# EFFECTS OF AGE AND SKILL ON DOMAIN-SPECIFIC VISUAL SEARCH

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It is frequently reported that there is an age-associated decline in visual search and target detection performance. Age-related declines and limitations in a wide variety of capacities and processing resources have been invoked to account for adult age differences in visual information processing performance, such as effortful processing (e.g., Salthouse, in press). However, older adults frequently show preserved function when carrying out attentionally-demanding visual search tasks in familiar domains (e.g., see Charness, 1987; Hoyer, 1985; Salthouse, 1984).

Although cognitive science researchers have studied novice versus expert differences in a variety of domains (e.g., Chi, Feltovich, & Glaser, 1981; Lesgold, Rubinson, Feltovich, Glaser, & Klopfer, in press; Patel & Groen, 1986), relatively little attention has been given to the study of the interaction of age and skill in accounting for differential (or dissociable) patterns of visual information processing performance. We report the results of a study examining skill-related (novice vs expert) and age-related (young vs middle-aged adults) differences in visual search performance under single-task and dual-task conditions. Our primary aim was to examine the extent to which skilled search performance requires less capacity for experts as compared to age-matched controls, and the extent to which there are age-related declines in general search performance. It was expected that younger and middle-aged control subjects would have longer reaction times and higher error rates under dual-task conditions of skilled visual search task compared to age-matched experts, and that older control subjects would be particularly disadvantaged in the dual task condition compared to older skilled subjects. The skill domain selected for study involved target detection in visual displays of microbiological materials.

## METHOD

Subjects. Thirty-two female subjects at two age levels (young and middle-aged adults), and at two skill levels (medical technologists and control group) were tested individually in two one-hour sessions. The young adults in the skilled group had a mean age = 26.5 years (range = 23-29 years). The mean age of the middle-aged skilled individuals was 41.6 years (range 31-56 years). In the control group, the mean age of the younger subjects was 21.6 years (range 20-26 years). Middle-aged control subjects had a mean age = 47.0 years (range 37-58 years). Scores on Lauzon's (1987) Clinical Microbiology Laboratory Test for the medical technologists ranged from 70% to 100% compared to 20% to 40% for the control subjects. All subjects were in good to excellent health (based on self-report) and had visual acuity of 20/40 or better (with correction) as measured by an Orthorater.

Design and materials. We used a dual-task procedure to examine age and skill differences in the attentional demands of visual search (e.g., see Logan, 1978; Madden, 1987). In the dual task condition, the secondary task was a simple tone reaction time, and the primary task was a complex visual search reaction time task. The visual search task required the subject to make a decision about the presence or absence of a target or probe item in a previously presented display. Two types of visual search tasks (skilled and general) were administered using computer-driven tachistoscopic displays to all subjects under single-task and dual-task conditions. The stimulus materials for skilled visual search task consisted of color slides (35 mm) of gram stains. The samples used as stimuli reflected pathogens commonly encountered in the microbiology section of a clinical pathology laboratory. Two blocks of forty-eight pairs of field displays and probes were presented. Each of the positive probes had some degree of diagnostic significance, and each was an exact copy of part of the field display. The stimulus materials for general visual search consisted of two blocks of forty-eight pairs of field and probe display slides. Stimuli varied along the dimensions of shading, size, shape, number of features, and orientation. The search displays consisted of four, six or eight objects.

Procedure. The procedures for both visual search tasks were as follows: 1) A LED warning light was presented for 100 ms at the central fixation point. 2) The visual display to be searched was then projected for 500 ms. 3) A mask of black and red diagonal lines was displayed for 100 ms, followed immediately by a centrally-presented probe. 4) A yes/no response indicating the presence or absence of the probe in the previous visual display removed the probe. 5) Onset of the LED for the next trial followed after a variable intertrial interval averaging 1.75 sec (range 1.25-2.25 sec). For each search task and block of dual-task trials, there were 30 trials in which both tone and visual display were presented and 18 trials in which only a visual display was presented. During the dual-task trials, tone onset followed the visual display by either 100, 550 or 700 ms. The 30 tone-present trials contained 10 trials at each SOA value. The order of the dual-task and single-task trials was randomized within each block of trials and the presentation of task type was counterbalanced across subjects. Viewing conditions were binocular at approximately 55 cd/m projected luminance.

