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Age Differences in Visual Evoked Potential Estimates of Interhemispheric Transfer

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Twenty-six younger (ages 18–36 years) and 19 older (ages 60–88 years) healthy right-handed men and women were tested for interhemispheric transfer by using visual evoked potentials to laterally presented checkerboards. Interhemispheric transfer time (IHTT) was estimated by subtracting latencies for both P100 and N160 peaks of the waveform contralateral to the stimulus from the waveform ipsilateral to the stimulus for homologous sites. The quality of interhemispheric transfer was estimated by comparing peak-to-peak amplitudes for homologous sites. IHTT did not change across age, but there was a suppression of the waveform over the indirectly stimulated hemisphere in the older participants. The significance of this finding for age-related changes in functions mediated by the corpus callosum is discussed.

The functions of the corpus callosum (CC) are beginning to be understood (see Hoptman & Davidson, 1994, for a review). It plays a critical role in information transfer between the cerebral hemispheres. In addition, interhemispheric interaction, which is primarily mediated by the CC, is beneficial under difficult task conditions (see Banich, 1995, for a review). During brain maturation, the development of interhemispheric interaction follows a time course that closely parallels the extent of myelination of the CC (e.g., Salamy, 1978). Although functions of the CC have become somewhat tractable, and developmental changes in its function during childhood are reasonably well established, developmental changes in older men and women have not been systematically studied.

The corpus callosum develops late both pre- and postnatally. First, it is fully formed only at 4 months gestational age (Rakic & Yakovlev, 1968). Second, it myelinates late relative to other brain structures (Yakovlev & Lecours, 1967). Third, both behavioral and psychophysiological studies have shown that interhemispheric transfer time (IHTT) becomes more rapid with age. In a cross-sectional study, Brizzolara, Ferretti, Brovedani, Casalini, and Sbrana (1994) found that simple reaction time (RT) estimates of IHTT were slower for 7-year-old than for 9-year-old children. In addition, Salamy (1978), using somatosensory evoked potentials (SEPs), found that IHTT became faster with increasing age during childhood. Although this result has not been replicated, Davidson and Saron (1992) found that visual evoked potential (VEP) estimates of IHTT were longer in adolescents than in adults. All of these data imply that the callosum is late to develop. These studies suggest that IHTT plateaus sometime during later adolescence, consistent with the anatomical maturation of the CC (e.g., Yakovlev & Lecours, 1967).

Age-related reductions in the size of the CC may have implications for callosal function, such that smaller callosa may function less well. Allen, Richey, Chai, and Gorski (1991) found that the cross-sectional area of the CC increased with age in children and decreased with age in adults. This decrease was significant in anterior, but not posterior regions of the CC. Witelson (1989) also found that callosal area declined with age in men but not in women. Similar findings for callosal thickness were obtained by Hayakawa et al. (1989). Weis, Jellinger, and Wegner (1991) found that normal aging affects primarily frontal-temporal interhemispheric fiber systems. Some investigators have found sex differences in reductions in the size of

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the callosum with age (e.g., Cowell, Allen, Zalatimo, & Denenberg, 1992; Witelson, 1989). However, in an analysis of extant data, McKeever (1993) found that these reductions did not vary by sex. Although almost all of these studies show age-related reductions in callosal anatomy, recent studies, some of which have included adjustments for head size, have not (e.g., Johnson, Farnworth, Pinkston, Bigler, & Blatter, 1994; Pozzilli et al., 1994; Rauch & Jinkins, 1994). The resolution of this issue thus awaits additional research with larger sample sizes and more consistent anatomical measures. Regardless of how this question is resolved, the functional significance of these data is unknown. This is especially so because Jäncke and Steinmetz (1994) found that callosal area was not correlated with an auditory measure of IHTT. Recently however, Jerger, Alford, Lew, Rivera, and Chmiel (1995) found evidence for reductions in performance for the less skilled hemisphere in dichotic listening tasks in older patients with losses in hearing discrimination compared with young controls. They interpreted the pattern of dichotic changes with age to reflect decreased efficiency of interhemispheric transfer.

