RELATIONSHIP BETWEEN THE ORIENTING REFLEX AND SERIAL LEARNING

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ABSTRACT

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By

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Isolation of an item in a serial list has been found to produce faster learning of at least the isolated item, an effect which is called the von Restorff phenomenon. The orienting reflex, having physiological concommitants, is an objectively measureable response which has been shown to be related to verbal learning. Since the isolation of a stimulus is likely to result in a large orienting reflex to that item, it is possible that the von Restorff effect may be explainable in terms of the effect of the orienting reflex. Since the orienting reflex was not measured in the studies reporting a von Restorff effect, no direct evidence concerning the relationship existed.

Three experimental conditions were selected for the current research, each condition being run in a warm

room and receiving a serial learning task using nonsense syllables. In the puff isolate condition, the seventh item of the list was isolated by being paired with a cool air puff in the warm room; in the puff control condition, the air puff was presented prior to the first item of the list. The control condition received no air puff and was simply the typical serial learning paradigm. The GSR as a measure of the orienting reflex was recorded in all conditions.

The following predictions were advanced: 1) The learning of the isolated item in the puff isolate condition would be enhanced, since the air puff should elicit an OR. 2) The learning of the first item in the puff control condition should not be enhanced, since the first item of a serial list is already isolated by its primary position and the position alone should yield a large OR; this condition should produce results similar to condition C. 3) In all conditions, the GSR should be negatively correlated with the number of trials to the last error for each item; that is large ORs should be associated with faster learning.

The expected von Restorff effect was not observed. It was concluded that the lack of von Restorff effect was due (1) to the long interstimulus interval and (2) to the possible inhibitory effect of the puff itself upon responding. A significant correlation was found between the GSR to each item and the speed of learning of the item.

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INTRODUCTION

Isolation of an item in a serial list by some method such as changing the color of the item (Jensen, 1962) or applying shock in temporal contiguity with the item (Raskin, Hattle, & Ruble, 1967) has produced faster learning of the isolated item. This effect is called the von Restorff phenomenon. Several explanations have been advanced for this phenomenon, including one derived from the principles of gestalt psychology (Koffka, 1935), and one derived from interference theory (Gibson, 1940, 1942).

Recent experimental research of Sokolov (1963) and Maltzman and Raskin (1965) and others has involved the concept of the orienting reflex (OR). This reflex, having physiological consommitants, can be measured during ongoing activity of an organism, allowing inferences to be made concerning the relationships between the OR and the ongoing activity. Several lines of evidence suggest that the OR may be strongly related to learning of several types. Brown (1937) found high correlations between the order of learning of items in a serial list and the GSR to the items. Belloni (1964) found high OR Ss superior to low OR Ss on a paired-associate learning task. It is the purpose of this study to investigate the relationship between the OR and serial learning, including the von Restorff phenomenon.

The Orienting Reflex

The orienting reflex is usually described as an organism's first response to any normal change in stimulation. Its apparent function is to bring the organism into closer contact with its environment following the occurrence of a novel stimulus. Although a broad range of stimuli can elicit the reflex, the same components are usually observed, and for this reason the OR is considered to be nonspecific.

Among the several components of the orienting reflex, a simultaneous dilation of the blood vessels of the head and constriction of the blood vessels of the peripheral areas is asserted by Sokolov (1963) to be the most reliable and distinctive component. Secondly, alpha-blocking occurs, that is the slow waves of high amplitude in the EEG characteristic of the relaxed state are replaced by fast waves of lower amplitude (beta waves) characteristid of an excited state. Other components of the OR include the occurrence of the galvanic skin response (GSR), dilation of the pupil of the eye, and an increase in the sensitivity of the retina. Certain somatic components are also observed, including cessation of general activity, change in respiration, an increase in muscular tonus, and turning of the receptors toward the source of stimulation.

