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Imagery Interference Diminishes in Older Adults: Age-Related Differences in the Magnitude of the Perky Effect

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Abstract

Studies have documented the negative effects of mental imagery on perception (also known as the *Perky effect*) in younger adults, but imagery-interference effects in older adults have never been assessed. Two experiments examined this issue directly. Experiment 1 demonstrated that visual mental images diminish visual acuity in younger adults (mean age = 19.0) but not older adults (mean age = 73.6). Experiment 2 obtained parallel results, showing that visual imagery interfered with performance on a visual detection task in younger (mean age = 18.7) but not older adults (mean age = 66.7). Processes underlying age-related differences in imagery-interference effects are discussed and implications of these results for changes in cognitive performance in older adults are considered.

Keywords

Imagery; Perception; Aging; Visual Acuity; Stimulus Detection; Perky Effect

There is an extensive research literature substantiating age related changes in cognitive abilities. Older adults (those 60 years and older) show poorer performance relative to younger adults (between 20 and 40 years) on a wide variety of tasks, most notably those involving divided attention,¹ working memory,^{2–4} explicit recall,^{5,6} episodic memory,⁷ performance intelligence (e.g., reasoning and problem solving),⁸ and speech recognition and speech discrimination.⁹ Aging may also adversely affect an array of imagery abilities including image generation,^{10–12} image manipulation,^{12–15,16} image maintenance¹⁷ and mental rotation.^{12,13,16,18} Although there have been reports that the effect of aging on mental imagery is selective (e.g., impairing mental rotation abilities but sparing accuracy in image scanning),¹² the selective effect of age on mental imagery is somewhat controversial.^{14,19,20} Nonetheless, there is a sizeable literature substantiating deficits in imagery performance among the elderly.

Numerous studies have been directed toward delineating the psychological and neurological processes through which aging impairs mental imagery. These studies have provided evidence that age-related deterioration in sensorimotor function, processing speed, working memory,

and executive function mediate the decline in mental imagery ability observed in the older population (see Ref. 20 for review). A component of mental imagery that has not previously been examined in the context of aging is the impact of mental imagery on perception; that is the purpose of the present investigation. This comparison is of both theoretical and practical interest as age-related differences have been reported for the ability to use mental images (e.g. Ref. 20).

The critical measure in this report concerns imagery-induced reduction of perceptual functions--the *Perky effect*. In her pioneering studies, Perky discovered that participants could not always distinguish their visual mental images from visual percepts; they were unable to detect dim (yet above threshold) pictures while mentally imagining common objects.²¹ Segal replicated and extended Perky's findings using signal detection methodology and Segal and Fusella found the effect of imagery on perception to be modality specific.^{22,23} For example, they reported that auditory images interfered with an auditory detection task, yet did not influence a visual detection task. This suggests that limitations in attentional capacity cannot by themselves explain imagery-perception interference effects.

Although there have been a number of studies demonstrating a Perky effect among college students,²²⁻²⁷ this effect has not been examined in older participants. The purpose of the present study was to determine whether a Perky effect occurs in older adults as it does in younger adults, with age-related imagery deficits examined by comparing performance across perceptual and imagery tasks in older and younger participants. We compared the effects of imagery on perception using two perceptual tasks. Experiment 1 examined the effect of visual imagery on visual acuity judgments while Experiment 2 used a detection task. On the basis of the literature, we hypothesized that older participants would produce significantly weaker Perky effects than the younger participants indicating an age-related deficit in their imagery ability.

Experiment 1

In Experiment 1, we used methods that have reliably produced a Perky effect in younger participants,^{29,30} but tested both young and older adults. Our participants generated and maintained simple images while performance was measured on a low level perceptual task, vernier acuity. Craver-Lemley and Reeves discovered a Perky effect--a decline in accuracy for judging vernier acuity targets--when college-age participants imagined a variety of patterns (e.g. vertical lines, horizontal lines) near a vernier target.²⁹ For young participants, the effect on vision is independent of the load on working memory, as demonstrated by equal decrements in visual acuity from complex visual images which differ on every trial versus simple images of straight lines which were repeated on every trial;³⁰ the latter images produced much less load on working memory than the former ones, but yielded a comparable visual acuity decrement in college-age participants.

In Experiment 1 we elected to use simple line images since it has been demonstrated that the elderly have more difficulty manipulating complex than simple images:^{10,17,20} the use of simple stimuli maximizes the possibility that a typical Perky effect will emerge in older participants. Thus, if the Perky effect is negligible or nonexistent under these conditions we will have provided compelling evidence that elderly participants do in fact have diminished imagery abilities. Alternatively, if elderly participants produce Perky effects of a magnitude comparable to that of younger participants, then we can conclude that aging does not affect all components of imagery equally (e.g., Ref. 14).