To examine interhemispheric interaction across the lifespan, we obtained VEP measures of interhemispheric transfer in both younger and older adults. Saron and Davidson (1989a) showed that these methods have extremely high internal consistency, and Saron and Davidson (1989b) showed they give results that are more often consistent with the requirements of neuroanatomy (i.e., the waveform over the directly stimulated cortex appears earlier than that over the indirectly stimulated cortex) than do conventional RT methods. Rugg, Milner, and Lines (1985) showed that a clear waveform ipsilateral to the stimulus was not present in a patient with congenital absence of the CC (i.e., *callosal agenesis*), and Mangun, Luck, Gazzaniga, and Hillyard (1991) found that it is absent in patients who have undergone section of the CC for treatment of intractable epilepsy (i.e., split-brain patients). These studies are important, for they show that the appearance of the ipsilateral waveform is due to callosal, rather than noncallosal transfer. If age-related changes in CC area have functional significance, they should be revealed by comparing evoked potentials in response to lateralized visual stimuli in the directly versus indirectly (through the CC) stimulated hemispheres. We expected changes in latency and amplitude of the transferred waveform with age.

Method

Participants

Thirty-two younger participants and 27 older participants gave informed written consent to take part in the study. Usable data were obtained from 26 younger and 19 older participants (see below). Participants were right-handed as indexed by the Chapman and Chapman (1987) 13-item inventory. On this questionnaire, participants respond to questions about the use of various objects as being with the "right hand," "left hand," or "either" hand. All participants wrote with their right hands; up to three non-right-handed responses out of the remaining 12 questions were permitted. No more than one left-handed response was allowed. Thirty-eight percent of younger participants and 35% of older participants reported a left-handed blood relative (2 in each age group provided no information on this variable). None of the analyses reported below was affected by the presence or absence of familial left handedness. All participants had visual acuity of at least 20/50 (corrected) as measured with a Snellen chart.

The 26 younger participants (18–36 years old) had a mean age of 21.2 ± 4.5 years. There were 15 men and 11 women. Participants were administered the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, & Erbaugh, 1961) and had scores of less than 12, which is in the nondepressed range. Participants also completed a four-page health questionnaire. Younger participants had health histories that were free of cardiovascular, cerebrovascular, hepatic, respiratory, and genitourinary disorders. No participant had taken any prescription or nonprescription medication with known CNS effects within 2 weeks of neuropsychological or psychophysiological assessment. Participants also were excluded if they had a history of psychiatric disorders.

In addition, there were 19 older participants (60–87 years old) with a mean age of 72.0 ± 7.1 years. There were 6 men and 13 women. Participants had BDI scores of less than or equal to 12. Older and younger participants did not differ in socioeconomic status (SES) as measured by the Hollingshead (1957) scale, $t(43) = -0.04, p < .97$.[1]

The health histories of the older participants were reviewed by a geriatrician (AG or RTS). Those who had a history of any neurological, neuropsychiatric, or respiratory disorders, as well as those with histories of cardiovascular events were excluded. The older participants also had a complete physical examination. In addition, they were given the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). Participants accepted for the study had MMSE scores of greater than or equal to 26, which is in the normal range of performance.

Recent and current use of medications also was reviewed. Participants who were using prescription or nonprescription medications with potential CNS effects (within 2 weeks of testing) were excluded from the study. In particular, participants who were taking psychotropic medications (i.e., benzodiazepines, neuroleptics, or antidepressants) were excluded from the sample. Demographic characteristics of the younger and older participants are given in Table 1.

Procedure

Participants took part in a larger experiment in which age-related changes in neuropsychological function and resting EEG also were examined. During the second session, evoked potentials (EPs) were obtained.

In the EP task, lateralized checkerboards were presented with MEL (Micro Experimental Laboratory), Version 1.0 (Psychology Software Tools, Pittsburgh, PA). Stimuli were 3 × 4 check checkerboards that subtended 4.90° vertical × 2.93° horizontal of visual angle. Checkerboards were 2.8° from the vertical midline at their medial edge. The fixation point was a 0.2° filled circle. Participants were seated 50 cm from the screen, a distance maintained by a chinrest with forehead restraint. They were instructed to make a simple button press every time a checkerboard was presented. Reaction times were recorded to 1-ms accuracy by the MEL software. RTs less than 100 ms and greater than 500 ms were eliminated (after Saron & Davidson, 1989b). Stimuli were presented for 17 ms. Left and right presentations initiated separate digital triggers that were recorded on two channels of the EEG acquisition computer. Stimulus brightness was 33.4 lux as measured at the screen, in a room with ambient light levels of 111.9 lux at the participant's screen.

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[1] The socioeconomic status for younger participants was based on that of their parents. For married or previously married participants, the occupational measure of the socioeconomic status was taken as that of the person with the more highly ranked job.