Relationships between the Orienting Reflex and Learning

An early study by Brown (1937) related the GSR to performance in a serial learning task. Stimuli were 19 nonsense syllables of 0% associative value, and an 8 second ISI was used. Brown rank-ordered the number of correct anticipations to each syllable and the GSR to each syllable (summed over all trials) for each subject. For individual subjects, correlation between the order of learning and the rank order of the GSR ranged from +.14 to +.67. The correlation for the measures summed over subjects was +.80. Brown also averaged the magnitude of GSR for each trial up to and including the first correct anticipation and found a correlation with order of learning of +.81. A lower correlation (+.58) was found between the average GSR on correct trials and the order of learning of each syllable. Brown concluded that the typical serial learning curve was observed because of "greater attention, tension, awareness, or apprehension on the part of the individual to those items occupying a primary and a final position."

Thompson and Obrist (1964) observed EEG activity during two control periods, a serial learning task, and overlearning. Measurements of wave activity were made in the 4 seconds immediately preceding the presentation of each syllable. In general terms, they found that alpha activity decreased and beta activity increased during learning. During overlearning, both measures recovered somewhat toward control levels. In order to examine the hypothesis that the maximal EEG changes took place near the point of learning of each syllable, the syllables were divided into 4 groups according to the quarter of learning within which the last error occurred. The mean number of alpha and beta waves for each type of syllable in each quarter was tabulated; the least number of alpha waves and the greatest number of beta waves were found during the quarter in which learning occurred for all of the four syllable groups.

Using the GSR, Kintsch (1964) has obtained data similar to the Thompson and Obrist (1964) data with the EEG. In the first experiment, the numbers 1 and 2 were associated with 12 nonsense syllables, a type of learning which has been previously shown to be all-or-none in character. When GSR data were plotted forward and backward from the last error, it was shown that the GSR increased to the point of the last error, then decreased. In Experiment II, Ss learned a 10-item list of different numbers paired with nonsense syllables. This type of learning has been described by a two-stage model in which the first stage is an initial string of errors, and the second is an intermediate stage which follows the first correct anticipation and in which response probability is expected to be approximately constant. Following the intermediate stage, there is a transition to the learned state. When the GSR was plotted for the items in each of these states, a non-significant increase was observed in the first stage, then a steady state in the intermediate stage, and finally a decrease in the GSR as in Experiment I. In both experiments there were no differences in GSR when correct trials were compared with incorrect trials prior to the completion of learning.

Maltzman and his associates have worked with the hypothesis that the OR is related to discriminative ability rather than to such gross excitatory mechanisms as drive. Belloni (1964) based a paired-associate experiment upon an experiment by Standish and Champion (1960), which supported the drive position by contrasting the S's rate of learning of easy and difficult lists. Belloni found no correlation between anxiety and the OR (as measured by the response to a word in a pretest), and Standish and Champion's results with respect to anxiety were not replicated. With respect to the OR, High OR males were superior to the Low OR males in both the easy and the difficult lists, supporting the position that the OR is related to discriminative ability.

Another more direct relationship between the OR and learning is that the OR itself can be conditioned. Furedy (1967) obtained a conditioned GSR using a tone as the conditioned stimulus and a cool air puff in a warm room as the unconditioned stimulus. Furedy employed a control group which received the airpuff approximately 10 seconds before the tone, and found a significantly greater amount of GSR to the tone in the forward conditioning group.

Raskin (1969) reported a semantic conditioning experiment in which the CS word "plant" was followed by a 110 db white noise, with filler words between the CS and UCS. He reported that evidence of conditioning was indicated by a reliably greater GSR to the CS word than to the preceding control words. The difference in OR level was highly significant, as was the evidence for semantic conditioning. Some Ss were informed that the white noise might follow some specific word. The High and Low OR Ss who were informed conditioned faster than their uninformed counterparts. Informed High Anxiety Ss, on the other hand, conditioned much faster than uninformed high anxiety Ss, while low anxiety Ss conditioned at about the same rate regardless of their information about the experimental contingencies. Thus, the independence of the OR from anxiety was supported in this context also.

The von Restorff Effect

Studies such as Kimble and Dufort (1955), Jensen (1962), and Newman and Saltz (1958) have isolated an item in a serial list, e.g. by changing its color or meaningfulness level. Typically it has been found that the learning of the isolated item as a response is enhanced, but that learning of the item immediately following the isolated item is not improved.

