believed to result from the varying planetary pulls, but there is also a possibility that other heavenly bodies may also exert potent influences.

Our personal fortunes through the years, as well as our health and energy, are thus linked to the sun and, through it, to the planets of our solar system—and perhaps to the nearer stars!

Today we pride ourselves upon our scientific achievements and the conquest of disease by men of medicine; yet months or years of unseasonable warmth bring devastating economic downturns against which we have found no defense, and at such times sickness and death rates decline, even while our physicians are least busy. Statistically, one might say that people are better off the less they see of a doctor, but in reality, it is the lessened storminess and reduction in bodily stress that account for the health betterment in hard times.

Man is in reality a pawn of the environmental forces encompassing him, being pushed forward to a vantage point at one time or held in lethargic bondage at another. Here is a challenge of the first magnitude —can human intelligence find an effective answer? If not an answer, then it should at least comprehend the forces at work and the major significance of their effects.

Evidences of Associative Interference in Psychomotor Performance[1]

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UNEQUIVOCAL EXPERIMENTAL EVIDENCE of associative interference in the performance of a task predominantly motor in character was presented by Lewis (*4*) in a paper read at the 1947 meeting of the Midwestern Psychological Association. Lewis' subjects performed on a special model of the Mashburn apparatus built at Iowa. They first practised with the three controls in their usual setting. After attaining proficiency in the required task, they were given practice with all controls reversed. Following this reversed practice, they relearned the original task. Reliable decrements in performance appeared during the initial stages of relearning.

Buxton, in collaboration with Henry and Grant (*1, 2, 3*), had previously studied the effects of three different varieties of motor activity on acquired ability to perform on a Koerth-type pursuit rotor, but had found only *relative retroaction* and not actual decrements in ability to perform—decrements such as those easily demonstrated in verbal learning. In contrast to the decrements obtained by Lewis, Buxton could point only to amounts of gain in pursuit rotor performance following the interpolated activities which were different from the amount following a period of rest.

[1] Studies of associative interference in psychomotor performance are being conducted at the State University of Iowa under Contract N5ori-57 with the Special Devices Center, Office of Naval Research.

The Mashburn apparatus[2] in modified form seemed ideally suited to the studies of associative interference undertaken by Lewis. Basically, the unit consists of three double banks of small pilot lights and of a control stick and rudder bar. Each bank has a row of 13 red stimulus lights and a parallel row of 13 green response lights. Various combinations of stimulus lights come on automatically in random order, to provide patterns of red lights that must be matched by corresponding green lights. The three rows of green response lights are separately controlled by means of commutators and brushes associated with the stick and rudder bar. The green lights in any row come on and go off in succession as the corresponding control is moved in a given direction.

When a subject performs on the apparatus, he is presented with three randomly selected red lights, one in each of the three double banks. His task is to manipulate the stick and rudder bar until a green light is shining opposite each of the three red lights. When this condition prevails, a stepping relay oper-

[2] The apparatus was originally devised by Mashburn (*6*) for use in detecting flying aptitude. The Iowa model was constructed by Lewis for an investigation of the effects of noise and vibration on psychomotor responses (*5*). During the recent war, a somewhat improved form of Mashburn's original instrument was used extensively in the selection of air cadets and came to be known as the S. A. M. Complex Coordinator, a general description of which has been provided by Melton (*7*).

ates automatically to bring up a new combination of red lights. This matching procedure may be continued for desired lengths of time; and the score a subject makes is the number of three-way matches accomplished during a trial period.

As first constructed for the study of noise and vibration effects, the Iowa apparatus, like Mashburn's original, was arranged to simulate the controls in the old-fashioned airplane and to provide a maximum amount of eye-hand and eye-foot coordination. The green lights in the curved bank at the top came on in order from left to right as the stick was moved from left to right. Sidewise motions of the stick constituted the so-called aileron control. Green lights in the vertical bank came on successively from above downward as the stick was pushed forward. Forward-backward stick movements constituted the elevator control. Pushing the rudder bar (the rudder control) with the right foot lighted the green lights in the bottom row in succession from left to right.

The Iowa model of the apparatus was modified to provide, through a number of convenient switches, for a reversal of the correct movement of each control. It was thus possible for Lewis to have his subjects practise for specified numbers of trials with the controls all set in their normal positions and then practise with all of the controls reversed. The interpolated practice, that is, the reversed practice, could be followed by relearning of the original task to discover the effects of the reversed practice. As previously indicated, Lewis' study yielded clear evidence of associative interference—evidence in the form of absolute decrements in ability to perform.

The decrements in performance were unmistakable, but they seemed far less extensive than would have been expected from the amount of confusion displayed by the subjects during the initial stages of relearning. Every subject was observed to make many false moves and yet the decrease in the number of matches was in some cases only slight. It was necessary to conclude that number of matches, as a measure of performance, was not sensitive enough to reveal the full extent of the interference effects. To increase the sensitivity of the apparatus, methods were developed for recording the number of false moves made by a subject immediately after each new combination of stimulus lights was presented. The three controls had to be placed in certain precise positions in attaining each three-way match. As soon as a match was made, a new combination of red lights appeared. The subject could then move each control either correctly or incorrectly —in the direction of the stimulus light or away from it. A movement of a control away from a light was counted as an error. It was thus possible for a subject to make three errors on each match. Separate error counters were provided for the three controls. The number of errors made during each trial period became a measure of performance along with the number of matches. The errors made on each of the controls can be studied separately or combined with those for the other two controls to yield a total error count.