## RESULTS

For both skilled and general visual search, median correct reaction times, proportional tone reaction times for correct trials, and error rates were calculated for each individual. Separate split-plot ANOVAs were computed for each measure with age and skill as between-subjects factors, and probe type and trial type (tone present vs. tone absent) as within-subjects factors. The simple RT data for skilled visual search are displayed in Figure 1. A significant main effect of age, $F$ (1,28) = 14.90, $MSe$ = 5921, revealed that middle-aged subjects exhibited longer reaction times ( $M$ = 1460.31 ms, $SD$ = 70.08) than younger subjects ( $M$ = 938.10 ms, $SD$ = 22.20). A significant age by skill by trial type (i.e., tone present vs. tone absent) interaction was also observed, $F$ (1,28) = 5.82, $MSe$ = 1612. A test of simple effects revealed that in the middle-aged group, the skill by trial type interaction was significant, $F$ (1,14) = 4.62, $MSe$ =3086. As shown in Figure 1, the middle-aged control subjects were significantly slower ( $M$ = 1794.10 ms, $SD$ =

24.72) during the tone present trials than the middle-aged medical technologists ( $\underline{M}$ = 1267.50 ms, $\underline{SD}$ = 26.59).

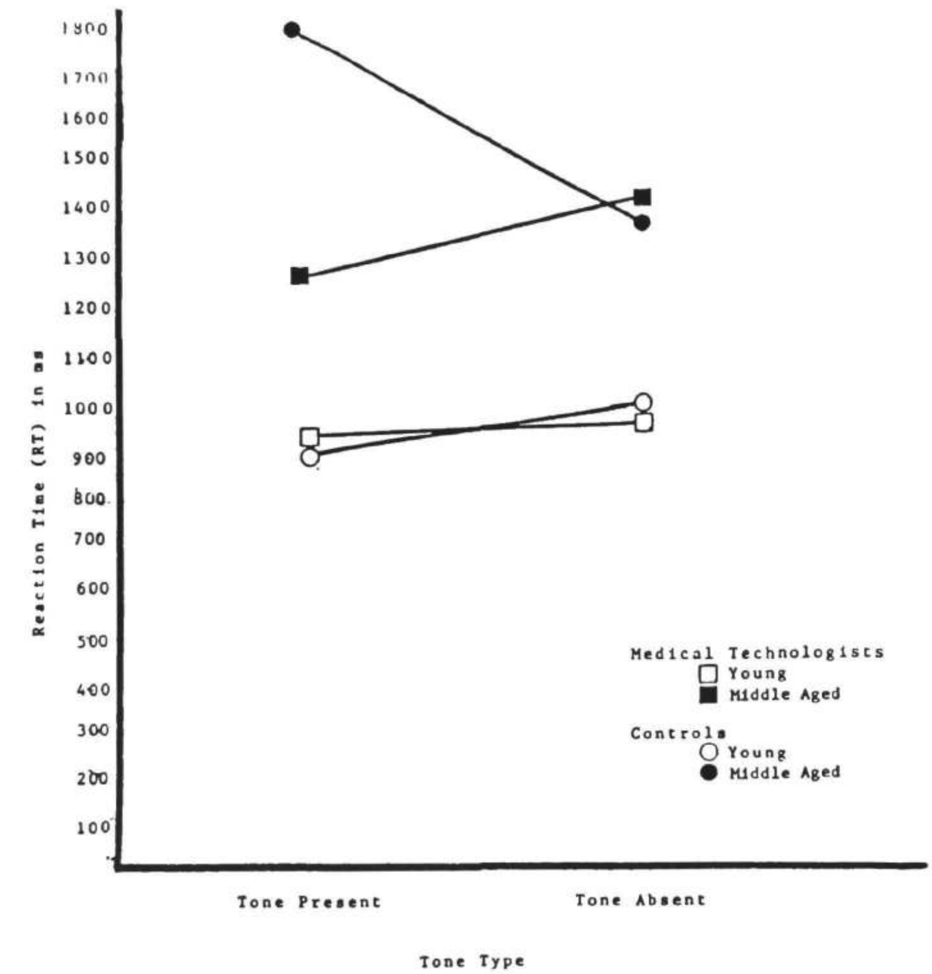


