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A paper by McCalley, Bouwhuis, and Juola (1995) suggested differences between younger and older adults in the use of visual cues. Furthermore, they reported these differences could largely be attributed to diminished (peripheral) visual processing capacities of elderly adults. Here, we reanalyze the data of McCalley and colleagues emphasizing relative rather than absolute differences. We find that when doing so, the data do not reveal differences in the way older and younger adults transiently allocate attention during visual search. Contrary to the conclusions of McCalley and colleagues, the similarity between the younger and older observers is therefore independent of the characteristics of the visual information. Furthermore, in our view the data suggest that older adults have foveal rather than peripheral visual processing difficulties. The results reemphasize the importance of the analytical approach taken in aging research. We discuss the difficulties and relevance of controlling and separating visual and attentional factors in age-related studies.

McCalley, Bouwhuis, and Juola (1995) examined whether younger and older adults differentially allocated selective attention in a visual search task. In two experiments, participants had to search for a target (a C) among 23 distractors (Os). Reaction times and errors for gap direction discrimination were recorded for a group of healthy young and old participants. The experiments compared the effects on target discrimination of cues presented at various locations and at various stimulus onset asynchronies (SOAs). In particular, a four-way interaction between age, target location, cue location, and SOA led to the conclusion that older and younger adults distribute attention differently, apparent from differential costs and benefits for valid and invalid cues. In a second experiment, in which target and distractor size were scaled with eccentricity, these age-related interaction effects disappeared. McCalley and colleagues therefore drew the conclusion that the differences between older and younger participants were due to differences in (peripheral) visual processing capacities.

These findings could have important implications for our understanding of how age affects the use of attention as well as older people’s visual task performance in general. Although it was a well-designed study, we believe some of its conclusions may depend strongly on the particular approach taken in the data analysis. Here, we propose a different method of analysis and reach different and sometimes opposite conclusions. Our main point of critique is that McCalley and colleagues used absolute reaction time (also referred to as linear reaction time) to assess age differences. In many “real-world, real-time” conditions, such as traffic or vocational tasks, absolute time differences are highly relevant. Therefore, an analysis of absolute reaction time data, such as carried out by McCalley and colleagues, is valuable for pointing out the extent to which an older person’s performance may deviate from that of a younger person’s in such circumstances.

However, when the goal is to examine possible age-related differences in the mechanisms underlying performance, analysis of absolute reaction-time data may not suffice. On nearly all tasks, older adults tend to be slower than younger adults are. As has been pointed out before (e.g., Cerella, 1985; Myerson, Hale, Wagstaff, Poon, & Smith, 1990; Salthouse, 1985), the principal effects of age on reaction time in sensory-motor tasks and mental functioning can be well understood on the basis of a simple, multiplicative “slowing” model. (Myerson and colleagues, 1990, proposed a nonlinear model, based on the assumption of information loss over multiple discrete processing steps, to also account for the positively accelerated relation between latencies for older and younger participants.) Because of the multiplicative nature of the slowing phenomenon, task manipulations that result in changes in performance in younger adults, such as cueing, can be expected to result in proportionally larger effects in older adults. Hence, before postulating specific deficits based on age by task interactions, general slowing should be ruled out as an explanation of the results. Salthouse (1988) presented an analogous line of reasoning with respect to the age by complexity phenomenon.

In this comment, we will examine the extent to which the results of McCalley and colleagues can be understood on the basis of general slowing. Whether general slowing can account for the pattern of results can easily be examined by using log-transformed, rather than absolute reaction-time, data (as has been suggested previously; Cerella, 1985; Salthouse, 1988). The log transformation treats equal ratios as equal intervals so that only influences exceeding the prediction made by general slowing will show significant age-
related interactions. Alternatively, reaction-time data can be normalized relative to a neutral condition.

There is also a statistical reason for using log-transformed rather than absolute reaction-time data. A statistical test like analysis of variance (ANOVA) requires that the measurement is normally distributed and that the variance in the data is the same for all groups or treatments tested. In the experiments of McCalley and colleagues, as in many other age-related studies, this requirement is not met because the variances in the data become larger as the absolute reaction time increases. A solution is to analyze mathematically transformed observations rather than the original observations. Clarke (1969) advises the use of a logarithmic transformation if the standard deviation increases at the same rate as the size of the response. This is clearly the case with the absolute reaction time data of McCalley and colleagues (young participants: mean = 619 ms, SD = 310; older participants: mean = 1132 ms, SD = 668; McCalley et al., 1995).

We used the original data of McCalley and colleagues’ first experiment and analyzed it using a repeated measures ANOVA and a 2 (age group) by 3 (target location) by 4 (cue type) by 4 (SOA) mixed model design. Target and cue location and SOA were treated as within-subject variables, and age as a between-subject variable. The only difference in approach with respect to McCalley and colleagues is that we log transformed the reaction time data prior to the statistical analysis.