Methods

Participants—Two groups of volunteers were tested in this study: 17 young adult participants with a mean age of 19.0 years (range = 18 – 21) and 17 older participants with a mean age of 73.6 years (range = 64 – 80). Both groups received payment for participating. All participants reported that they had normal or corrected-to-normal vision and were in good health. Participants provided self-reports indicating that they were not on medications that might impair their cognitive performance.

The older adults were living at home and traveled to the laboratory to be tested. They were recruited through the Penn State College of Medicine, and had previously served as controls in unrelated cognitive studies.³² The younger participants were Elizabethtown College undergraduates recruited through a notice placed in a campus wide e-mail.

Apparatus and Materials—Stimuli were presented binocularly using a Gerbrands two-field tachistoscope (Model G11192F7). The fields were 58 cm from the eyes. The fixation field was a white 14cd/m 10×15 deg rectangle subtending 19×19.5 deg at the eye. There were two dots placed 5.2 deg apart above and below the center of fixation. A relative intensity of 90 was set on the 400 series Lamp Drive circuit. The test field was used to present the vernier acuity targets. Stimulus duration was controlled by the Experimenter and adjusted to achieve about 80% correct performance for each individual participant.

Acuity task—The vernier acuity targets (Figure 1a) comprised two thin black (75% contrast) lines, subtending 2.2 deg vertically and 0.1 deg horizontally, with a vertical gap of 0.5 deg between them. The bottom line was equally often offset to the left or to the right in relation to the top line. For each trial, participants were to report whether the bottom line was offset to the left or the right in relation to the top line. Participants were informed that task difficulty would vary and that the correct response would always be either “left” or “right” (none were the same). There were 10 different offsets that were presented in random order and used equally often; the range of offsets was between 4.2 and 22 min visual angle with mean offset being 9.7 min.

Imagery task—There were two conditions. In the imagery condition participants were asked to evoke a mental image of four black vertical lines (VL) (Figure 1b). The VL image was to be projected within the fixation region and maintained concurrent with the target. Participants were shown a sketch of four black vertical lines and were asked to center their image between the two points in the fixation field. In the “no-image” (NI) condition participants simply made acuity judgments without evoking any mental images.

Procedure—Participants were individually seated in front of the tachistoscope and informed that we would be measuring acuity under two conditions: On some trials they would be asked to evoke an image of four black vertical lines (VL), while for other trials they would just be asked to make the acuity judgments without an image (NI). They were instructed to initiate the trials themselves, after they had fixated and after (in VL) forming an image. The duration of stimulus presentation was determined individually for each participant during an initial practice period of about 15 minutes. Stimulus duration was initially set at 90 milliseconds (ms), progressively reduced during practice until each participant reached 80% correct performance in NI, then set at that duration for the test session. Mean stimulus duration for the college students was 9.0 ms (range 3 to 30); mean duration for older participants was 42.9 ms (range 15 to 125). Imagery (VL) and no-imagery (NI) instructions were randomized and participants received 50 trials in each of the two intermixed conditions. Participants were run individually and the experiment lasted about 35 minutes.

The Experimenters in both experiments were undergraduate assistants with no knowledge of the predicted outcome of the studies. The stimulus cards in Experiments 1 and 2 were placed into the tachistoscope so that the Experimenter could not see what was on the card; therefore the Experimenter was unaware as to whether the participant had made a correct or incorrect response until after each trial was over.

Results

The college students replicated Craver-Lemley and colleagues' earlier results by showing a Perky effect in the VL condition (NI [82%] – VL [69%] = 13% reduction in accuracy). A Repeated Measures t-test revealed the overall imagery effect to be significant in younger adults, $t(16) = 8.72, p < .001$. However, there were no comparable NI-VL differences for the older participants, $t(16) = 0.28, ns$ (for older adults mean accuracy in NI = 76%, VL = 75%). (See Figure 2). A focused comparison of effect sizes confirmed that the effect size (t value) associated with the imagery effect in younger adults was significantly larger than that associated with the Perky effect in older participants, $Z = 3.74, p < .0001$.³²

A Mixed Model ANOVA revealed a main effect for type of image on accuracy, with accuracy in the NI condition ($M = 78.53, SD = 8.11$) being higher than the VL condition ($M = 71.94, SD = 8.44$), $F(1, 32) = 21.05, p < .001$. There was also an interaction between type of image and age of the participants, $F(1, 32) = 16.78, p < .001$: The accuracy rate of older adults was lower than that of college students in the NI condition, but higher than that of college students in the VL condition. There was no main effect for age on accuracy, with college students ($M = 75.30, SD = 4.34$) and older adults ($M = 75.18, SD = 10.09$) performing similarly, $F(1, 32) = 0.00, ns$.