Raskin et al. (1967) noted that the above studies used relatively innocuous methods of item isolation. Using mild shock to isolate the seventh item of a 12-item serial list, Raskin et al. found significantly faster learning of the 6^{th}, 7^{th}, and 8^{th} items, as well as significantly faster learning of the entire list in the shock-isolated condition. It was reasoned that the facilitation of learning was related to the elicitation of large ORs by the shock isolated item. They suggested that other investigations have failed to find overall facilitation because other methods of isolation did not produce strong, sustained ORs to the items in the middle of the list. The use of electric shock was said to have overcome this difficulty.

Statement of the Problem

Since experimental research has established a relationship between components of the OR and verbal learning, and since the isolation of a stimulus to obtain the von Restorff effect is likely to produce a large OR to that item, it is possible that the von Restorff effect may be explainable in terms of the effects of the OR, as suggested by Raskin et al. (1967). In the present experiment, cool air was used in an attempt to isolate items, since it was an appetitive stimulus instead of aversive, and had been shown by Furedy (1967) to be capable of eliciting a conditioned GSR.

Three experimental conditions were established for the current research, each condition being run in a warm room with a serial-learning task using nonsense syllables. In the puff-isolate condition (PI), the seventh item of the list was isolated by being paired with a cool air puff in the warm room; in the puff control condition (PC) the air puff was presented prior to the first item of the list. Condition C (control) received no air puff and was simply the typical serial learning paradigm. The GSR as a measure of the OR was recorded in all conditions.

The following predictions were advanced: 1) The learning of the isolated item in Condition PI should be enhanced, since the air puff should elicit an OR. The critical items with respect to this prediction were items 7 and 8. Isolation was expected to affect item 7 in its function as a response; and was expected to affect item 8 insofar as it changed the stimulus properties of item 7. 2) The learning of the first item in Condition PC should not be enhanced, since the first item of a serial list is already isolated by its primary position, and the position alone should yield a large OR. This condition was expected to produce results similar to Condition C. 3) In all conditions, the GSR should be negatively correlated with the number of trials to the last error for each item; that is large ORs should be associated with faster learning.

METHOD

Subjects.--Forty-seven male Ss from the introductory psychology course at Michigan State University volunteered for the experiment. Each S received extra course credit for his participation. Two Ss were rejected from the subject pool. One had previously participated in a similar experiment, the second failed to meet a criterion of six correct responses by the twenty-fifth trial. Fifteen of the Ss were assigned to each of the three experimental conditions. Assignment of Ss to the experimental conditions was made by predetermined random order, based upon the order of the Ss' appearance at the laboratory.

Apparatus.--The learning material was presented by an MTA Scholar 100. The GSR was recorded with a Marietta Apparatus 12-13R recorder. The first and third fingers of the S's left hand were moistened with electrode paste and an electrode was placed on each of the two fingers. The teaching machine controlled an event marker which recorded the time of presentation of each stimulus on the recording of the GSR. The teaching machine also signalled a Hunter timer at the proper time for presentation of the air puff.

The air puff was administered to the S by a system involving compressed air, the timer, and a solenoid switch valve. The timer completed an electrical circuit, opening the solenoid switch valve. Air was then released from the compressed air cylinder for 1 second at a regulated pressure of 25 psi. and was cooled by being passed through 25 feet of 1/4 inch copper tubing immersed in ice water. The final section of tubing was plastic of 3/8 inch diameter, attached to the teaching machine such that it would emerge on the forehead of the S, from a distance of 2 feet from the S.

Learning Materials.--Twelve CVC nonsense syllables of 42% associative value according to the Krueger (1934) norms were selected for this experiment. In order to control for any specific effects of any stimulus or of stimulus order, three different randomized orders of the list were constructed; 5 Ss of the 15 in each group received one of the three different lists. Each of the lists began with four asterisks as a signal to anticipate the first item. The three versions of the list are shown in Appendix A. The lists were constructed such that successive nonsense syllables had no letters in common. No syllable was used in the same position in more than one list, and each syllable was used in both the first half of one list and the second half of another. Also no identical strings of successive syllables longer than two syllables were repeated between lists.

