Supplemental Table 1

Assignment of two coherence levels and directions to each subject. Each from the older and younger groups of subjects was trained on two coherent levels (lower-coherency and higher-coherency). A pair of directions was 120 deg apart from each other and was randomly selected from the following 6 pairs of directions, (10 deg, 130 deg), (70 deg, 190 deg), (130 deg, 250 deg), (190 deg, 310 deg) (250 deg, 10 deg), (310 deg, 70 deg). One of the directions was presented at the low coherency level and the other direction was presented at the high coherency level.

Group	Paired with the first selected direction (x threshold)	Paired with the second selected direction (x threshold)
A	1.0	0.3
B	1.0	0.6
C	4.0	0.3
D	4.0	0.6

Supplemental Experimental Procedures

Subjects

We recruited 10 older adults (mean of age ± SD: 71.78 ± 4.02, range of age: 67-79) and 10 younger adults (mean of age ± SD: 25.9± 4.04, range of age: 19-30) with normal or corrected to normal vision. The older subjects were recruited from the Brookline Senior Center, MA. Younger subjects were recruited from undergraduate students at Boston University and Brown University. In order to make sure that older subjects had normal cognitive and memory functions, we conducted a screening session that consisted of the Mini Mental Status Examination[S1], WAIS sub-tests: digit span, digit symbol coding, and activity level evaluation[S2]. Subjects gave the informed consent reviewed and approved by the Institutional Review Board at Boston University or Brown University, and by the Elder Rights Review Committee (ERRC), Executive Office of Elder Affairs, Massachusetts Councils on Aging with the experiment site approval in local senior centers in the Commonwealth of Massachusetts.

Useful Field of View (UFOV)

In order to evaluate whether subject's attention ability is affected by task-irrelevant VPL, subjects were asked to perform the UFOV before and after training of the experiments. The UFOV test is a computer-based test that assesses parallel attention processing and visuospatial attention (Visual Awareness Research Group Inc, http://www.visualawareness.com). The test consisted of three sub-tasks for processing speed, divided attention, and selective attention, each of which measures the ability to perform a central visual identification task, the ability to divide attention on both central and peripheral stimuli, and the ability to select peripheral stimuli from distracters, respectively.

Stimuli including coherent motion

A display including coherent motion used in the present study was a standard display used in research on motion perception[S3], and subjects were asked to fixate their eyes at the center of the display. It contained approximately

70 dots per frame. Each frame was displayed for approximately 16.7 ms. In the 10% display including coherent motion, for example, 10% of the dots presented moved in a uniform direction and speed from their previous locations (10% coherent motion), while the remaining 90% of the dots moved in random directions. Coherently moving dots moved at a speed of approximately 24 deg/sec. On the next frame, another 10% of the dots were selected for coherent motion and so on. Dots not selected for coherence on a given frame were replotted at random locations. The luminance of the background and dots were 0.5 cd/m^2 and 53 cd/m^2, respectively.

Coherent motion threshold measurement

The threshold of coherent motion for each subject was measured before the pre-test stage (see below) by a standard motion detection task[S4]. On a half of 600 trials, a display consisting of coherently moving dots mixed with randomly moving dots was presented for 500 ms and on the other half of the trials a display consisting only of randomly moving dots was presented for 500 ms (Fig. 1 in the main text). Which one of the displays was presented was randomly determined from trial to trial. After the disappearance of the display, subjects were asked to press key “1” if they perceive coherent motion in the display and key “2” if not. Throughout a trial, a light-grey bulls eye was presented at the center of the display (0.5 deg in radius) to maintain subjects’ fixation. The coherent motion percentage was varied in 5 steps (3, 13, 23, 33 and 53%) and randomly determined from trial to trial. The coherent motion direction was randomly chosen from 6 motion directions (10, 70, 130, 190, 250, and 310 deg rotated clockwise from the upward direction). The threshold measurement took approximately 40 min. The 80% threshold was determined for each subject from a psychometric function (logistic regression) made based on the mean performance across the 6 coherent motion directions (the mean threshold ± SEM: 21 ± 1.3% for older, and 16 ± 1.5% for younger adults).

