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AUTHOR Spangenberg, Ronald W.
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INSTITUTION Human Resources Research Organization, Alexandria, Va.
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ABSTRACT

The learning effects of display motion in procedural learning tasks were examined in two studies. In the first study, two videotapes with identical sound tracks were constructed--one using the recorded television camera motion, the other substituting a parallel series of still camera shots. The results showed a superiority of the motion condition. The second study was designed to test the hypothesis that motion functions so as to cue the critical elements of the display. Cuing arrows were added to the videotapes to show the direction of motion. The results again showed the superiority of the motion condition. No effect was attributable to the cuing arrows, and no interaction was observed. For the motion conditions, significantly less time was required to perform the task in both trials. (Author/JY)

PROCEDURE LEARNING AND DISPLAY MOTION

by

Dr. Ronald W. Spangenberg
Research Scientist
Human Resources Research Organization (HumRRO)
Division No. 2
Fort Knox, Kentucky

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The film mediation of procedural learning has been examined by many researchers. Many of the early research studies are contained in Lumsdaine (1961). Motion, as a variable, has received less attention in these studies, being represented only by Roshal's (1961) significant contribution. Roshal (1961), using three different knot tying tasks, showed that motion facilitated performance, as indicated by the number of correct knots which were tied in the various experimental conditions. Laner (1954), however, did not find motion as a significant factor in learning to dismantle, repair, and reassemble a sash-cord window, a task involving twenty-two discrete sub-operations.

Using the overhead projector, Silverman (1958) found that students who learned with the aid of manually-operated animated transparencies could better load and dry fire three different weapons than those who learned with the aid of static transparencies. He specifically related an increased effectiveness, due to motion when more than one part of the display is in motion at the same time. Most recently, Allen and Weintraub (1968), comparing motion sequences with two different still sequences for fact recall, serial ordering, and concept learning tasks in three different subject areas concluded that serial ordering of the content seemed to be most susceptible to influence by the motion picture mode.

STUDY I

The first study was designed to authenticate, in a previously unstudied task, (disassembling a weapon) the importance of display motion in procedure learning. The design was intended to clarify the locus of an anticipated motion effect. Following an overview of the entire disassembly, the removal of each of the sub-units was cued by a short demonstration. After the learner completed the entire task, he was required to perform the entire disassembly, without cues, to show if the conditions enabled differential recall of the order of the sub-units of the disassembly task.

METHOD

The 40 male subjects were Army enlisted personnel in their sixth week of basic training. The subjects were selected by their unit first sergeant in groups of eight or twelve to fulfill a mandatory requirement for personnel. On arrival, the subjects were divided by random assignment between the experimental conditions (which were presented in a pre-determined random sequence).

Two conditions were created to compare a motion sequence with a still sequence. An on-the-shelf videotape, used to teach turret mechanics the disassembly of an M85 machine gun, was selected to provide the motion sequences. In the first condition the videotape was re-edited to consist of (1) general orientation and nomenclature of the weapon, (2) an overview of the entire disassembly, and (3) a step-by-step repetition of the nine discrete sub-units, each followed by two segments of time: learner performance opportunity time (with a still picture of the completed operation on the screen) and black screen time to permit the experimenter to perform the operation in the event the learner was unable to perform it. In the second condition a set of still sequences was used to replace the second and third parts of the re-edited videotape. Using the identical sound track, this set of still photograph sequences was placed on videotape for showing the disassembly phases of the demonstration. These still shots were selected to provide the maximum assistance to the learner, rather than to imitate the motion sequence camera angles.

Each subject was placed at a table, the rear of which was 58" from a 24" television screen. On each table an M85 machine gun was placed so that its configuration would match the one as shown on the TV screen. Each subject was assigned an experimenter who provided the initial instructions, recorded the time it took the subject to perform each of the disassembly operations, and performed a specific sub-operation for the subject if he was unable to perform it, prior to the next videotaped segment. On completion of the disassembly of the first weapon, the TV was turned off and the subject was immediately taken to a second table on which was placed an identical weapon and instructed to disassemble this weapon. The times for each of the sub-operations were again recorded and if the maximum time was exceeded, the experimenter performed the proper operation for the subject. Prior to this experiment, the weapon was unfamiliar to all subjects.