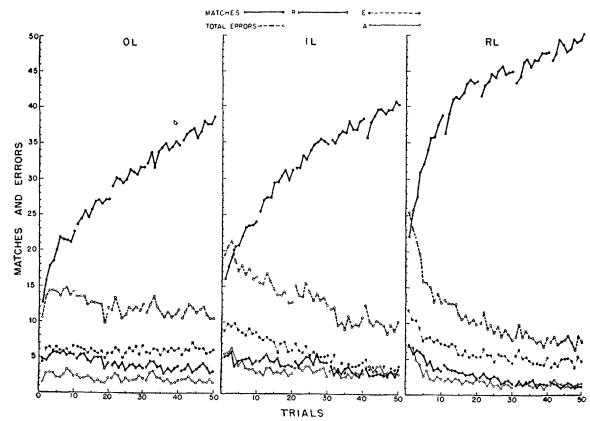

FIG. 1

The addition of the error counting procedure has added greatly to the usefulness of the Mashburn apparatus as a device for investigating associative interference.

As part of a rather extensive study of interference, eleven male students volunteered to take ten practice trials on the apparatus on each of 15 consecutive days. Each trial had a duration of two minutes. On each practice day, there was a rest period of two minutes between trials 5 and 6. All other trials were separated by a pause of 15 seconds. On the first five days (the first 50 trials), the subjects practised with the controls set in their normal positions. On the next five days (50 trials), the practising was done with the controls reversed. The original task was relearned on the last five days (50 trials).

The results for the eleven subjects are shown in Fig. 1, where mean number of matches and mean number of errors are both plotted as ordinates while trials are represented along the abscissa. There are separate plots for original learning, interpolated learning, and relearning. The upper curve in each case depicts the mean number of matches, while the heavy dashed curve (second from the top) shows total number of errors. The three lower curves are based on the mean number of errors made separately on the three controls, the control for each being indicated in the legend at the top of the figure.

During original learning, the mean performance of the subjects improved from 12.7 matches on trial 1 to 38.5 matches on trial 50. There was an initial in-

crease in total number of errors from 10.5 to 14.4, then a leveling off for a few trials, and finally a slight downward trend. Most of the decrease in errors occurred on the rudder control.

At the outset of the reversed practice (interpolated learning), the mean number of matches was 16.0. The facilitation was undoubtedly the result of positive

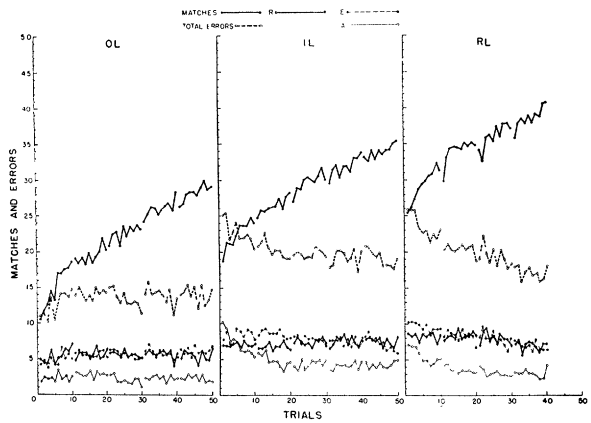

FIG. 2

transfer. Positive transfer in the task was to be expected because the subjects, during original learning, became familiar with the general requirements and with the way the controls were best manipulated. Associative interference was also to be expected. The combinations of stimulus lights were the same for original and interpolated learning, but exactly opposite movements of the controls had to be made in response to the lights. The error curves provide clear evidence of interference at the beginning of reversed practice.[3] (The mean number of errors on trial 3 was 21.4.) Mistakes on all three controls contributed to the increase in total errors, but the contribution made by false moves on the elevator control was greatest. The subjects all reported experiencing the greatest amount of difficulty with the elevator control. As shown by the curves, there was a general trend downward in total errors and in errors on the elevator control during interpolated learning.

At the outset of relearning, the mean number of matches was 22.0—a sharp reduction from the number on the last trials of original learning. The mean number of errors (25.3) was sharply increased. Mistakes were made on all of the controls, but the number made on the elevator was again conspicuously large. The decrease in number of matches and the increase in errors both pointed unmistakably to the functioning of associative interference. The interference effects were largely dissipated by the end of the first day of relearning, although remnants of them probably persisted into the third or fourth day. The reduced number of matches on the first and second trials of days 2, 3, and 4 of relearning may have arisen from lack of warm-up, but may have resulted in part from a recovery of interference effects during 24-hour periods without practice.

Evidences of associative interference similar to but less conspicuous than those displayed in Fig. 1 may be seen in Fig. 2, where results are presented for a group of nine male students given practise on 14 consecutive days[4] on the Mashburn apparatus with a different arrangement of the controls. On the Iowa model, it is possible to connect any one of the three controls to any one of the three banks of lights. When the data for Fig. 2 were collected, the rudder bar controlled the upper curve bank of green lights, while the aileron and elevator controls were associated with the vertical and horizontal banks, respectively. The resulting task was somewhat more difficult than the one arising with the standard arrangement of the controls. This greater difficulty was revealed not only by the smaller number of matches made after equal amounts of practice but also by a somewhat greater number of errors. The functioning of positive and negative effects at the outset of interpolated learning may be readily inferred from the data, and the functioning of associative interference during relearning is unmistakably revealed.

[3] Initial performance on the Mashburn apparatus with the controls reversed had been shown to be quite similar to initial performance with the controls in their normal position.

[4] Five days (50 trials) of original learning, five days (50 trials) of interpolated learning, and four days (40 trials) of relearning.

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