From the Institute of Human Learning, University of California, Berkeley*

An *adjacency effect* was demonstrated at a high level of significance in the free recall, by 123 subjects, of a list of 40 high-frequency nouns presented in varying order on successive trials. The phenomenon referred to as the adjacency effect consists of the fact that when a subject is given repeated trials of study and free recall of a list of words (always presented in a different order), the probability of recalling a given item is greater when the item is presented temporally adjacent to an item which is already learned (as evidenced by recall on the previous trial) than when the item stands temporally between other items which are not yet learned. The enhancement of recall is greater when the item is presented between two previously learned items. The implications of the adjacency effect for verbal learning theory, particularly for the serial-position effect in serial learning and the concepts of interference and neural consolidation, are discussed.

## INTRODUCTION

The experiment reported here is directly relevant to two familiar topics in the psychology of verbal learning: (*a*) serial learning, particularly the determinants of the serial-position effect, and (*b*) free recall, particularly the determinants of the recall of individual items when there are repeated presentations of the list.

The rationale of the present experiment is based on an hypothesis originally suggested by the writer to help explain the well-known serial-position effect found in serial rote learning by the anticipation method (Jensen, 1962). It was noted that subjects learn the items of a serial list in a rather definite order, as if the first item in the list (or possibly the signal to anticipate the first item, or even the blank inter-trial interval) acts as a kind of "anchor" point around which the other items of the list become "attached" on successive trials. For example, the rank order in which the items of, say, a nine-item list are typically learned (i.e. attain some designated criterion of mastery) would be:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Serial position:* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| *Order of learning:* | 1 | 2 | 4 | 6 | 8 | 9 | 7 | 5 | 3 |

If the item in Position 1 is regarded as the anchor point, the following rearrangement of the list illustrates more clearly how the items appear to become "attached" around the anchor on successive trials (assume one item learned per trial):

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Serial position:* | 6 | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 |
| *Order of learning:* | 9 | 7 | 5 | 3 | 1 | 2 | 4 | 6 | 8 |

The distinctive skewed bow-shape of the serial-position curve can be thought of as being a direct consequence of this order of learning the items of a serial list. The descriptive evidence concerning this proposition has been presented in detail elsewhere (Jensen, 1962; Jensen, 1963; Jensen and Roden, 1963).

The crucial question, of course, is what causes this particular order of learning. A possible explanation was put forward by Jensen (1962), which is referred to as the *adjacency* hypothesis. This states that an item is more readily learned if it is presented adjacent to another already-learned item than if it is presented adjacent to other items that are as yet unlearned. We are concerned here with adjacency in temporal, rather than spatial, order. The adjacency effect might also be manifested in spatial

Downloaded by [University of Washington Libraries] at 18:11 18 September 2017

arrangements and would be sought in the simultaneous presentation of the items of a serial list over a number of trials. The adjacency hypothesis now being considered, however, concerns adjacency in the temporal sequence of presentation of stimuli, as in the usual case of serial rote learning by the method of anticipation. According to the adjacency hypothesis, if the subject learns only the first item of a serial list on the first trial, the item he will most probably acquire on the next trial will be the item in Position 2, since it is temporally adjacent to the item in Position 1. The next one to be learned will be the item in the last position, since it is the next most temporally adjacent to Position 1; then the next one to be learned will be Position 3, because of its adjacency to the already-learned Position 2; and so on, in the order which has been described above and which has already been substantiated for a wide variety of serial learning conditions (Jensen, 1962).

If the adjacency hypothesis is to be used in explaining the serial-position effect, however, the adjacency principle must itself be a more general and fundamental effect than the phenomenon it is intended to explain. Adjacency must therefore be regarded as a more basic principle of learning than the serial position phenomenon, and it must be capable of being shown to operate in other forms of learning than serial learning. Preferably it should be demonstrated in some simpler type of learning than serial learning.

In one sense, at least, free recall can be considered a simpler form of learning than serial learning, in that the subject is required only to reproduce the items in the list in free recall, without having to recall them in any prescribed order. The question therefore arises of whether the hypothesized adjacency effect can be found in free recall under the appropriate conditions for its demonstration, viz. a list which is (*a*) composed of too many items to allow complete recall after a single presentation and (*b*) which gives the subject the opportunity for repeated trials presented in a manner of study and recall. In other words, we are asking whether the adjacency effect can be demonstrated under conditions which are quite different from those of serial rote learning, i.e. where there is no constant order of presentation of items and where subjects are instructed only to recall as many of the items as they possibly can, without regard to their order of presentation.

