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Thirty seconds of adaptation produce spiral aftereffects three days later

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Subjects fixated the center of a rotating spiral for 30 sec. They returned 1, 2, or 3 days later to view one of three test targets: spokes, concentric rings, or a floating disk. Seventeen of 18 subjects reported long-term spiral aftereffects whose motion components were similar to those of the short-term spiral aftereffect.

Spiral aftereffects (SAEs) produced after long adaptations (15 min) have been observed a full day after cessation of stimulation (Kalfin & Locke, 1972; Masland, 1969). This experiment examined the long-term SAEs in more detail. Specifically, it determined whether the long-term SAEs (1) could be produced by short (30-sec) adaptation periods, (2) lasted longer than one day, and (3) showed motion characteristics that were the same as those of the short-term SAEs. The first question was resolved relatively quickly in a series of pilot tests: Long-term SAEs could be generated by as little as 30 sec of adaptation. Therefore, this adaptation duration was used for all subjects in this experiment.

The other two questions could not be answered so easily. Masland's (1969) subjects reported that the long-term SAE observed over a stationary spiral 20 to 26 h after adaptation for 15 min was a clear, negative SAE that was similar in pattern and direction of motion to the SAE observed immediately after adaptation. But the component motions of the SAE were not described. A more precise comparison is possible using procedures that isolate the various components of perceived motion that the SAE comprises (Hershenson, 1982).

The radial and rotational components of stimulus motion of rotating spirals were described in detail by Scott and Noland (1965). These stimulus motion components produce corresponding motion aftereffects (MAEs): The rotation motion component produces a rotation MAE, and the radial motion component produces an expansion/contraction MAE. These orthogonal components of the SAE can be made manifest by using contours that are orthogonal to the motion component as test stimuli. Specifically, the rotational motion component in the rotating spiral stimulus produces a strong negative rotation MAE over a test stimulus consisting of a set of radii (*spokes* test stimulus), and the radial motion component in the rotating spiral stimulus produces a strong negative expansion/contraction MAE over a test stimulus consisting of a set of concentric circles (*rings* test stimulus). These orthogonal components of the SAE are easily demonstrated as strong components of the first phase (Hershenson, 1982). Therefore, the spokes and rings test stimuli were used in the experiment to determine whether similar components could be observed in the long-term SAE.

Although there are only two orthogonal motion components in the stimulus motion produced by a rotating spiral, perceived motion-in-depth is a third orthogonal motion component that can be observed in the SAE (Hershenson, 1982; Holland, 1965; Scott & Noland, 1965; Wohlgemuth, 1911). This component is difficult to observe when the test stimulus is clearly flat, although a depth component frequently is reported when a SAE over a stationary spiral is observed. An excellent test stimulus for producing a motion-in-depth aftereffect is one that is apparently floating in space and is, therefore, free to move in depth in perception. The *floating disk* is such a stimulus and has been shown to produce a strong negative motion-in-depth MAE in the initial phase of the SAE (Hershenson, 1982). The floating disk was used in this experiment to test for a motion-in-depth component in the long-term SAE.

METHOD

Design

The design of the experiment was relatively simple. Each subject adapted for 30 sec to a rotating spiral and was instructed to return 1, 2, or 3 days later. Each subject saw one of the three test stimuli in the test session. At no time was the subject aware of the purpose of the experiment or of the type of test that would be given.

Adapting Stimulus

The adapting stimulus was a three-turn Archimedes spiral whose alternating black and white areas were 1.5 cm wide. The spiral subtended a visual angle of approximately 3.3°. It rotated at 40 rpm. The adapting and test stimuli were illuminated by two 75-W floodlights approximately 1.8 m from the plane of stimulation.

Test Stimuli

There were three test stimuli: spokes, rings, and a floating disk. The spokes test stimulus consisted of four equally spaced diameters produced by black lines of 2-mm thickness in an imaginary circle on white paper. It subtended a visual angle of approximately 3.3° of arc. The rings test stimulus consisted of five concentric equally spaced black circles 2 mm thick drawn on white paper. The largest circle subtended a visual angle

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of slightly less than 3.3° of arc. The test stimuli were mounted on a white background that was at the same distance from the viewer as the adapting stimulus. The floating-disk test stimulus was suspended by strings in the test-stimulus area, approximately 18 cm closer than the plane of the adapting stimulus. It subtended approximately 1.5° of visual angle. The background was a wall, approximately 1 m behind the disk, that was painted flat black. Thus, the disk appeared to float in space with little or no support.

Procedure

The subject's head was held relatively immobile in a chin and head holder. The adapting stimulus was viewed through an aperture measuring 4° of visual angle horizontally and 6° of visual angle vertically. The subjects fixated with the right eye a small red circle in the center of the adapting spiral. The subjects adapted for 30 sec and returned 24, 48, or 72 h later for a test session. They were given no information about their prospective test until they had returned. Direction of rotation of the adapting stimulus was counterbalanced across subjects within cells.

In the test sessions, the subjects were told to fixate the center of the test stimulus and to describe their perceptions of the stimulus. They were told that the stimulus might appear to be stationary or moving. They were given no information about the possible directions the motions might take. If the subjects reported seeing motion, they were told to describe its direction and to rate the motion as strong, medium, or weak. If perceived motion was reported but the descriptions were not clear, the subjects were asked probing questions to determine as carefully as possible the direction of the perceived motion.

Subjects

The 18 subjects were volunteers from an undergraduate course in psychology. They had no knowledge of the purpose of the experiment.

RESULTS AND DISCUSSION

After having fixated the center of a rotating spiral for 30 sec, 17 of 18 subjects reported SAEs when they were tested 24 to 72 h later. The subjects described the SAEs as clear. The reported directions of motion of the various aftereffects were appropriate to the stimuli with which they were tested.

Five of the six subjects who viewed the spokes test stimulus reported that they saw rotation motion. The only subject who failed to report a SAE was the one who viewed the spokes test stimulus after a 24-h delay. The direction of rotation that was indicated was opposite to that of the adapting stimulus. The six subjects who saw the rings test stimulus reported expanding or contracting motion in the aftereffect, depending on whether they had been exposed to contracting or expanding motion of the spiral adapting stimulus, respectively. The six subjects who saw the floating-disk test stimulus reported that they saw the disk moving in depth. The subjects who had adapted with an expanding spiral reported that the disk appeared to move directly away from them; the subjects who had adapted with a contracting spiral reported that the disk appeared to move directly toward them.

The patterns in the strength judgments suggest that both type and length of delay were important variables. The only subjects who reported strong MAEs were the two who saw the floating disk (i.e., reported a motion-in-depth aftereffect) after a 24-h delay. The other subjects rated the motion-in-depth aftereffect as being of medium strength. The subjects who reported an expansion/contraction MAE over the rings test stimulus rated its strength as weak regardless of delay. The subjects who saw a rotation MAE over the spokes test stimulus rated it as being of medium strength at 24- and 48-h delays and weak after a 72-h delay.

The long-term SAEs described above were produced by a rotating spiral in combination with three different test stimuli. Clearly, these SAEs are similar to those reported for short-term SAEs produced by the same combinations of adapting and test stimuli (Hershenson, 1982; Scott & Noland, 1965). That is, the short- and long-term SAEs apparently show the same components having the same directional qualities.

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