Table 1
Demographic Characteristics of Younger and Older Participants

	Younger		Older	
Characteristic	*M*	*SD*	*M*	*SD*
n	26		19	
Age (years)	21.2	4.5	72.0	7.1
Socioeconomic status[a]	1.9	0.8	1.9	0.9
MMSE	—	—	29.0	1.3
Sex				
Women	11		13	
Men	15		6	

Note. Only age differed significantly between groups. MMSE = Mini-Mental Status Examination.
[a] Hollingshead (1957).

Trials were presented in four blocks of 100 trials: two blocks were performed with each hand. In each block, 50 trials were presented to each visual field. Order of response hand was randomized across subjects within groups. Order of visual fields was randomized with the constraint that there were no more than three consecutive trials to the same visual field. There were 25 trials each at interstimulus intervals (ISIs) of 1.5, 2, 2.5, and 3.0 s. These orders were randomly determined for each session.

EP acquisition. Participants were fitted with a stretchable Lycra cap (Electro-Cap, Eaton, OH). Recordings were acquired from the T5, T6, O3, and O4 electrode sites referenced to physically linked ears. These electrode locations were used because they exhibit large amplitude evoked responses with lateralized checkerboard stimuli, and they have been used in previous studies of interhemispheric transfer from Davidson's laboratory (e.g., Saron & Davidson, 1989b). In addition, these sites are likely to reflect the sources of the P100 and N160 components of the visual evoked response (Maier, Dagnelie, Spekreijse, & van Dijk, 1987; see Saron & Davidson, 1989b, for a discussion). Impedance at each site was below 5,000 Ω, as was the ear impedance. Ear impedances were matched to within 500 Ω.[2] Two electrooculogram (EOG) channels also were recorded. Vertical EOG (VEOG) was recorded from electrodes at the supra and suborbit of one eye, whereas horizontal EOG (HEOG) was recorded from electrodes placed at the outer canthus of each eye. The eye at which VEOG leads were placed was determined at random. EOG impedances were below 20 kΩ.

EEG was amplified by a Neurodata 12A5 system (Grass, Quincy, MA). Amplification was set at 30,000 × with a 1–300 Hz bandpass. MF6 chip low pass filters (48 dB per octave) were set at 65 Hz to avoid aliasing, and the 60-Hz notch filter was in. Data were digitized at 2000 Hz on a 386-25 MHz personal computer with a 12 bit A/D board (Analog Devices, Norwood, MA). Data acquisition was started and stopped by digital signals from the parallel port of the control computer to the parallel port of the acquisition computer.

Artifact editing. Data were carefully scored for eye movement artifact. Data from all channels were removed if artifact was present on any channel.

Data reduction. VEPs were created with James Long software (Version 6.946). Epochs from the same Block × Visual Field condition were averaged and smoothed with a truncated sinc function ($[\sin x]/x$). There were no main effects for or interactions with response hand. Accordingly, grand averages were formed across response hand conditions, separately for each visual field. The P100 was defined as the largest positive deflection between 80 and 166 ms, whereas the N160 was defined as the largest negative deflection between 112 and 234 ms. Latency and amplitude were automatically reported by the software.

It was not possible to get clear waveforms from all participants. Three older participants blinked on nearly every trial and thus did not generate useful data. In addition, 6 younger participants and 5 older participants generated neither clear ipsilateral nor contralateral waveforms. Their data were not included in final data analyses. Thus, 26 younger and 19 older participants were available for analysis.[3]

Results

Reaction Time Data

Means of the mean reaction times for each participant in each Visual Field × Hand condition are presented in Table 2. Mean reaction time was the dependent measure in a repeated measures analysis of variance (ANOVA) in which age group (younger or older) was the between-subjects variable, and hand (left or right) and visual field (left or right) were the within-subjects variables. Unpredicted effects (i.e., other than a Hand × Visual Field effect) were Bonferroni-corrected to control for Type I errors. Because of the small number of older men ($n = 6$) in the present sample, sex differences were not examined in any of the data analyses.