Figure 1. Mean Skilled Visual Search Reaction Time (RT) in ms as a Function of Tone, Skill and Age in Experiment II.

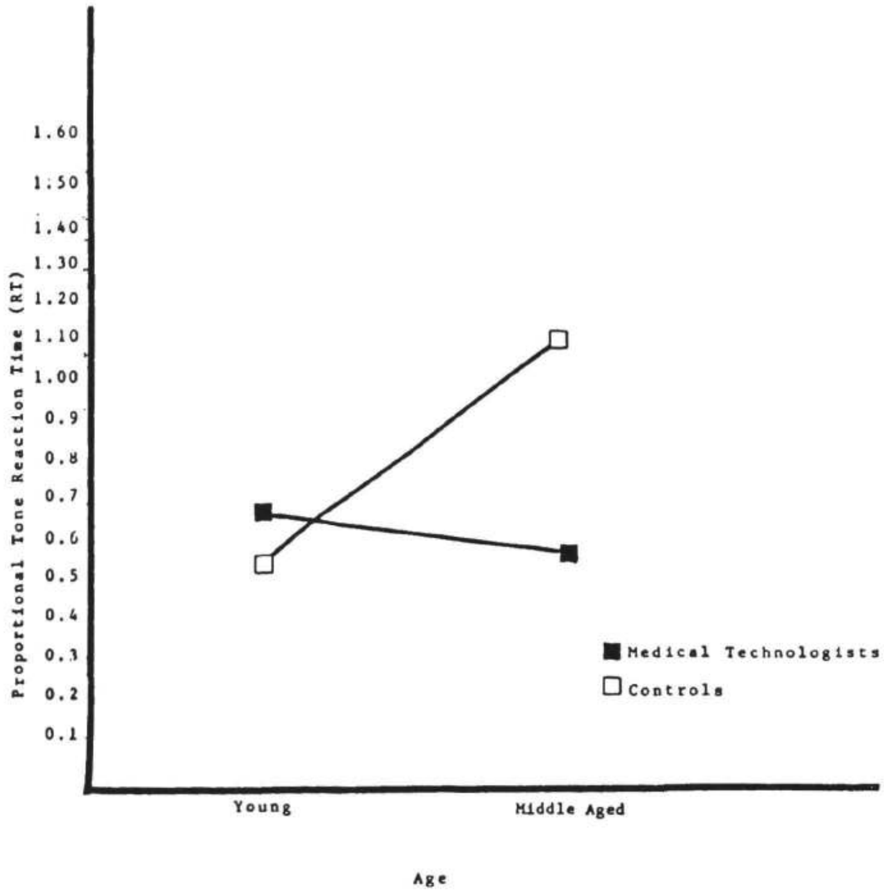


Figure 2. Proportional Tone Reaction Time (RT) as a Function of Age and Skill in Experiment II Under Skilled Visual Search Conditions.

Proportional tone reaction time data are displayed in Figure 2. Analyses revealed a significant main effect of age, $F$ (1,28) = 7.49, $MSe$ = .51 with middle-aged adults having higher proportional tones ( $M$ = .80, $SD$ = .57) than younger subjects ( $M$ = .52, $SD$ = .33). In addition, a main effect of probe type $F$ (1,28) = 5.07, $MSe$ = .14 was also obtained in which the proportional reaction time to tones during negative probe trials ( $M$ = .72, $SD$ = .54) was higher than proportional reaction time to tones during positive probe trials ( $M$ = .60, $SD$ = .42). Analyses also revealed an age by skill interaction, $F$ (1,28) = 10.41, $MSe$ = .51. No age effects were observed in proportional tone in the medical technology group, $F$ (1,14) = .32, $MSe$ = .24. However, in the control group, middle-aged subjects had significantly larger proportional tone reaction times ( $M$ = 1.07, $SD$ = .67) than younger individuals ( $M$ = .45, $SD$ = .28), $F$ (1,14) = 11.70, $MSe$ = .77.