Procedure.--The Ss were seated in front of the teaching machine in a room maintained at 95°F. The electrodes for measurement of the GSR were attached, and Ss were read Part I of the instructions in Appendix B. Ss learned a pretest serial list consisting of four common words in order to familiarize them with the serial learning task and to allow the GSR to become habituated to the general experimental situation. Part II of the instructions in Appendix B were then read to the S, the GSR recorder was adjusted, and the serial list was presented to the S.

The syllables were presented at a 6-second rate, a time judged to be long enough for the occurrence and recovery of the GSR to each stimulus. The inter-trial interval was 18 seconds, consisting of two 6-second periods of nothing in the window followed by 6 seconds of a row of 4 asterisks.

In conditions PI and PC, an air puff was administrated within the list. The _S_s in Condition PI were administered an air puff at the onset of the seventh item of the serial list, i.e. during anticipation of the eighth item. The _S_s in Condition PC received the puff during presentation of the asterisks, i.e. during anticipation of the first item. Condition C involved no air puff and was simply the standard serial-learning paradigm.

RESULTS

In order to assess the speed of learning, the mean trial to last error was calculated for each syllable. Figure 1 presents these results for the three conditions. In general, Condition PI produced faster learning with respect to trials to the last error. According to the analysis of variance in Table 1, only the effect of serial position was significant $F(11,462) = 10.86$, $p < .001$.

TABLE 1

Analysis of Variance of Mean Trial to Last Error for All Serial Positions

Source of Variation	SS	DF	MS	F	P
Between Subjects	8415.90	44			
Groups	393.41	2	196.71	1.03	
Ss within groups	8022.49	42	191.01		
Within Subjects	7881.83	495			
Serial position	1546.89	11	140.63	10.86	.001
Groups X serial position	351.03	22	15.96	1.23	.2
Serial position X position within groups	5983.91	462	12.95		