Right-hand responses ($M = 264.7 \pm 31.0$ ms) were faster than left-hand responses; $M = 273.0 \pm 32.0$ ms; main effect of hand, $F(1, 43) = 11.47, p < .0015$. In addition, as expected, RTs were faster when the response hand and stimulus were ipsilateral than when they were contralateral; Hand × Visual Field interaction, $F(1, 43) = 8.01, p < .007$. This interaction occurred because reaction times to stimuli ipsilateral to the response hand were 2.1 ± 4.8 ms shorter than those contralateral to the response hand. The patterns at each visual field are confounded by the overall right hand advantage, which leads to an unexpected contralateral advantage for the LVF condition. There were no effects of age group.

There were no significant main effects or interactions for accuracy. As can be seen from Table 2, there was clearly a ceiling effect because the task was very easy, with accuracies ranging from 97% to 99%.

Evoked Potential Data

The mean number of trials comprising the grand averages did not differ between younger and older participants for either the left visual hemifield (LVF), $t(43) = -0.52, p < .60$, or the right visual hemifield (RVF), $t(43) = -0.13, p < .90$. The LVF grand averages comprised a mean ($\pm SD$) of 113.6 ± 37.1 trials (57%) for younger participants and 119.4 ± 36.1 trials (60%) for older participants. The RVF grand averages comprised a mean of 111.3 ± 36.2 trials (57%) for younger participants and 112.8 ± 40.1 trials (56%) for older participants. Grand average waveforms for each Age × Side × Visual Field condition for lateral occipital sites are presented in

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[2] For 2 younger women (differences = 0.9 and 2.1 kΩ) and 1 younger man (difference = 1.9 kΩ), this criterion was not met.

[3] Of these 45 participants, 1 participant had incomplete data for some of the Side × Site × Visual Hemifield conditions for the N160 peak and 4 participants had incomplete data for some of the P100 peak conditions. Data from those participants were used when possible. For this reason, the degrees of freedom differ in different analyses.

Table 2

Mean Reaction Times (RT in Milliseconds) and Accuracy by Visual Field (VF) and Hand and in Younger and Older Age Groups

	Younger				Older			
	Left VF		Right VF		Left VF		Right VF	
Hand	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Left								
RT	274.6	33.4	274.5	32.5	269.4	32.0	272.2	32.6
Accuracy	.98	.03	.97	.03	.99	.02	.99	.02
Right								
RT	270.6	32.3	265.6	29.4	260.3	32.4	259.8	31.9
Accuracy	.98	.02	.98	.03	.99	.01	.99	.01

Note. Accuracy measured as proportion correct.

Figures 1 and 2. Waveforms over lateral temporal sites were similar to those in Figures 1 and 2. For unpredicted effects (i.e., other than main effects of side, and Age Group × Side interactions), p values for ANOVAs were Bonferroni corrected to control for Type I error.

Analyses on latencies. Mean latencies for each Peak × Visual Field × Side condition are presented in Table 3. Peak latency was the dependent variable in a repeated measures ANOVA separately for the P100 and N160 peaks. The between-subjects variable was age group (younger or older), and the within-subjects variables were site (temporal or occipital), side (contralateral or ipsilateral), and visual field (left or right).

For the P100 peak, latencies were 23.4 ms shorter for contralateral ($M = 112.0 \pm 15.9$ ms) than ipsilateral waveforms ($M = 135.4 \pm 16.3$ ms); main effect of side, $F(1, 39) = 89.22$, $p < .0001$. In addition, contralateral latencies were shorter at occipital ($M = 111.5 \pm 16.5$ ms) than temporal sites ($M = 112.5 \pm 15.6$ ms), whereas ipsilateral latencies were shorter at temporal; $M = 134.6 \pm 16.0$ ms, than occipital sites, $M = 136.2 \pm 16.8$ ms; Site × Side interaction, $F(1, 39) = 9.46$, $p < .0038$. This result implies that IHTTs were shorter at temporal than occipital sites. For the N160 peak, contralateral latencies ($M = 162.1 \pm 15.4$ ms) were 23.3 ms shorter than ipsilateral ones ($M = 185.4 \pm 21.4$ ms); main effect of side, $F(1, 42) = 67.62$, $p < .0001$. No other main effects or interactions were significant after Bonferroni correction. There was a statistically significant directional effect for the N160 peak such that contralateral latencies were shorter for the RVF (158.5 ± 17.0 ms) than the LVF (165.7 ± 17.2 ms), whereas ipsilateral latencies were shorter for the LVF (184.4 ± 22.8 ms) than the RVF; 186.3 ± 23.0 ms; Visual Field × Side interaction, $F(1, 42) = 4.72$, $p < .04$. The resulting asymmetry of IHTT in favor of the LVF is consistent with that found by others (e.g., Bisiacchi et al., 1994; Brown, Larson, & Jeeves, 1994; Saron & Davidson, 1989a).