The literature on free recall was searched for some indication of the adjacency effect, but no hint of it was found. The variables that have been found to determine the probability of recall of any given item in a free recall test, however, are numerous: the length of the total list in which the item occurs; the serial position of the item in the list; the rate of presentation of items; the frequency of the item in the language; the item's association value; the rated meaningfulness of the item; the "interest" value of the item to the particular subject; the strength of previously established association between items in the list (inter item associative strength); the degree of intra-list similarity, and conversely, the degree of "isolation" of the item; the degree to which the sequence of items approximates the sequential probabilities of normal language; the degree of opportunity for clustering; and the number of classificatory categories provided by the list. A number of these variables, of course, overlap one another in the total variance accounted for. But if they were all combined into a multiple regression equation probably a quite good job could be done of predicting the probability of recall of individual items under various conditions.

If the hypothesized adjacency effect were substantiated, it would be an important addition to this list and to our understanding of the psychological processes underlying free recall. Adjacency might even be regarded as a more fundamental determinant in free recall than many of the other variables listed above, in the sense that it may be less dependent upon antecedent experiences and may be a more intrinsic property of

Downloaded by [University of Washington Libraries] at 18:11 18 September 2017

the learning process. Therefore, the adjacency hypothesis seemed worth testing: if the adjacency effect were demonstrated we would have one more principle of free recall and we would also be provided with some knowledge of a process which might contribute to the formulation of a more satisfactory theory of serial learning and the serial-position effect.

## METHOD

### *Materials*

In attempting to detect the adjacency effect in a free recall situation it seemed advisable to try and minimize the role of other variables known to affect free recall. So the lists were made as homogeneous as possible with respect to such potent variables as familiarity and meaningfulness. In fact, the attempt was made to have lists in which all the words might be regarded as being asymptotic with respect to familiarity.

Thus, a pool of 100 words was made up having the following characteristics: (*a*) all concrete, common nouns, (*b*) no fewer than three nor more than six letters, (*c*) high familiarity as indicated by membership in the AA category (at least 100 per million) of the Thorndike-Lorge (1944) frequency count, (*d*) as many different initial letters as possible (*q*, *x* and *z* are the only ones not represented), and (*e*) easy spelling as indicated by correct spelling by at least 90 per cent. of eighth graders, according to the Iowa Spelling Scale (Green, 1954).

To enhance the generality of the findings, four "equivalent" forms of a free recall test were composed from this pool of 100 words. Each of the forms involved 60 words, so the forms were partially overlapping. All 100 words, however, occurred with equal frequency within the total of all four forms.

The same procedure was used for composing each of the forms. In one form there were six lists, with 40 words in each list. Lists 1, 2, and 3 consisted of the same 40 words, but they were always presented in a different order. List 4 consisted of only 20 words from the three previous lists (Lists 1, 2, and 3) and 20 "new" words. All the words of List 4 were repeated in Lists 5 and 6, always in a different order. Thus, subjects were presented with the same list of 40 words, each time in a different order, for three trials; then 20 of these words were discarded and 20 "new" ones were added, and this list was presented for three more trials, again with a different order of the words on each trial.

The problem of the serial-position effect was handled in a systematic fashion, the aim being to minimize the effect as much as possible. In hopes of accomplishing this the following restrictions were imposed on the ordering of the words on each successive list.

Think of the list of 40 words as being divided up into eight equal sections of five words each, i.e. Sections I to VIII. Then consider any two successive lists, say, Lists 1 and 2. The rules of ordering were: (*a*) A word should not occur again in the same section of the list or in either of the two adjacent sections. This insures that each word holds a variety of serial positions on successive trials. (*b*) Words in Sections I and VIII should not appear in either of these sections or in Sections II or VII on succeeding trials. This insures that no word will benefit from "primacy" or "recency" on more than one trial. (*c*) No more than one of the five words within a given section on one list should appear in any one section on the succeeding list. This insures that the words will not maintain any temporal proximity to one another from trial to trial. (*d*) Two words should never be adjacent to one another more than once in all six lists. (*e*) Any pair of adjacent words which were judged to suggest some rather common pre-experimental association which might cause them to be recalled together was broken up and rearranged (always in accord with the other rules). For example, the adjacent words *fire* and *bird* had to be broken up to avoid the suggestion of Stravinsky's *Firebird*.