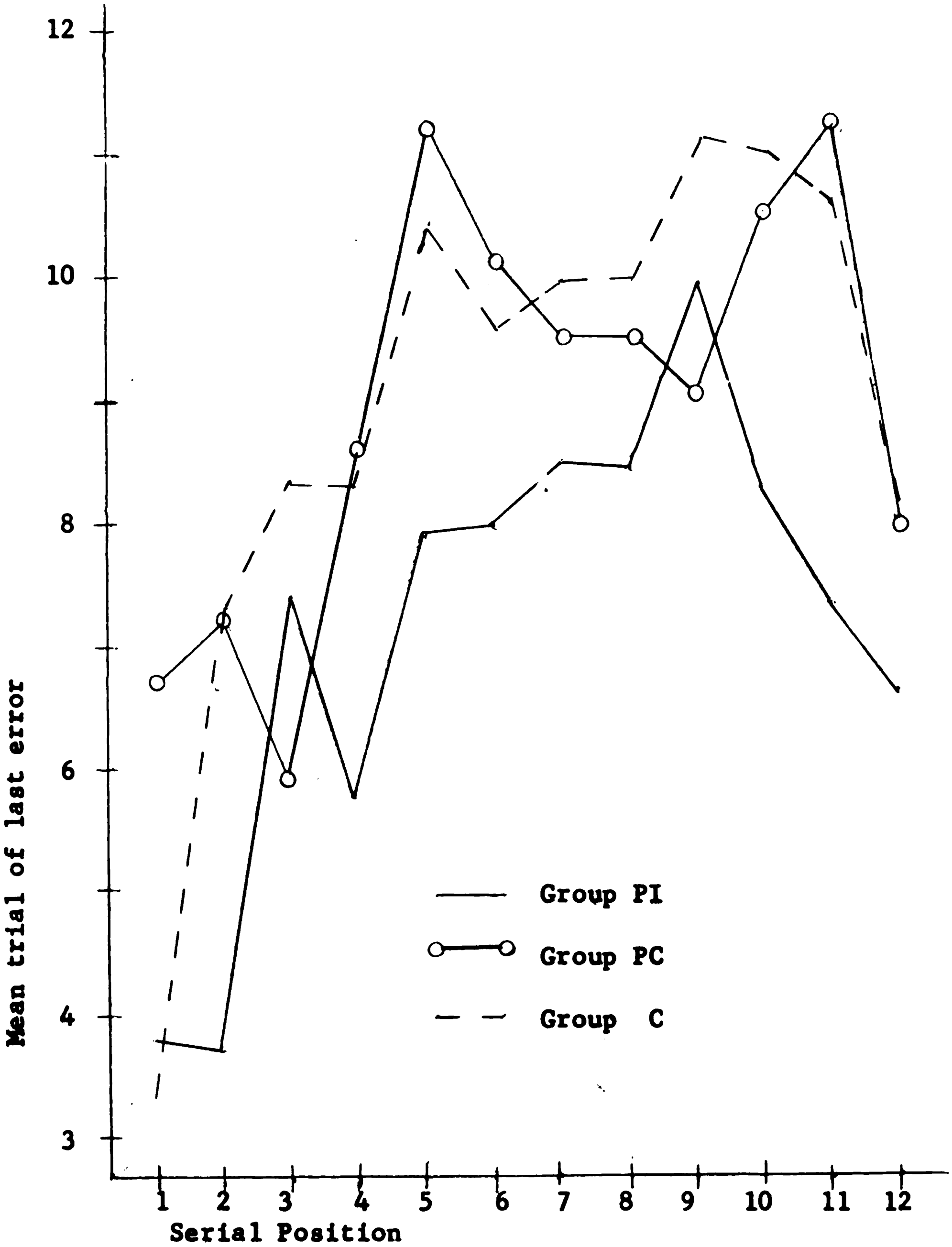

FIGURE 1
Mean trials to last error as a function of serial position

A finer examination of the learning data in terms of trials to last error was made on individual serial positions. Table 2 shows that learning of the first item in Condition PC was slower than the learning of that item in the other (PI and C) conditions but the differences were not significant, $F(2,42) = 2.42$, $p < .10$. Tables 3 and 4 show that, with respect to the number of trials to the last error, there were no significant differences between the PI, PC, and C conditions at either item 7 or item 8.

TABLE 2

Analysis of Variance of Mean Trials to Last Error, Serial Position 1

Source of Variation	SS	DF	MS	F	P
Total	989.11	44			
Groups	101.91	2	50.96	2.41	.10
Error	887.20	42	21.12		

TABLE 3

Analysis of Variance of Mean Trials to Last Error, Serial Position 7

Source of Variation	SS	DF	MS	F	P
Total	1231.24	44			
Groups	16.84	2	8.42	.29	
Error	1214.40	42	28.91		

TABLE 4

Analysis of Variance for Mean Trial to Last Error, Serial Position 8

Source of Variation	SS	DF	MS	F	P
Total	1040.80	44			
Groups	18.53	2	9.27	.38	
Error	1022.27	42	24.34		

It was predicted that the GSR within each of the three experimental conditions would be inversely related to trials to last error within each of the three conditions. Figure 2 shows the mean GSR, averaged over all

