Lateralization of Peripherally and Centrally Masked Words in Young and Elderly People\textsuperscript{1}

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Twenty three-letter, vertical words were presented to the right or left visual fields followed by either a flash, a visual noise, or a pattern mask at various stimulus onset asynchronies. For both young and elderly adults, target identification decreased from the flash to the pattern mask condition, whereas the magnitude of the right visual advantage increased. Although the elderly people identified fewer targets than the young, especially in the pattern mask condition, the magnitude of the right visual field advantage did not vary with age. The results argue against the hypothesis that the cerebral hemispheres deteriorate at different rates with age.

Key Words: Hemispheric specialization, Perception

MANY cognitive changes accompany old age, but their neuropsychological causes are poorly understood. One hypothesis that has been influenced by research on hemispheric specialization is that the cerebral hemispheres are differentially affected by aging (Brown & Jaffe, 1975). Unfortunately, there are rival claims about which hemisphere ages more quickly. Those championing the right hemisphere cite evidence that old people score more poorly on the performance than the verbal subtests of the Wechsler Adult Intelligence Scale and, in general, do more poorly on spatial than on verbal problem-solving tasks (Albert & Kaplan, 1979; Ben-Yishay et al., 1971; see Botwinik, 1978, for review). On the other side, a number of investigators have called attention to changes in verbal functions in old adults, particularly those such as increased loquacity, word-finding difficulty, and semantic paraphasias, that suggest deteriorating left hemisphere functions (Albert, 1981).

One way of testing these hypotheses is by administering laterality tests to normal people. In these tests the direction and magnitude of hemispheric specialization is inferred from the person's ability to perceive stimuli presented to the left or right sensory field that are thereby directed initially to the contralateral hemisphere. Thus, perceptual superi-

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the neural mechanisms involved in processing written language may be affected differently by age than those involved in processing speech. The present investigation was designed to test the effects of age on perceptual asymmetry for written words in individuals who show equivalent peripheral sensory sensitivity in the two visual fields. The study was also designed to determine whether central visual processing deficits exist in old people even when peripheral processes are relatively unimpaired.

The technique used was backward masking. The target was a three-letter word presented vertically in either the right or left visual field, and the mask was either a homogeneous flash of light, a randomly distributed pattern of black and white squares, or a pattern mask made up of black bars that resembled those found in the letters. Subjects were admitted into the experiment only if they were right-handed and could identify all targets essentially perfectly in both the right and left visual field at exposure durations of 2 ms without a mask. This procedure ensured that old people were admitted to the experiment only if their acuity and ease of target identification was equivalent to that of the young. Once this was established, the mask was presented after the target at different stimulus onset asynchronies (SOA), and the accuracy of target identification at each SOA was noted.

Both the homogeneous flash of light and the random noise mask are considered to act peripherally because they are primarily effective if they are presented to the same eye as the target. The pattern mask, on the other hand, has been shown to be effective even if it is presented to the eye opposite the target, suggesting that it can also act centrally at the point where the input from the two eyes converge (see Breitmeyer & Ganz, 1976; Michaels & Turvey, 1979; Turvey, 1973, for review and discussion of the differences between the two types of masks).

If the screening procedure was correct, and the masks act as hypothesized, then old and young people should perform equivalently under the peripheral mask conditions but might differ in the central, pattern mask condition (Walsh, 1982). Moreover, if perceptual asymmetries emerge primarily at the later, higher-order stages of processing, visual field differences should be greatest in the pattern mask condition and should be absent or minimal in the peripheral flash and noise mask conditions. Indeed, Moscovitch (1983) found this to be the case in a study on young people that used similar stimuli and procedures. Lastly, if the two hemispheres are affected equally by age, then the pattern and magnitude of perceptual asymmetries in elderly adults should resemble that of young adults, although the absolute level of performance may be lower.

**Method**

**Participants.** — Thirty old people between 62 and 77 years of age ($M = 68.7$) who were either alumni of the University of Toronto or who were active and living at home volunteered to participate in the study. The 30 young people, undergraduates of Erindale College, were between 18 and 25 years of age ($M = 20.3$) and received course credit for participating. All participants were right-handed as determined by the Edinburgh handedness inventory (Oldfield, 1971). The subjects were evenly divided by age group and sex into each of three masking conditions.