RESULTS

The data was analyzed, using an analysis of variance for unequal groups, since scores of three of the subjects were omitted due to procedural error.

The mean times for each sub-operation and the F ratio are recorded in Table 1. A superiority of the motion condition is shown by the

Sub-Operation Removal of:	Trial No.	Motion Sequence Mean Time (Seconds)	Still Sequence Mean Time (Seconds)	F Ratio	Variance Accounted For ω^2
Barrel	1.	11.824	9.350	1.15	----
	2.	6.941	8.550	0.73	----
Back Plate	1.	14.706	25.500	21.31**	0.35
	2.	10.412	18.150	6.37*	0.13
Bolt Buffer	1.	7.353	11.600	6.93*	0.14
	2.	8.647	8.500	0.00	----
Feed and Ejector	1.	22.500	25.200	0.49	----
	2.	23.647	25.850	0.18	----
Sear	1.	11.059	14.800	1.57	----
	2.	14.059	19.350	1.76	----
Bolt	1.	13.941	16.050	1.29	----
	2.	10.412	16.000	4.72*	0.09
Charger	1.	7.706	19.050	21.18**	0.35
	2.	13.706	16.550	0.60	----
Cover and Feed Tray	1.	42.286	67.700	10.60**	0.31
	2.	31.533	47.789	4.94*	0.10
Accelerator	1.	10.059	14.950	3.37	0.06
	2.	6.529	8.350	0.67	----
Total Time	1.	148.353	204.500	14.79**	0.27
	2.	130.647	169.600	4.76*	0.09

* $p \leq .05$
** $p < .01$

Table 1

Mean Time, F Ratio and Variance Accounted For Between Still and Motion Sequences For Disassembly of the M85 Machine Gun results. For the first trial (cued), significantly less time was required to perform the total task and four of the nine sub-operations. The number of sub-operation sequencing errors on the second trial did not differ between conditions. Since the experimenter demonstrated the correct operation when the subject failed to perform it on trial one, the times for the second trial are partially confounded, and therefore, cannot be interpreted as representing the difference between experimental conditions.

STUDY II

The first study clearly showed a learning effect attributable to the motion of the learning display. The motion effect did not appear for all sub-operations. The second study was designed to test the hypothesis that motion functions so as to cue the critical elements of the display. Therefore, cuing was provided in an alternative way in the second study.

METHOD

The 80 male subjects were Army enlisted personnel in their sixth week of basic training. The subjects were selected by their unit first sergeant to fulfill a requirement to provide personnel. On arrival, the subjects were divided by random assignment among the experimental conditions (which were presented in a pre-determined random sequence).

Condition A was the videotape used in the first study to represent the motion condition. Condition B was the identical sound and video recording of Condition A with the addition of white cuing arrows intended to emphasize the critical motion of the various sub-operations.

Condition C was a slightly modified version of the videotape representing the still sequences in the first study. The original sequences, which were shown in Study one as inferior, were reshot and revised so as to provide the best possible sequences of still shots. Condition D was the identical sound and video recording of Condition C with the addition of white cuing arrows intended to indicate the critical motions of the various sub-operations.

Each subject was placed at a table, the rear of which was 58" from a 24" television screen. On each table an M85 machine gun was placed with the barrel pointing to the subject's left. Each subject was assigned an experimenter who provided the initial instructions, recorded the time it took the subject to perform each of the disassembly operations, and performed a specific sub-operation for the subject if he was unable to perform it, prior to the next videotaped segment. On completion of the disassembly of the first weapon, the TV was turned off and the subject was immediately taken to a second table on which was placed an identical weapon and instructed to disassemble this weapon. The times for each of the sub-operations were again recorded and if the maximum time was exceeded, the experimenter performed the proper operation for the subject. Prior to this experiment, the weapon was unfamiliar to all subjects.

RESULTS

The data was analyzed, using a 2 x 2 analysis of variance. Scores of four subjects were omitted on the first trial due to a procedural error and the necessary balancing.