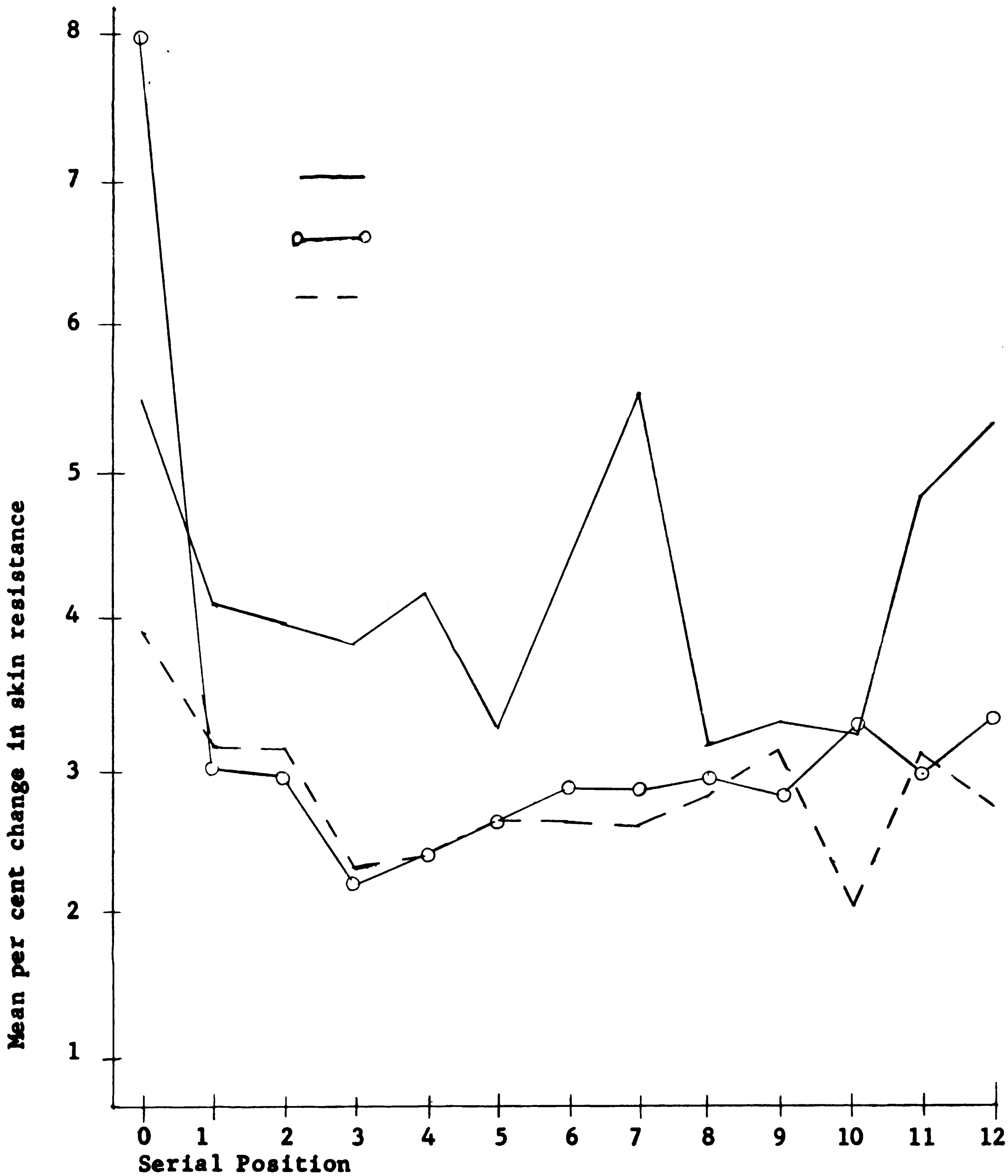

FIGURE 2
Mean percent change in skin resistance as a function of serial position

trials, for the anticipation interval preceding each item in each condition. GSR was measured in terms of per cent change of conductance during the anticipation of each item. In Condition C, the GSR was inversely related to trials to last error, the GSR being highest at the primary items of the list, dropping in the middle and rising slightly at the final position. The reliability of this relationship was supported by a significant correlation, $r(11) = -.73$, $p < .01$, between GSR and trials to last error for Condition C. Figure 2 also shows that the GSR data for group PC were similar to the GSR data for Condition C, with the exception of item 1. Item 1 in the PC group received the air puff during the anticipation period, and correspondingly had an elevated GSR. The learning data, as previously mentioned, showed a nonsignificant increase in number of trials to last error for this group with respect to item 1. Correspondingly the correlation between GSR and trials to last error for the PC group was not significant, $r(11) = .38$, $p = .22$. The results for GSR in Condition PI evidenced a basically inverse serial learning curve with the exception of item 8, the item during the anticipation of which the air puff was administered. The learning data at this point did not show a decrease in trials to last error, and the correlation between trials to last error and GSR within this condition was not significant, r(11) = -.43, p = .16. However, the correlation between the same two variables for all items excluding the eighth item was -.72 df = 10 (p = .01).