**Stimuli.** — The targets were 20 consonant-vowel-consonant words written vertically in black capitals that were symmetrical about the vertical axis (for further details, see Moscovitch, 1983). Each word subtended 1.6°, had a luminance of 2 footlamberts against a 7 footlambert background, and appeared for 2 ms at .7° (inner edge) to either the right or left of fixation. Three types of masks were used: a homogeneous flash of light, a random square matrix (noise mask), and a random pattern of bars similar to the stems and crosses in the letters. The masks appeared in both visual fields for 50 ms at a luminance of 50 footlamberts. Except for the fixation dot, the pre- and post-exposure fields were blank and had a luminance of 2 footlamberts. The room in which the participants performed was dimly lit.

**Procedure.** — On each trial the individual fixated the right eye on a small cross in the prestimulus field of Scientific Prototype three-channel tachistoscope, Model X-4000, fitted for monocular viewing. When ready, the participant pressed a key with the index finger of the right hand thereby initiating the presentation of a target to the right or left field. One of the three masks always followed at SOAs of either 0, 15, 30, 60, 90, or 120 ms.

At each SOA, there were 20 targets, divided equally and randomly between fields, making 120 trials in all. All trials at a given SOA were blocked, and the order of presentation proceeded from the lowest SOA to the highest. Each group of 10 people received only one type of mask.
Participants were required to name each target and were encouraged to guess. Accuracy of target identification was noted by the experimenter who was in the same room. To qualify for admission into the experiment, participants had to be right-handed, have normal or corrected-to-normal vision, and be able to identify 8 out of 10 targets correctly in each visual field without the mask present (i.e., the blank exposure field preceded and followed the target). Eleven elderly adults, 7 men and 4 women, but no young adults were denied participation in the experiment for failing to meet the last criterion.

**RESULTS AND COMMENT**

As Figure 1 shows, performance varied with age, mask type, SOA, and visual field. Both age and visual field differences were found primarily in the pattern mask condition. Visual field differences, however, did not seem to interact with age. These impressions are generally confirmed by a four-way analysis of variance with age and mask type as between-subject variables and SOA and visual field as within-subject variables; age, $F(1, 54) = 17.89, p < .01, \omega^2 = .012$, mask type, $F(2, 54) = 12.74, \omega^2 = .017, p < .01$, SOA, $F(5, 270) = 564.53, p < .01, \omega^2 = .775$, and visual field, $F(1, 54) = 80.65, p < .01, \omega^2 = .006$, were all significant. Not surprisingly, age differences were observed only at those SOAs where performance was above the floor and below the ceiling (Age $\times$ SOA, $F(5, 270) = 2.48, p < .05, \omega^2 = .007$. There was a significant interaction of Age $\times$ SOA $\times$ Mask Type, $F(10, 270) = 2.48, p < .05, \omega^2 = .004$, indicating that at those SOAs at which age differences were found, the differences increased from the flash to the pattern mask condition, becoming disproportionately large in the latter. Age also interacted significantly with SOA and visual field, $F(5, 270) = 2.73, p < .05, \omega^2 = .001$. This interaction is not as interesting as might first appear because it results primarily from differences between young and old adults at the extremes of the masking function. When young people's performance rises substantially above the floor, old people still cannot identify a sufficient number of items, if they identify any, to demonstrate any field differences. Conversely, once the young adults have reached or approached ceiling, where performance is almost perfect in both fields, the elderly adults are still well below ceiling and show the same visual field differences as the young did at that level of performance. Indeed, the performance of the old looks similar to that of the young, except that it is shifted downward.

Visual field interacted significantly with mask type, $F(2, 54) = 17.86, p < .01, \omega^2 = .002$, and with mask type and SOA, $F(10, 270) = 4.53, p < .01, \omega^2 = .003$, indicating that visual field differences became larger as one moved from the flash to the pattern mask and that this effect was exagger-
ated in the middle of the SOA distribution. The difference in accuracy of target identification among the different masking conditions increased at longer SOAs leading to a significant SOA × Mask Type interaction, $F(10, 270) = 6.03, p < .01, \eta^2 = .014$.

It should be noted that practice and SOA were confounded. Although the effects of practice may contribute to the significant SOA effects, it is unlikely that the contribution was substantial. At low SOAs, the items identified correctly were so few in number (often the person claimed to have seen nothing) that it is unlikely that practice could account for the rapid improvement in performance that occurs at SOA 60. Moreover, a previous study (Moscovitch, 1983, Experiment 3) using similar procedures and stimuli found similar effects of SOA despite balancing for order of SOA-presentation.