The 20 words discarded from the list prior to Trial 4 were eliminated on a random basis. The 20 "new" words that were added (from the pool of 100 words) were unsystematically intermixed with the "old" words. The ordering of the old words, however, was strictly in accord with the rules outlined above.

### *Procedure*

Subjects were tested in groups of approximately 30. To guard against copying, they were required to leave at least one seat vacant between them and to put all books, etc., under their seats. Each of the four groups received a different form of the test, as described in the preceding section. Aside from the different forms, the procedure was the same for all groups.

Downloaded by [University of Washington Libraries] at 18:11 18 September 2017

Subjects were instructed to attend to the series of words presented on the screen, and, when the room lights were turned on after the presentation of the last word, to write down as many words as they could recall in whatever order the words came to mind. Subjects were urged to record only the words in the list presented just prior to the recall period. Every subject was provided with six sheets of ruled paper, each labelled with the trial number. At the end of each trial subjects placed their answer sheets in a large manilla envelope to insure that the recalled words would be out of sight on subsequent trials.

The words were automatically projected on the screen at the rate of one word every 2 sec., with a 0·5 sec. blank interval between words. The words appeared in black against a white background; the letters (all lower case) stood approximately 5 in. high on the screen. The room was darkened during the presentation. Immediately after the last word in the series, the lights were turned on and subjects were given 4 min. to write the words they could recall and to place the sheets in the manilla envelopes. All six trials proceeded in this fashion.

### *Subjects*

A total of 123 undergraduate students in an introductory course in educational psychology at the University of California served as subjects. They were unsystematically divided into four groups of approximately 30 subjects in each, so that four different sets of word lists could be used.

## RESULTS AND DISCUSSION

The data from each of the four groups were first analyzed separately, but since there were no appreciable or significant differences among groups on any of the relevant measures, the data were combined and the results are reported for the composite $N$ of 123.

It should be noted that the free recall performance was quite typical for the type of materials and method of presentation used here. The mean number of words recalled (out of the list of 40) on each of the Trials 1–6 were 15·06, 21·25, 26·75; 21·06, 26·43, and 29·12, respectively. Extralist intrusions accounted for 2·8 per cent. of the total recall; the intrusions were eliminated from the analysis. As one would expect, most of the intrusions appeared to be common associates of words in the list: boy—girl, king—queen, star—sky, fire—water, etc.

### *Adjacency effect*

The following discussion will be simplified if it is constantly kept in mind that the *adjacency effect* always refers to the order of *presentation* of the items and has nothing to do with the order of recall.

*Analysis 1a.* The optimal condition (Condition $A$) for adjacency to enhance the probability of recall of item $i$ would exist when item $i$ is presented between two items ($i - 1$ and $i + 1$) which had been recalled on the previous trial ($t - 1$), and which, furthermore, were sufficiently well-learned to be recalled again on trial $t$. The condition making for the lowest probability of recall of item $i$ (Condition $B$) would exist when item $i$ is presented between two items ($i - 1$ and $i + 1$) which had not been recalled on the previous trial ($t - 1$), and which, furthermore, had acquired insufficient strength to be recalled on trial $t$. These two sets of conditions ($A$ vs. $B$) define the *independent variable* of our first analysis.

The *dependent variable* is the recall ($R$) or nonrecall ($NR$) of item $i$ on trial $t$.

The adjacency effect would be demonstrated by a positive correlation between the independent and dependent variables.

Since the independent and dependent variables are both dichotomous, we can have a $2 \times 2$ contingency table, i.e. $A$ vs. $B \times R$ vs. $NR$. An appropriate measure of degree of relationship between the independent and dependent variables in this case is the phi coefficient.* The null hypothesis states that the mean phi over all subjects is zero.

Thus, for each subject, every item of the list (except the first and last, which were omitted from the analyses) from List 2 through List 6 was tabulated in one of the appropriate cells of the 2 × 2 contingency table, and the corrected phi coefficient was computed. (Fortunately, it was possible to do all the tabulations and computations on the IBM 7094 computer!) The phi coefficients thus obtained are treated only as a kind of *score* for each subject. Since the cell entries upon which phi is based are not strictly independent, it would be incorrect to attempt to evaluate the significance of phi by means of the usual chi square test. Nevertheless, the phi thus obtained is a legitimate measure of correlation. But since it is treated merely as a score, it is possible to test the adjacency hypothesis by computing the mean and *SD* of phi over all subjects and use the $t$ test to determine whether the mean phi is significantly greater than zero. Since the hypothesis predicts a positive correlation, a one-tailed $t$ test is called for.