Analyses of amplitudes. Mean amplitudes are presented in Table 4. Peak-to-peak amplitude from the P100 to N160 peak was the dependent measure in a repeated measures ANOVA with age group, site, and side as variables. Peak-to-peak amplitude was greater for occipital ($M = 9.2 \pm 3.4$ μV) than temporal leads; $M = 8.1 \pm 2.5$ μV; main effect of site; $F(1, 39) = 10.51$, $p < .0024$. This effect was moderated by an Age Group × Site interaction, $F(1, 39) = 11.11$, $p < .0019$. Occipital peak-to-peak amplitudes were larger than temporal ones only for younger participants. In consequence, older participants had larger peak-to-peak amplitudes at temporal sites ($M = 8.2 \pm 2.2$ μV), and smaller amplitudes at occipital sites ($M = 8.2 \pm 2.7$ μV), than did younger participants ($M_{\text{temporal}} = 7.9 \pm 2.7$ μV, $M_{\text{occipital}} = 9.9 \pm 3.8$ μV). Contralateral peak-to-peak amplitudes ($M = 10.0 \pm 3.0$ μV) were larger than ipsilateral ones ($M = 7.2 \pm 4.0$ μV); main effect of side, $F(1, 39) = 25.97$, $p < .0001$. However, this effect was moderated by an Age Group × Side interaction, $F(1, 39) = 13.24$, $p < .0008$. Older participants showed a larger difference between contralateral and ipsilateral waveforms than did younger participants (see Table 4). Post hoc t tests showed that this interaction occurred because older participants had smaller ipsilateral waveforms than their younger counterparts, $t(39) = 2.44$, $p = .019$, and that for older participants contralateral waveforms were significantly larger than ipsilateral ones, $t(17) = 6.46$, $p < .0001$.

Separate ANOVAs were computed for P100 and N160 amplitudes. Amplitudes were corrected for average baseline amplitude (0–50-ms prestimulus) for the appropriate Site × Visual Field condition. In these analyses, age group (younger or older) was the between-subjects variable, and visual field (left or right), site (temporal or occipital), and side (ipsilateral or contralateral) were the within-subjects variables. For the P100 peak, there was a statistically significant Age Group × Side interaction, $F(1, 39) = 6.60$, $p < .0141$; see Figure 3. Post hoc t tests showed that the ipsilateral amplitude was smaller for older ($M = 3.3 \pm 1.7$ μV) than younger participants ($M = 5.2 \pm 3.0$ μV), $t(39) = 2.45$, $p < .019$. Contralateral P100 amplitudes did not differ for the two groups ($M_{\text{younger}} = 4.1 \pm 2.2$ μV, $M_{\text{older}} = 3.8 \pm 1.6$ μV); $t(39) = 0.41$, $p < .68$.

For the N160 peak, contralateral peaks ($M = -6.2 \pm 2.8$ μV) were larger than ipsilateral ones ($M = -2.8 \pm 2.4$ μV); main effect of side, $F(1, 42) = 66.56$, $p < .0001$. This effect was moderated by an Age Group × Side interaction, $F(1, 42) = 10.71$, $p < .0021$. Post hoc t tests showed that older participants had larger contralateral N160 peaks ($M = -7.4 \pm 2.8$ μV) than did younger participants; $M = -5.3 \pm 2.5$ μV; $t(42) = 2.66$, $p < .011$. Ipsilateral N160 amplitudes did not differ between younger ($M = -3.2 \pm 2.8$ μV) and older participants ($M = -2.4 \pm 2.0$ μV); $t(42) = -.98$, $p < .33$.