As for the analysis of the absolute reaction time data by McCalley and colleagues, our current analysis supports the existence of a highly significant age effect, $F(1,21) = 56.0, p < .0001$, as well as significant target location, $F(2,2) = 26.2, p < .0001$, and cue, $F(3,63) = 12.7, p < .0001$, effects. The results start to differentiate from those reported by McCalley and colleagues when we look at age-related interactions. In particular, McCalley and colleagues reported the existence of a significant interaction between all four experimental variables. A four-way interaction would indicate that the two age groups show significantly different cue effects for the different target interactions with increasing SOA.

To further substantiate this, McCalley and colleagues calculated cueing effects (shown in Figure 3 and tabulated in Table 2 of McCalley and colleagues, 1995). (This approach can enhance the statistical power in a way that is similar to using a paired $t$ test.) However, no statistical analysis was performed on these data.

In our current log-based analysis, the four-way interaction is not significant, $F(18,378) = 1.33, p = .17$. (Note that after log transformation the reaction-time data now behave similarly to the error data for which this four-way interaction was not reported as significant in McCalley and colleagues’ original analysis [p. 320]).

Using the log-transformed reaction-time data, we further calculated for each participant the cueing effect, that is, the costs inflicted by invalid cues plus the benefits caused by valid cues. We analyzed these cueing effects using a repeated measures ANOVA with target location and SOA as within-subject variables, and age as a between-subjects variable.

Except for an overall trend in the effect of SOA, $F(3,63) = 2.69, p = .05$, none of the parameters significantly affects the cue effects or shows a significant interaction with age (age: $F(1,21) = 0.135, p = .72$; age by SOA: $F(3,63) = 1.94, p = .13$; age by target: $F(2,42) = 0.223, p = .80$; age by target by SOA: $F(6,126) = 0.422, p = .86$). We performed the same analysis for the error data. Although there is a significant effect of target position, $F(2,42) = 5.695, p = .007$, the results further mimic those for reaction time in that there are no significant age-related interactions (age by SOA: $F(3,63) = 2.164, p = .10$; age by target: $F(2,42) = 1.052, p = .36$; age by target by SOA: $F(6,126) = 1.165, p = .33$). Figure 1 plots these cue effects for older and younger adults for reaction time as a function of SOA (this is essentially Figure 3 of McCalley et al., 1995, plotted logarithmically and split for the different target positions).

Therefore, when relative rather than absolute differences in performance are emphasized, the reaction time results of this experiment reject the notion that there are spatial or temporal differences in the way older and younger adults used the cue information (this result is confirmed by the error data). Hence, there is no evidence that older and younger adults make different trade-offs between selection and inhibition, as is clear from the comparable cue effects.

According to McCalley and colleagues, the (in our view nonexistent) age-related differences in attentional processing of Experiment I might have been caused by differential visual processing capacities. They attempted to control for such effects in their second experiment. This experiment was nearly identical to the first one except that target and distractor sizes were scaled with eccentricity to compensate for the reduced resolving power of peripheral vision. In this

![Figure 1](image-url)
Therefore, the age-related change in reaction time with eccentricity is such that we would conclude that older adults have relatively more problems identifying central and fewer problems identifying peripheral targets. This could potentially be due to their somewhat lower foveal visual acuity.

We agree with McCalley and colleagues that the age by target location interaction in the error data of Experiment I might indicate that older people use attention to offset visual processing difficulties (but then only the sustained component of attention; see Nakayama & Mackeben, 1989). Our interpretation, however, would be that older participants were using attention to attempt to compensate for their foveal rather than peripheral visual difficulties.

We further agree with McCalley and colleagues that such visual factors need to be controlled before definitive conclusions can be drawn on age-related effects in visual attention. In our view, one further aspect that should be controlled when investigating visual attention is the effort with which people carry out the task that serves to establish baseline performance. Ideally, effort and baseline performance should be similar for both older and younger adults. The large differences in reaction time and error rates in the neutral conditions suggest this was not the case in the experiments of McCalley and colleagues. It will be hard to obtain comparable baseline performance for older and younger participants using the same stimulus display (even when targets are scaled for eccentricity as the results of McCalley and colleagues’ second experiment show). A potentially viable approach might be the use of different stimuli for older and younger adults, adapted in size and contrast to each group’s or even individual’s visual capacities. Cue effects could then be established relative to the baseline performance that is established using these individually scaled stimuli.

Furthermore, large differences in error rate between younger and older adults, as was the case in the experiments of McCalley and colleagues (see Tables 1 and 7, in McCalley et al., 1995), may indicate the use of different speed-accuracy trade-offs (e.g., Pachella, 1974). Such differences should be avoided because they imply younger and older participants operated at different levels of certainty when responding, thereby hampering a proper evaluation of age-related influences on processing (e.g., Myerson et al., 1990).

In conclusion, McCalley and colleagues’ (1995) results on the influences of aging on the use of selective attention in visual search can be accommodated by the notion of general slowing. As such, our current interpretation of their results is in line with other recent findings on visual search, attention and peripheral target localization (e.g., Hartley & Kieley, 1995; Hartley, Kieley, & McKenzie, 1992; Kramer, Hahn, Irwin, & Theeuwes, 1999; Scialfa, Esau, & Joffe, 1998; Seiple, Szlyck, Yang, & Holopigian, 1996).

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