For the contingency described above, the mean phi was 0·216, $SD = 0{\cdot}246$. This value is significantly greater than zero ($t = 9{\cdot}40$, $d.f. = 122$, one-tailed $p < 0{\cdot}0005$). The total range of phi for the entire sample went from $-0{\cdot}24$ to $+0{\cdot}78$. The frequency distribution of phis may be roughly described as follows: $-0{\cdot}24$ to $0 = 21$ per cent., 0 to $+0{\cdot}24 = 30$ per cent., $+0{\cdot}25$ to $+0{\cdot}49 = 40$ per cent., $+0{\cdot}50$ to $+0{\cdot}79 = 19$ per cent.

These results clearly substantiate the adjacency hypothesis. Yet it should be noted that many other factors must obviously play a heavy role in determining the probability of recall of an item, since the adjacency effect, as measured by the present method, accounts for only a small percentage of the total variance and shows a wide spread of values for various subjects. Approximately one-fifth of the subjects in this study did not evince the effect. In these cases adjacency was probably swamped by other determinants of recall. Another possibility is that the adjacency effect might be maximal for a given subject only under a particular rate of presentation, with the effect diminishing in proportion to departure from this rate. Thus it might be possible to demonstrate the adjacency effect in every single subject provided the subjects × presentation rate interaction were taken account of experimentally.

*Analysis 1b.* When the same type of analysis as above was carried out for each trial separately, the mean phi coefficients for Trials 2 to 6 were 0·11, 0·21, 0·23, 0·24, and 0·26, respectively; all are significant beyond the 0·001 level. The fact that phi increases consistently over trials could mean that the adjacency effect becomes stronger when some of the items in the list are overlearned. It could also mean that other factors, such as serial position, meaningfulness, etc., largely determine recall in the early trials and that adjacency is manifested more clearly in later trials after the other factors have become more or less asymptotic in their influence.

*Analysis 2a.* The next two analyses were intended to determine the degree of the adjacency effect separately for adjacency of item $i$ to the preceding item ($i - I$) and to the item following ($i + I$).

---

* Since the magnitude of the phi coefficient is affected by the degree to which the marginal frequencies on either variable depart from a 50–50 split, and since this degree of departure varies from trial to trial and from subject to subject, it seemed advisable to apply the correction suggested by Guilford (1956, pp. 314–315), which, in effect, puts every phi coefficient on the same baseline and also makes phi equivalent in magnitude to the product-moment coefficient of correlation. All the phi coefficients reported here have been thus corrected.

Downloaded by [University of Washington Libraries] at 18:11 18 September 2017

Downloaded by [University of Washington Libraries] at 18:11 18 September 2017

First, the preceding item, $i - I$. The dichotomous independent variable is: item $i - I$ recalled on the previous trial ($t - I$) and on trial $t$ vs. item $i - I$ not recalled on trial $t - I$ nor on trial $t$. The dichotomous dependent variable is: item $i$ recalled on trial $t$ vs. item $i$ not recalled on trial $t$.

In this case the mean phi ceofficient was 0·07, $SD = 0{\cdot}19$ ($t = 4{\cdot}05$, $d.f. = 122$, one-tailed $p < 0{\cdot}0005$). Though the effect is again highly significant, it is actually of quite small magnitude.

*Analysis 2b.* Here we are concerned with the effect of adjacency of item $i$ to the following item, $i + I$. The independent variable is: item $i + I$ recalled on the previous trial ($t - I$) and on trial $t$ vs. item $i + I$ not recalled on trial $t - I$ nor on trial $t$. The dependent variable is: item $i$ recalled on trial $t$ vs. item $i$ not recalled on trial $t$.

In this case the mean phi was 0·09, $SD = 0{\cdot}27$ ($t = 3{\cdot}67$, $d.f. = 122$, one tailed $p < 0{\cdot}0005$).

The "forward" and "backward" adjacency effects are thus of approximately the same magnitude, and the two effects separately do not produce nearly as great an effect as they do in combination, which indicates a strong interaction between "forward" and "backward" adjacency.

### *Adjacency and the serial position effect*

Since the adjacency effect was originally hypothesized to explain the serial position effect in serial learning, the next analysis was intended to determine the precise relevance of the adjacency effect to the serial position effect.