An analysis of variance of the per cent change of skin resistance showed that there was not a statistically significant difference between the three groups on this measure, F(42,2) = .12.

The base level of skin resistance was also computed. However, plots of those data showed that the base level remained nearly constant over the various serial positions, yielding no reliable relationship between base level and either the GSR or serial-learning data.

DISCUSSION

It was expected on the basis of previous research that three main predictions would be upheld by this experiment. The prediction that the learning of the isolated item in Condition PI should be enhanced was not supported by the data. Item 7, where the isolated item functioned as a response, and Item 8, where the isolation of the 7th item affected its stimulus properties were the critical items in this prediction. One reason for the failure of this prediction with respect to item 8 may be related to the next prediction. The prediction that the learning of the isolated item in Condition PC should not be enhanced was supported by the finding that the learning of item 1 in the PC group was inferior to the learning of the item in the other two groups, although the difference was not significant. The occurrence of the air puff, therefore, may have interfered with the emission of the response being anticipated. Interestingly, this result was found even though all Ss in the PI and PC groups reported during post-experimental questioning that the airpuff did not interfere with their response to those items.

The final prediction that the GSR should be negatively correlated with the measure of trials to last error was partially supported by the data. Group C, the group most similar to that used by Brown (1937), produced the correlation of -.73. Brown's correlation of -.80 was obtained by correlating rank order of amount of GSR with the rank order of learning. Thus, this replication has been obtained using measures with stronger quantitative assumptions. The correlation of -.72 for the eleven non-isolated items in group PI supported this prediction also.

A possible factor in the failure to obtain a von Restorff effect or a spread of the isolation effect may have been the long presentation rate of six seconds. Although similar items were used in the experiment by Raskin et al. (1967), the mean trial to last error ranged between about 3 and 12 in this experiment as compared with a range of about 10 to 30 in the Raskin et al. experiment. This difference in speed of learning may have been a result of increased rehearsal time allowed by the 6-second presentation rate in contrast with the Raskin et al. rate of 2 seconds. Thus, a limitation may have been placed upon the amount of improvement in learning which could have been produced by the air puff. This factor is especially relevant in view of the Jenkins and Postman (1948) hypothesis that isolation attracts attention and attention leads to increased rehearsal time.

Another factor in the failure of the prediction of a von Restorff effect appears to be that the air puff interfered with emission of correct responses. The experiment, if run to adequately test the prediction, should use a puff strong enough to elicit an OR, but not strong enough to interfere with responding, as was apparently the case in this experiment. With respect to the spread of isolation effect, an additional possibility is that the air puff, in contrast to electric shock, may not have been salient enough to produce heightened ORs to other items in the list.

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APPENDIX A

CONSTRUCTED LISTS

List 1	List 2	List 3
XEC	VUB	WUC
KYV	YAD	PAF
ZOB	TEV	BYP
YAD	BYP	XEC
VUB	GOX	ZOB
PAF	QIF	JUF
QIY	JUF	TEV
TEV	ZOB	GOX
JUF	XEC	KYV
GOX	IYV	YAD
WUC	PAF	VUB
BYP	WUC	QIY

APPENDIX B

INSTRUCTIONS

PART I

This is an experiment in verbal learning. The electrodes which I have just attached will measure electrical responses in the skin. Please rest your hand quietly on the table in front of you; any movement of the fingers will be picked up by the recorder and will interfere with the measurement of the electrical responses.

The first list that you are to learn is a practice list of four items. The items will appear in the window of the machine in front of you. The first time through the list, simply watch to see what the items are and their order. Starting with the second trial, when the asterisks appear try to anticipate the first word, when the first word appears try to say the second, and so on. In general, then, your task is to try to anticipate the next item on the list each time an item appears.

Appendix B (cont.)

PART II

This second list is a list of twelve nonsense syllables which is to be learned similarly to the first list. Again, when each preceding item appears you are to try to anticipate the next items; in this case, however, please spell out the syllables. Occasionally, there may be puffs of air from the tube in front of you.

The experiment will end when you correctly anticipate all items of the list on two consecutive trials. Are there any questions?