Independent Groups t-tests revealed reliable differences in performance between college students ($M = 81.53, SD = 2.88$; $M = 69.06, SD = 5.79$) and older adults ($M = 75.53, SD = 10.41$; $M = 74.82, SD = 9.77$) in both the NI condition and the VL condition, $t(18) = 2.29, p = .034$ and $t(26) = -2.09, p = .046$, respectively.

Discussion

Young and elderly participants maintained mental images while making vernier acuity judgments. As expected, while the younger participants replicated previous research on the Perky effect, showing reduced accuracy under imagery, elderly participants showed comparable performance in the imagery and control conditions. This finding suggests that imagery had no effect on older adults' acuity abilities. The results of this study lend support to reports of age-related performance decrements for image generation and maintenance tasks.^{10,12,17}

Experiment 2

Experiment 1 revealed that imagery produced interference for an acuity task in younger but not elderly participants. Since an absence of a Perky effect in the elderly has not been previously reported, it was of interest to determine whether we could replicate this finding with a different perceptual task that also occurs early in visual processing. Experiment 2 used a design similar to Craver-Lemley and Arterberry (Ref. 23), in which college students were given a two-alternative forced choice task. Participants were asked to project an image into a specified location in the fixation field of a tachistoscope and at the end of a given trial to report whether or not a target had been presented. Craver-Lemley and Arterberry's participants showed a Perky effect under conditions in which their image overlapped with the target region. It was expected that in the present experiment younger participants would replicate the patterns obtained by

Craver-Lemley and Arterberry while elderly participants would—as in Experiment 1—fail to demonstrate a Perky effect.

Methods

Participants—Ten Elizabethtown College students (mean age 18.7 years; range 18 – 20) and 10 older adults (mean age 66.7 years; range 60 – 79) participated in this study. The college students were enrolled in an introductory psychology course and received course credit for their participation. The older participants were recruited through the Penn State College of Medicine and had previously served as controls in an unrelated cognitive study (e.g. ref. 31). All older participants were in good health and living unassisted at home. They were not on any medications that might impact their performance, and were paid for participating in the study.

None of the volunteers, younger or older, had participated in an imagery experiment before. All participants had normal or corrected-to-normal vision.

Apparatus and Materials—Stimuli were presented in the same tachistoscope as in Experiment 1. The stimuli were identical to those described in reference ²³, Experiment 5. Thus, a nine cell display was used for fixation (Fig. 3a). The display was 12.4 deg horizontally by 6.9 deg vertically (12.6 cm by 7.0 cm). Each cell measured 4.2 deg across 2.3 deg vertically (4.2 cm by 2.3 cm). A fixation point was placed in the center of the central cell. The fixation field was presented continuously. The test field was used to present the asterisk targets.

Detection task—There were 40 target cards. Each of the 15.0 cm by 9.3 cm target cards contained one 2.0 mm asterisk (the target) which fell within either the top central cell (20 cards) or bottom central cell (20 cards) (Fig 3b). There were also forty white blank cards.

Imagery task—On imagery trials, participants were instructed to generate an image of a gray vertical bar (VB) that would fill the three central cells of the fixation field (Fig 3c). Participants were provided with a sketch of the requested image during the practice session. As in Experiment 1 there was also a no-image (NI) condition which served as a baseline control for the detection task. For NI trials, participants simply executed the detection task.

Procedure—Participants were tested individually during sessions that lasted about 45 minutes. Stimulus duration was set by the Experimenter so each participant was at approximately 90% correct performance during the NI condition. The mean stimulus duration for the college students was 11.0 ms (range 4 – 25) and 46.2 ms for the older participants (range 20 – 70). Participants were instructed to maintain central fixation throughout the experiment. The detection task was to report whether an asterisk had been presented in either of the two possible locations on each trial. Participants responded verbally with either a “yes” or “no.” Asterisk targets were randomly presented on half the trials and blank cards were presented for the remaining trials. Trials were run in two blocks of 80 for a total of 160 trials. Participants received a 10 minute break after the first block of trials.