In order to produce, or to contribute to, the serial position effect, adjacency would have to operate under somewhat different conditions from those selected for our previous analyses. Consider the way in which a serial list is typically learned: The order of learning the items begins with the extremes of the list and proceeds towards the middle, with the forward rate of progress being about one item ahead of the progression from the end of the list. To facilitate explanation, the process can be simply represented by the serial list *abcdef*. Items not learned are represented by lower case letters and learned items by capitals. Thus, on Trial 1 (following the study trial) we have *Abcdef*, on Trial 2 we have *ABcdef*, on Trial 3: *ABcdeF*, Trial 4: *ABCdeF*, Trial 5: *ABCdEF*, and Trial 6: *ABCDEF*.

Now consider the situation that exists after Trial 1: *A* has been learned, and on the next presentation of the list *b* will be temporally the most adjacent to *A*. The adjacency hypothesis, therefore, would predict that *b* should be the next item to be learned. But note that *b* is followed by *c*, which also is not yet learned—neither was it recalled on the preceding trial nor will it be recalled on the trial for which we predict the recall of *B*. The crucial question, then, is: how strong is the adjacency effect under this particular condition as it exists in our free recall situation?

*Analysis 3a.* This analysis is intended to provide the answer. The independent variable in this case is: item $i - I$ recalled on the previous trial ($t - I$) and on trial $t$, and item $i + I$ not recalled on trial $t - I$ nor on trial $t$ vs. $i - I$ not recalled on trial $t - I$ nor on trial $t$, and item $i + I$ not recalled on trial $t - I$ nor on trial $t$. Again, the dependent variable is recall vs. non-recall of item $i$ on trial $t$.

The mean phi in this case was 0·11, $SD = 0{\cdot}23$ ($t = 5{\cdot}26$, $d.f. = 122$, one-tailed $p < 0{\cdot}0005$). Adjacency is obviously manifested in the forward direction under these special conditions, that is, a learned item facilitates the acquisition of any item that immediately follows it, though the effect is not especially strong, as indicated by a phi of only 0·11. Now, what about adjacency in the backward direction?

*Analysis* 3*b*. In the serial learning paradigm above, note the condition that prevails after Trial 4; the next item that should benefit from adjacency, according to our hypothesis, is item $E$. In this case, the preceding item ($d$) has not yet been learned, while the following item ($F$) has been learned. The corresponding independent variable for our analysis is: item $i - 1$ not recalled on trial $t - 1$ nor on trial $t$ and item $i + 1$ recalled on trial $t - 1$ and on trial $t$ vs. item $i - 1$ not recalled on trial $t - 1$ nor on trial $t$. The dependent variable is recall vs. non-recall of item $i$ on trial $t$.

The mean phi in this case was 0·01, $SD = 0{\cdot}21$, which does not differ significantly from zero. It is interesting to note that the adjacency effect was not manifested under these conditions, although it showed up very significantly in Analysis 2b, in which there was no regard for the state of the preceding item. Apparently the preceding item ($i - 1$) carries more weight in the interaction between $i - 1$ and $i + 1$. Adjacency to $i - 1$ alone is enough to yield the effect, while adjacency to $i + 1$ alone is not. Item $i + 1$ seems to add its increment to the effect only when $i - 1$ is also lending its effect.

This finding is quite bothersome in terms of our hypothesis concerning the relation of the adjacency effect to the serial position effect, for it implies that the order of learning the items of a serial list should progress consistently from the beginning to the end of the list, rather than from the extremes toward the middle, which is in fact the case. Therefore, the relevance of the adjacency phenomenon, at least as it is manifested in free recall, to the serial position effect seems quite doubtful. Furthermore, the small magnitude of the effect also leaves it wanting as an explantaion of the serial position effect. It seems doubtful if an effect which accounts at most for some 5 per cent. of the variance in probability of recall could alone produce such a strikingly powerful phenomenon as the serial position effect. On the other hand, it is possible that many of the factors that determine probability of recall in the free recall situation might not play as important a role in serial learning and thereby would leave greater scope for the operation of adjacency. Certainly there are great enough differences between free recall and serial learning to caution against a too hasty rejection of our original hypothesis. But at the moment the relevance of the adjacency effect to serial learning does not appear very promising.

### *Adjacency, consolidation, and interference.*

What this study has established with a high degree of confidence, however, is the adjacency effect itself. Adjacency is clearly a fact of the process of free recall.