The mean time for each sub-operation on each of the four conditions and the F ratios are recorded in Table 2. The results of the analysis of variance indicate a superiority of the motion condition, no effect attributable to cuing arrows, and no interaction. For the motion conditions, significantly less total time was required to perform the total task on the first trial. Of the four modified sequences (those which showed a significant difference in the first study), only two showed the motion condition as superior in the second study. However, three other sequences showed the motion sequence superior, and one showed the still sequence as superior.

Analysis of the sub-operations seems an effective way to determine factors which may be involved in learning the weapon disassembly. Barrel. The removal of the barrel showed the superiority of a still sequence over the motion sequence. It is notable that many subjects had difficulty with the latch lock and the depressing of the latch in the motion condition. An examination of the motion sequence display suggests that the explicit cue to press the latch was not provided (save by inference). The motion sequence did not clearly provide the information required to perform the task. Back plate. The still sequences did not provide as good an orientation to perform the sub-operation as did the motion sequence. Only seven subjects from the motion seq ences were noted as having difficulty in locating the latch and latch lock, while twenty subjects in the still sequences were indicated as having difficulty locating the latch and latch lock. These

Table 2.

Mean Time, F Ratio and Variance Accounted For Between Still and Motion Sequences For Disassembly of the M85 Machine Gun

Sub-Operation Removal of:	Trial No.	Motion Sequence Mean Time (Seconds)	Motion & Arrows Sequence Mean Time (Seconds)	Still Sequence Mean Time (Seconds)	Still & Arrows Sequence Mean Time (Seconds)	Arrow Effect F Ratio	Motion Effect F Ratio	Variance Accounted For ω^2	Interaction F Ratio
Barrel	1.	16.789	16.526	10.579	8.526	0.32	12.21**	0.13	0.19
	2.	8.889	8.778	6.000	6.833	0.11	4.73*	0.05	0.18
Back Plate	1.	17.737	15.368	21.158	25.158	0.15	9.95**	0.10	2.31
	2.	12.444	12.222	17.333	14.667	0.46	2.99	0.03	0.33
Bolt Buffer	1.	19.053	16.421	15.737	16.316	0.48	1.33	----	1.17
	2.	12.722	14.056	10.778	12.667	1.07	1.15	----	0.03
Feed & Ejector	1.	24.842	20.579	20.158	20.210	0.76	1.09	----	0.79
	2.	24.056	22.167	20.833	26.611	0.41	0.04	----	1.60
Sear	1.	10.421	11.000	16.737	21.263	1.84	19.44**	0.19	1.10
	2.	14.222	17.500	19.056	19.167	0.41	1.52	0.01	0.36
Bolt	1.	14.000	14.210	19.421	16.684	0.68	6.64*	0.07	0.93
	2.	11.111	8.500	17.056	13.667	2.37	8.12**	0.09	0.04
Hand Charger	1.	9.421	6.947	17.474	14.316	2.20	16.53**	0.17	0.03
	2.	5.611	7.833	13.500	11.111	0.00	8.76**	0.10	1.49
Feed Tray	1.	51.947	46.526	63.368	55.474	1.31	3.07	0.03	0.04
	2.	35.944	44.722	44.778	44.722	0.38	1.00	----	1.00
Accelerator	1.	10.526	8.842	13.526	14.632	0.02	4.10*	0.04	0.41
	2.	5.611	5.722	11.833	10.667	0.08	9.53**	0.11	0.12
Total Time	1.	174.737	157.474	198.158	192.579	0.88	5.76*	0.06	0.23
	2.	130.611	141.500	161.500	160.111	0.16	4.33**	0.04	0.27