Pre- and post- test stages

Before and after the training stage (see below), we measured performance (percentage of correct responses) for coherent motion direction discrimination. Each of the pre- and post-test stages consisted of 720 trials. At the beginning of each trial, a light-grey bulls eye was presented at the center of the display (0.5 deg in radius) for 300 ms to maintain subjects' fixation. Then, a display including coherent motion (6.5 deg in radius) was presented for 500 ms together with the fixation point. The coherent motion direction was randomly chosen from 6 motion directions (10, 70, 130, 190, 250, and 310 deg rotated clockwise from the upward direction). The coherent motion level was randomly chosen from the four levels of the display (0.3 X threshold, 0.6 X threshold, 1.0 X threshold, 4.0 X threshold). The individual threshold was used. After the disappearance of the display with coherent motion, six arrows were presented. Within 3000 ms from the onset of the arrows, subjects were asked to click on the arrow that represented the perceived coherent motion direction[S1, 3, 4]. No feedback regarding response accuracy was given to subjects. This was followed by a 500 ms blank inter-trial interval before the onset of the next trial.

Training stage

On each trial of the training stage, subjects were presented with a sequence of eight items (two digits out of “1”, “2”, “3” and “4” as targets and six letters out of “A”, “B”, “C”, “D”, “E”, “F”, “G”, “H”, “J”, “K”, “L”, “M”, “N”, “P”, “Q”, “R”, “S”, “U”, “V”, “W”, “X”, and “Y” as distractors) in a light-grey disk (0.5 deg in radius) at the center of the display. Each item was presented 75 ms after the onset of the display with coherent motion and disappeared 75 ms before the offset of the display including coherent motion which was presented for 500 ms. Each trial lasted 4000 ms[S3, 5]. Subjects were asked to press the corresponding number keys to report the presented two digits in the sequence with the respective order of presentations. This task is known as a rapid serial visual presentation (RSVP) task[S6]. No feedback as to response accuracy was provided to subjects.

In the background annulus (0.5 to 6.5 deg in eccentricity), a display including coherent motion was merely exposed as task-irrelevant. Each subject was assigned to one of 4 groups by the combination of two exposed coherent motion levels (Group A: 1.0 X threshold and 0.3 X threshold; Group B: 1.0 X threshold and 0.6 threshold; Group C: 4.0 X threshold and 0.3 X threshold; Group D: 4.0 X threshold and 0.6 X threshold, see Supplemental Table 1). For each subject, two coherent motion directions that were 120 deg apart from each other were randomly selected from six directions (10, 70, 130, 190, 250, and 310 deg) and used throughout the training stage. Each of the two selected coherent motion levels was randomly determined to be constantly paired with one of the two selected coherent motion directions. The two pairs (e.g., one pair of the 1.0 x threshold coherent motion level and 130 deg coherent motion direction and the other pair of the 0.3 X threshold coherent motion level and 10 deg coherent motion direction) were determined and used for a subject throughout the training stage. In each trial, one of the two selected pairs of coherent motion level and direction was presented in a random order and was consistently presented with two targets (digits) presented at the center for the RSVP task. Each of the remaining 6 items (2 items were targets) at the center was a letter as a distractor in the RSVP task and was presented with one of the 4 remaining coherent motion directions in a random order (2 directions presented with targets). The coherent motion level with distractors was the same as that of the coherent motion presented with targets. Thus, the coherent motion level throughout a trial was constant. The order of presentations of two selected coherent motion levels (paired with two selected coherent motion directions) was randomly determined from trial to trial for each day for each subject. The temporal locations of targets were also randomly determined from trial to trial.

The procedure of the training stage was used in previous studies of task-irrelevant VPL. These studies have consistently reported that coherent motion directions as task-irrelevant were learned only if they were presented with targets in an RSVP task[S3, 5, 7].

The reason why only two levels of coherent motion were presented to each subject throughout the training stage was to ensure that learning of two exposed directions (each of which had one of two coherent motion levels) would not interact with each other. As mentioned above, each subject was exposed to 2 coherent motion directions with respective coherent motion levels paired with targets (digits) and the remaining 4 coherent motion directions paired with distractors (letters). Thus, the closest motion directions were 60 deg apart. In a preliminary test, we have found that 60 deg is the minimum difference between two directions of which learning does not interact with each other. Since each of two selected coherent motion directions was always paired with one of two selected coherent motion directions, to avoid interactions of learning of two coherent motion directions, two coherent motion levels were used for each subject. This procedure was successfully used in the previous study[S3]. There were 400 trials in each day of training.

Supplemental References

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