VB and NI trials were randomly intermixed. Participants were told at the beginning of a trial to either have no image or to imagine the gray vertical bar. For VB trials, participants signaled the Experimenter when they had projected their image. Then the Experimenter presented either a blank or target card, after which participants reported whether or not a target had been presented. Feedback was not provided regarding performance on the detection task.

Results

A Perky effect was found in the imagery condition (NI [90%] – Bar image [81%] = 9% reduction in accuracy) for the college students. A Repeated Measures t-test revealed the overall

imagery effect to be significant in younger adults, $t(9) = 8.31, p < .001$. However, a Repeated Measures t-test revealed no comparable differences for the older participants, $t(9) = 0.34, ns$ (Mean accuracy in NI = 93%, Bar image = 93%). As in Experiment 1, a focused comparison of effect sizes³² confirmed that the effect size associated with the imagery effect in younger adults was significantly larger than that associated with the Perky effect in older participants, $Z = 13.73, p < .0001$.

A Mixed Model ANOVA revealed a main effect for imagery condition on accuracy, with accuracy in the NI condition ($M = 91.60, SD = 6.39$) being higher than that in the VB condition ($M = 87.15, SD = 9.62$), $F(1, 18) = 42.31, p < .001$. There was also a main effect of age on accuracy, with older adults ($M = 93.05, SD = 9.26$) having a higher overall accuracy rate than the college students ($M = 85.70, SD = 3.65$), $F(1, 18) = 5.60, p = .029$. Finally, there was a reliable interaction between imagery condition and age of the participants, $F(1, 18) = 36.80, p < .001$: Accuracy declined from the NI to VB condition in college students, but was comparable across the NI and VB conditions in older adults.

A follow-up Independent Groups t-test found no reliable differences in performance between college students ($M = 90.00, SD = 2.31$) and older adults ($M = 93.20, SD = 8.68$) in the NI condition, $t(18) = 1.13, ns$. However, an Independent Groups t-test did reveal a reliable difference in performance between college students ($M = 81.40, SD = 4.99$) and older adults ($M = 92.90, SD = 9.84$) in the VB condition, with college students performing reliably worse than the older adults, $t(18) = 3.30, p = .004$.

Finally, a focused comparison of effect size³² confirmed that the magnitude of the Perky effect in younger participants did not differ across Experiments 1 and 2 (t 's were 8.72 and 8.31, respectively, with corresponding d 's of 2.20 and 2.76, $Z = 0.45, ns$). Similarly, the magnitude of the effect was comparable across Experiments 1 and 2 in our older participants (t 's were 0.28 and 0.34, respectively, with corresponding d 's of 0.07 and 0.11, $Z = 0.09, ns$).

Discussion

As in Experiment 1, the results of Experiment 2 revealed that imagery did not produce a Perky effect in elderly participants. Because a different perceptual task was used in Experiment 2 these results both replicate those of the first experiment and indicate that these patterns are not task-specific, but generalize across perceptual tasks that involve similar processes. This finding provides additional support to age-related deficits in imagery.

General Discussion

The aim of the present study was to determine whether or not there were differences in the magnitude of the Perky effect in young and elderly adults. Experiments 1 and 2 revealed that elderly individuals lose an effect of imagery that is well documented in younger adult populations. For our older participants, performance on two simple visual tasks--acuity and detection--was not impacted by the presence of a concurrent mental image. As a result our older participants--unlike our younger participants--did not demonstrate a Perky effect. Thus, we have provided the first empirical evidence that the Perky effect does not occur for elderly individuals.

Although our finding is new, it was replicated in two separate samples using two different perceptual tasks, and is in line with previous reports of reduction in imagery capabilities among elderly populations.^{15,19,20} Moreover, despite using very different tasks and procedures in Experiments 1 and 2, remarkably consistent patterns were obtained within each age group. In fact, a focused comparison of effect size³² confirmed that the magnitude of the Perky effect in younger participants did not differ across Experiments 1 and 2.

An alternative that should be briefly addressed is whether or not the absence of a Perky effect among our older groups in Experiments 1 and 2 could be attributed to differences in stimulus durations rather than to the effects of aging on mental imagery ability. The younger participants, showing a Perky effect, had much shorter stimulus durations. Perhaps older participants with shorter stimulus durations (relative to their age group) might exhibit the Perky effect as well. However, this alternative may be discounted because only one of the older participants tested with a shorter stimulus duration (below the median split) demonstrated decreased accuracy for the imagery condition.