For general visual search, no main effects of skill or interaction effects involving skill were expected; nor were they obtained. By extending the results of previous studies of older adults (e.g., see Madden, 1986), the dual task condition was expected to be relatively more difficult for middle-aged subjects than for younger adults. As predicted, there was a main effect of age, $F$ (1,29) = 11.92, with middle-aged subjects having longer reaction times ( $M$ = 1516.60 ms, $SD$ = 53.13) than younger subjects ( $M$ = 1102.10 ms, $SD$ = 27.52). Although the age by dual task interaction did not reach significance based on the analysis of simple RT data, the analysis of proportional tone RT did yield a statistically significant age by dual task effect. Simple effects and other interactions based on the analysis of proportional reaction times and errors supported the expected finding of age-related decline as processing demands increased.

## DISCUSSION

It is interesting that age differences in the efficiency of general visual search can be found even when comparing middle-aged subjects with young adults. Our results raise several important questions regarding nature of age-related decline in domain-general visual processing in the absence of age-related reductions in domain-specific visual search. There are several ways of interpreting the beneficial effects of the observer's domain-specific experience on adult age differences in search performance. First, consistent with previous work, domain-general computational processes are susceptible to age-related decline because they require more of some unspecified limited capacity, but once developed less of this general capacity is required for the "run off" or execution of performance (Salthouse, 1987). Although it may be reasonable to speculate that with advancing age, there is increased constraint on the extent to which general computational processes can be applied to specific contents, it is difficult to formalize such an explanation.

Alternatively, it can be suggested that if skilled observers know what to see or look for in familiar displays, then compared to less skilled observers, less processing time (and/or capacity) is required for handling nonsalient information. That is, compared to novices, skilled observers use different (or fewer) processing components to perform the same molar task. Thus, age-normal deficits in processing speed or capacity are either circumvented or such processes as orientation, recognition, input analysis, filtering, search, comparison, and other normally age-sensitive, capacity-demanding processes have sufficient lead time to "run off" without noticeable deficit. For example, there may be reduced susceptibility to distractor information in skilled domains. Compared to younger adults, older adults have been shown to be more susceptable to the effects of noise factors which disturb the reception and processing of incoming signals (e.g., see Lindholm & Parkinson, 1983; Sekuler & Ball, 1986). Skilled older observers, may be able to effectively "see through" noise in familiar information processing tasks, even though older adults are generally more prone to noise distractors when searching unfamiliar domains/displays. It may be that the disadvantageous effects of noise are at minimum for experts, within a relatively wide age range, because of the benefits of attentional selectivity and preparation, which attenuate the typical pattern of age-related differences found when familiarity or preparation effects are not available (e.g., see Hoyer & Familant, 1987). That is, domain-specific search minimizes the differential effects of distractors on age differences in visual search.

It is also reasonable to suggest that search performance in skilled domains involves a criterion adjustment at the encoding or identification stages of information processing. Familiar context may affect the observer's criterion for accepting partial stimulus information as evidence for the presence or absence of a probe. Particular features of the display may operate as primes for the expert, which facilitate the encoding and stimulus identification processes through network activation (e.g., Chiarello, Church, & Hoyer, 1985). Thus, skilled visual search performance may involve increased contextualization and the activation or imposition of useful constraints on the processing of visual information. Although it may be useful to explain age by skill interactions in terms of contextual factors which support access and/or retrieval of information within domains of expertise, the problem remains of critically testing the various available explanations of the paradoxical effects of age and skill in visual search performance.

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