*$p < .05$
**$p < .01$

critical parts are under the weapon so that it must either be tipped or moved so that the latch and latch lock are over the edge of the table. [There were no verbal cues in the sound track, although the weapon was shown as tipped in the still conditions and over the edge of the table in the motion conditions. The original still sequence showed the weapon over the edge of the table, but in the first study the subjects did not appear to use this information.] Bolt buffer. Both sequences seemed equivalent, following revisions of the still sequence, as comments on high scorers only indicated slowness in all conditions. Feed and ejector. Both sequences seemed equivalent. Sear. The motion sequence was slightly superior, as only two subjects had difficulty locating the sear detent release hole, while twelve, who saw the still sequence, had difficulty in locating the hole and two others failed to pull the sear when released. Bolt. The superiority of the motion sequence appears to be traceable to a greater slowness in separating the two pieces by the group exposed to the still sequence. Charger. The time for removal of the charger, following revision and additional cuing, indicated a superiority of the motion sequence. Two kinds of notations were identified with the still sequences; subjects attempted to unscrew the detent knob and subjects failed to move charger forward when the dent knob was released. Feed tray. Two sorts of errors may have balanced to provide the seemingly equivalent performances of the still and motion groups. Five subjects in the motion sequence forgot to remove the feed tray (versus one of the subjects who saw the still sequence). However, six subjects were noted as failing to release the cover pin tension in the still sequences, while only one notation for this error was made concerning subjects in the motion sequences. Accelerator. The motion sequence seemed to provide a better cue as to the level of effort required to pull out the accelerator. Only three subjects were noted as not pulling hard enough in the motion sequence, while seven subjects in the still sequence provide this notation.

DISCUSSION

The results of these two experiments do not provide evidence to suggest a single explanatory principle for the apparent superiority of a motion display over a static display in the learning of a procedural task. It does not appear that motion functions so as to focus the learner's attention upon critical elements of the display, since the use of cuing arrows provided neither a main effect nor an interaction. The performance improvement, following redesign of the still sequences which were shown as inferior to the motion sequences in the first study, suggests the possibility that the pretesting and redesign of still sequences can provide equivalent learning to some motion sequences. That is, the difference between the sequences cannot be attributable to motion as such, although it seems quite probable that not as much pretesting and revision may be required for motion sequences to reach an optimal level.

Two of the motion sequences and three of the still sequences failed to show explicitly the information that some learners need to orient themselves or to perform the sub-operation. These flaws probably could be remedied by revisions of the sequences.

One still sequence, for some learners, failed to cue as adequately the level of effort required to perform the sub-operation. The motion sequence, therefore, in some instances can provide a cuing of effort level which is not possible with a still sequence. However, verbal cues on the sound track might provide equivalent performance on the still sequence.

Three instances of the superiority of the motion sequences over the still sequences remain. Simultaneous motion in different directions by the learner was involved in these sub-operations. The sear had to be pulled as the detent was disengaged, the charger had to be pulled forward as the spring-loaded detent knob was pulled, and the accelerator had to be slightly raised as the feed tray cover was lowered to release the tension on the cover pin. These results tend to agree with Silverman's (1958) conclusion that the differences between still and moving displays can be related to the factor of simultaneously moving parts. The present studies did not, however, explicitly test for this factor.

Simultaneous motion may not be the explanatory factor involved in the superiority of motion sequences over still sequences. The still sequence concerning the charger provided explicit verbal and pictorial cues to lift the knurled head of the detent knob. Some learners who saw the still sequence erroneously attempted to unscrew this knob (which does resemble the knurled head of a thumb-screw). It is possible to assume that the learner is asked to perform an unfamiliar action (i.e., lifting) on an object which has previously been associated with a twisting action (i.e., unscrewing). The continuous minute changes depicted in the motion sequence appear to have provided a different internalization of what the learner perceived that he was to perform than did the still sequence, for at least some learners.

For operations involving simple readily codable motion actions there seems little difference whether or not display motion is present. Erroneous verbal cues were included for one sub-operation in these studies. The script on the sound track stated, "Now, lift up firmly on the accelerator and close the cover." The pictorial cues in both motion and still sequences showed that the cover had to be lowered to nearly 45° before the accelerator could be raised. In this example, actions spoke louder than words for the motion sequence, but several learners exposed to the still sequences erroneously attempted to follow the verbal instructions as stated.

It appears that Roshal's (1954) knot tying task consists of actions not overly familiar or highly codable into words. Allen and Weintraub (1968) seemed to find a motion effect in serial ordering recall when the events were unfamiliar or not readily codable into words. Further studies to explore the relationship of the factors of unfamiliar movements and verbal codable movements with moving and still sequences are suggested by these studies, as well as the factor of simultaneous movement. The role of individual learner differences should also be examined.

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