Why do the elderly lose the Perky effect? First consider the imagery tasks. Both tasks required participants to generate and to maintain the same simple image throughout a series of trials. Although there are reports that the elderly are slower in tasks involving image generation, speed was not a factor in our experiment. In fact, we were not concerned with how long it took our participants to generate their images; all participants had as much time as they required. Moreover, all participants reported an ability to generate their mental images with ease (we deliberately required our participants to evoke simple images since there are reports that the elderly are impaired in their ability to generate and maintain complex images).^{10·17·20} Thus, we have no reason to believe that our elderly participants had difficulty maintaining their image for the brief time that the stimulus was presented in each of the experiments (42.9 ms and 46.2 ms).

In this context it is important to note that—even if some of our older adults had had difficulty maintaining their simple images—previous research indicates that the Perky effect can last up to 4 sec after image offset. Thus, a deficit in the ability to maintain the image during the course of typical trial could potentially weaken the effect, but should not eliminate it.²⁹ It does not appear that age-related differences in image generation and maintenance capabilities underlie our findings.

Could it be that another component of mental imagery, specifically the vividness of the image, can account for the differences we found? Although self-reports on the vividness of images have shown predictive value for some tasks (e.g. visual memory, image resolution), Craver-Lemley and Reeves found that vividness had minimal (nonsignificant) predictive power with respect to the magnitude of the Perky effect.³⁰ In fact, their analysis revealed a weak relation in the opposite direction: Participants who reported more vivid images tended to have slightly smaller Perky effects. Kemps and Newson also reported that their young and older participants had comparable vividness ratings even though the older adults showed diminished imagery ability along a number of dimensions.²⁰ Therefore, it seems unlikely that differences in imagery vividness (i.e., elderly having less vivid images) can account for our results.

The inability of older adults to demonstrate a Perky effect might instead be a consequence of a strategy they elected to use; there is evidence that young and older adults rely on different strategies when performing various cognitive tasks^{34·35} (also see Ref. ³⁵ for a critical discussion) and that older adults may use strategies more poorly than younger adults.⁶ If this were the case, then the older participants' slower performance might reflect more than just an age-related decline in acuity and detection abilities. For example, Dror, Schmitz-Williams, and Smith directly examined changes in strategy use during mental imagery and found that young and older participants used different strategies depending upon the complexity of the image.³⁴ They concluded that older participants may have elected to use a strategy that was less demanding on their cognitive resources. Potential variability between groups regarding strategy use was not assessed in our study, but because our participants evoked simple images and performed simple tasks, there is little reason to believe that demand features of our experiments necessitated the use of a less effective strategy for our older participants. Future

research should assess whether or not there were age-related differences in strategy use and whether elimination of such a difference would result in a Perky effect for older adults.

A more likely possibility is that the present results are due in part to declines in attentional distribution with increasing age. Although Craver-Lemley and Reeves demonstrated that the Perky effect results from sensory interference and not impairment in global attention in college-age participants, it may be that the loss of the Perky effect among the elderly reflects an overall reduction in their ability to distribute attention across mental imagery and ongoing perceptual tasks.³⁰ It may be that in order for elderly participants to be successful at the perceptual tasks used in these experiments (they required longer stimulus durations), resources available for imagery-generation become reduced, thus eliminating the Perky effect. Future work could determine if this is a causal factor in the loss of the Perky effect in the elderly.

Finally, it may be that age-related changes at the neurological level can help account for age-related decline in cognitive skills relevant to imagery-induced interference. For example, there is evidence that age-related changes in the prefrontal cortex and the dopamine system may influence cognitive functioning.^{37–40} Notably, Raz, Briggs, Marks, and Acker found that age-related deficits in mental imagery tasks may stem in part from age-related shrinkage of the prefrontal cortex.⁴¹ Future studies using neuroimaging (e.g., fMRI) methodologies may help determine the degree to which these (and other) neurological changes underlie age differences in imagery-interference effects.

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Figure 1a

Figure 1b

Figure 1.

- a. Example of acuity targets, Experiment 1.
- b. Requested mental image of four black vertical lines, Experiment 1.

Figure 2. Mean acuity performance with and without mental imagery, Experiment 1. The error bars were created using standard error.

2a

2b

2c

Figure 3.

- a. Fixation field, Experiment 2.
- b. Example of target in Experiment 2. Note for a given trial the target may appear as depicted in the center top cell, in the bottom center cell, or not at all.
- c. Requested mental image of a gray bar, Experiment 2.

Figure 4.

Mean detection performance with and without mental imagery. The error bars were created using standard error.