Is there any accounting for this phenomenon in terms of more basic principles? The most obvious explanation is in terms of the amount of time it takes for a subject to "process," "encode," or "rehearse" a given item to make it available for later recall. The term "consolidation" is used here loosely to designate this process, whatever it might actually constitute. If an item requires $x$ sec. to be consolidated in the subject's memory for later recall, and if the item is presented for something less than $x$ sec. and is followed immediately by another non-consolidated item, one of two things can happen: (*a*) either the consolidation of the first item is interfered with by the appearance of the second item and the consolidation of the second item is begun, or (*b*) the consolidation of the first item continues until it is complete, thereby overlapping the presentation of the second item and interfering with its consolidation. Once an item has been consolidated, it need not use up further time for this process. Therefore, when a non-consolidated item is presented between two consolidated items, it is relatively "insulated" from interference on both sides—the consolidation process can begin immediately upon presentation of the item and can continue through the presentation time of the following item. The act of paying attention to each item in the

Downloaded by [University of Washington Libraries] at 18:11 18 September 2017

Downloaded by [University of Washington Libraries] at 18:11 18 September 2017

list, whether it has been consolidated or not, might, of course, result in some interference, but non-consolidated items would cause more interference than consolidated items.

The fact that the adjacency effect on item $i$ was found to be greater for the preceding item ($i - 1$) than for the following item ($i + 1$) suggests that it is somewhat easier to interfere with the *beginning* of the consolidation process than to interfere with the process once it is underway. If item $i - 1$ has already been consolidated, the consolidation of item $i$ can begin at once and will probably continue until it is complete. Of course, it will continue with less interference if item $i + 1$ has already been consolidated. If item $i - 1$ has not been consolidated on a previous trial ($t - 1$), however, it is apt to be consolidated on trial $t$ and would then overlap the presentation of item $i$, so that even if $i + 1$ had already been consolidated, the start on item $i$ might come too late to avoid interference from item $i + 2$.

There is also evidence in the present data that the consolidation of an item can interfere with an already consolidated item and "undo" it. In *Analysis* 3*b* it was found that the following item ($i + 1$) alone produced no adjacency effect *when item* $i + 1$ *is also recalled on trial* $t$, which of course, means item $i + 1$ did not suffer appreciable interference from item $i$. But it is most interesting to note the case where item $i + 1$ was recalled on trial $t - 1$ but was *not* recalled on trial $t$. Here the adjacency effect *did* occur (phi $= 0{\cdot}06$, $SD = 0{\cdot}26$, $t = 2{\cdot}50$, *d.f.* $= 122$, one-tailed $p < 0{\cdot}01$), which suggests that the consolidation of item $i$ interfered with the retention of item $i + 1$. In other words, it was found that when an item was recalled on trial $t - 1$ and then was *not* recalled on the following trial ($t$), it was preceded, in the presentation for trial $t$, by an item ($i$) that was recalled on trial $t$. The consolidation of item $i$ (as inferred from the fact that it was recalled) apparently interfered with the retention of item $i + 1$.

According to this hypothesis the rate of presentation of items is a crucial factor in the adjacency phenomenon. The hypothesis might be tested by inserting "blank" spaces of various lengths into the presentation series and noting the effects on the probability of recall of the items adjacent to the "blanks" which presumably would not much interfere with consolidation. Relevance to the von Restorff effect is thus also suggested. But any further speculation about the basic nature of the adjacency effect hardly seems warranted at this stage.

This study was aided by a National Science Foundation grant to the Institute of Human Learning.

## REFERENCES

GREEN, H. A. (1954). *The New Iowa Spelling Scale.* Bureau of Educational Research and Service, State Univ., Iowa.

GUILFORD, J. P. (1956). *Fundamental Statistics in Psychology and Education* (3rd ed.). New York.

JENSEN, A. R. (1962). An empirical theory of the serial-position effect. *J. Psychol.*, **53**, 127–42.

JENSEN, A. R. (1963). Serial rote-learning: Incremental or all-or-none? *Quart. J. exp. Psychol.*, **15**, 27–35.

JENSEN, A. R., and RODEN, A. (1963). Memory span and the skewness of the serial-position curve. *Brit. J. Psychol.*, **54**, 337–49.

THORNDIKE, E. L., and LORGE, I. (1944). *The Teacher's Word Book of 30,000 Words.* New York.

*Manuscript received 6th April,* 1965.