**DISCUSSION**

The results show that both the direction and magnitude of perceptual asymmetries remain relatively unchanged in old age. In order to understand the significance of this result, two other findings will be discussed first.

Differences between old and young adults were found primarily on the pattern masking task. These results are similar to those of other studies that equated mask-free target identification thresholds in young and old adults (Till & Franklin, 1981; Walsh, 1982; Walsh et al., 1978; Walsh et al., 1979). That is, to qualify, old people had to identify the targets at a target energy that was close to threshold for perfect identification even for the young. This procedure ensured that if any differences in ocular mechanisms still existed between the young and old, they would not interfere significantly with near-threshold target identification accuracy. The equivalent peripheral masking functions in the two groups in the flash mask condition and the small, though noticeable differences between them in the noise mask condition attests to the effectiveness of this procedure. When care is not taken to equate identification thresholds so that groups with different thresholds, and presumably ocular mechanisms of different efficiency, are admitted to the experiment, elderly adults as a group will be much more severely impaired when homogeneous masks are used (Kline & Szafran, 1975).

Despite the small differences between the young and old on susceptibility to homogeneous masking, the elderly adults nonetheless remained far more vulnerable to the effects of the central pattern mask. Walsh (1982) showed that there is no correlation in elderly adults between identification performance under homogeneous and pattern masking conditions. The results of this study confirm his findings and suggest that central visual mechanisms in aged individuals that are involved in pattern perception deteriorate even when peripheral mechanisms are relatively intact. Functionally, the locus of this deficit is probably at or beyond the stage at which the output of sensory feature analysis is integrated to form a patterned percept (Michaels & Turvey, 1979; Turvey, 1973). If we accept some current views of pattern masking (Breitmeyer & Ganz, 1976; Turvey, 1973), the results suggest that old people integrate this information more slowly and hence are susceptible to masking effects for a longer period of time. Because a pattern mask is effective even when the mask and target are presented to opposite eyes, the structural locus at which pattern masking occurs is at or beyond the striate cortex, the first region at which input from the two eyes first converge to any great extent (Hubel & Wiesel, 1968; Zeki, 1978). Data from patients with Alzheimer’s disease who have a relatively intact striate, but severely deteriorated extrastriate, cortex suggest that the effects observed on pattern masking are mediated in large part by extrastriate regions (Schlotterer et al., 1984). When compared with age-matched controls, these patients perform normally under homogeneous masking conditions but are severely impaired when a pattern mask is used.

The second noteworthy result is that perceptual asymmetries for words were found primarily in the pattern masking condition in both the young and the old adults. This finding is consistent with others in the literature (Hellige, 1983; Michaels & Turvey, 1979; Moscovitch, 1979) and suggests that hemispheric asymmetries underlying perceptual asymmetries are found only at the later, central stages of information processing. During the early, peripheral stages both hemispheres process the information in a similar fashion. Because these ideas have been discussed at length elsewhere (Moscovitch, 1979, 1983), it will suffice to say here that at the moment the best guess as to the functional and structural locus at which these asymmetries emerge is at the extrastriate regions, or beyond, the same ones at which we proposed the effects of age on central masking occur, and for the same reasons.

Now we return to the finding of primary interest, namely, that the right visual field advantage does not differ significantly between young and old people. Taken against the background of the other
findings, namely, that peripheral sensitivity does not differ greatly either between the visual fields or between young and old adults, this result does not support the hypothesis that one hemisphere deteriorates more quickly (Albert & Kaplan, 1979) or becomes more specialized with age (Brown & Jaffe, 1975; Porac & Coren, 1981). Were the mechanisms responsible for target identification deteriorating more quickly in one hemisphere than the other, a change in magnitude or direction of perceptual asymmetries would have been expected (see Moscovitch, 1981, for a discussion of such changes consequent to known unilateral brain damage). Rather, the results indicate that the advantage in favor of the right visual field remains relatively constant despite an increased vulnerability to pattern masking with age. These findings by themselves do not rule out the possibility that areas not involved with visual word identification may be affected more by aging in one hemisphere than the other. The fact that similar results were obtained with both verbal and nonverbal stimuli in the visual (Elias & Kinsbourne, 1974) and auditory (Borod & Goodglass, 1980) modality, however, argues against this possibility and for the generality of the conclusion that the effects of age on hemispheric processes are not uniformly greater in one hemisphere than the other.

REFERENCES