Variability in amplitude. It could be argued that older participants had flatter ipsilateral peaks because of an age-related increase in latency jitter. To address this issue, we made the intraindividual standard error of the amplitude of

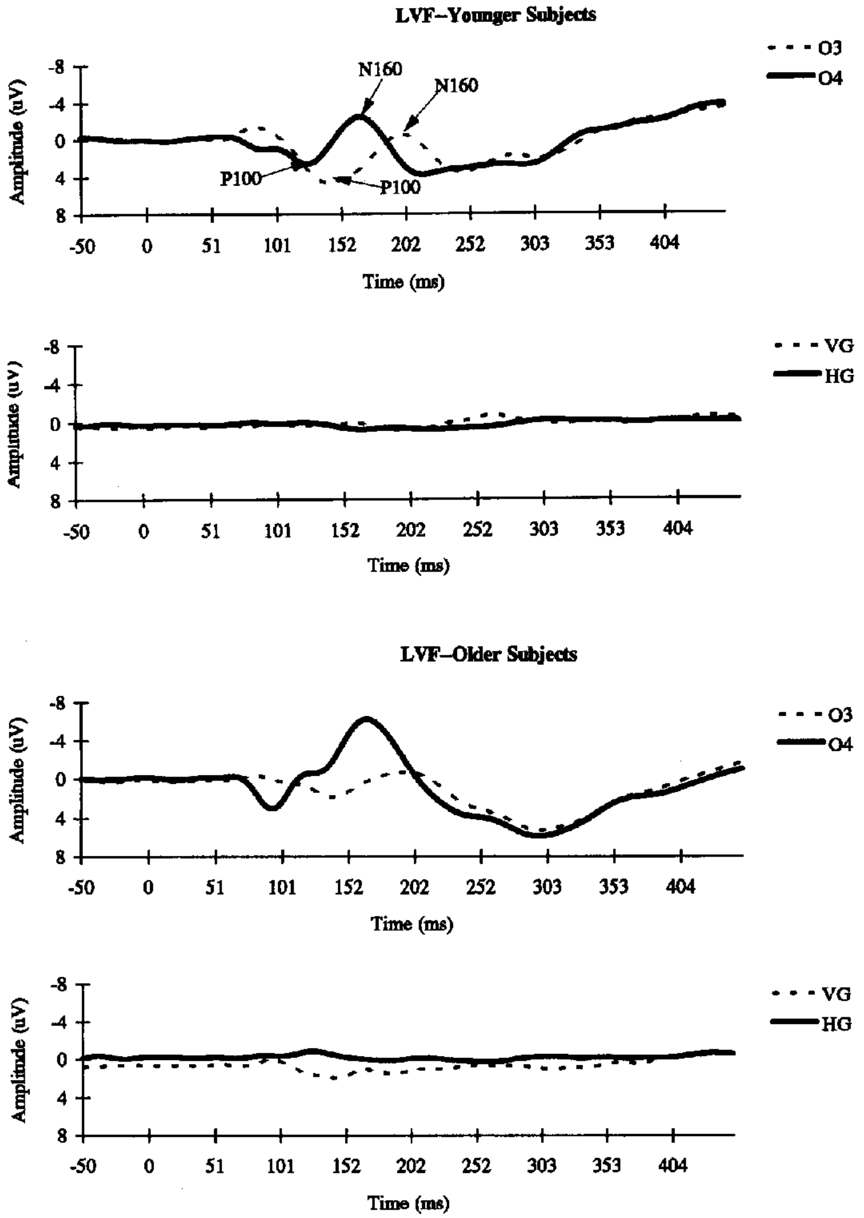

Figure 1. Grand average waveforms for left visual field (LVF) stimuli. Top: Younger participants. Bottom: Older participants. VG = vertical electrooculogram (EOG); HG = horizontal EOG. Amplitude expressed in microvolts. O3 and O4 indicate respectively left and right lateral occipital electrode sites.

each peak the dependent measure in a repeated measures ANOVA in which age group (younger or older) was the between-subjects variable and visual field (left or right), site (occipital or temporal), and side (contralateral or ipsilateral) were within-subjects variables. This analysis was conducted separately for the P100 and N160 peaks.

For the P100 peak, standard errors showed a trend to be larger for younger ($M = 0.80 \pm 0.35$ μV) than older participants; $M = 0.62 \pm 0.25$ μV; main effect of age group, $F(1, 39) = 3.18, p < .082$. In addition, standard errors were larger for occipital ($M = 0.76 \pm 0.34$ μV) than for temporal sites ($M = 0.68 \pm 0.29$ μV); main effect of site, $F(1, 39) = 17.09$, $p < .0009$. Decomposition of a statistically significant Age Group × Site interaction, $F(1, 39) = 11.26$, $p < .002$, by Spotvoll–Stoline post hoc tests (Kirk, 1982) showed that the standard error for the occipital sites was larger than for temporal sites only for younger participants.

For the N160 peak, again standard errors were larger for younger ($M = 0.78 \pm 0.29$ μV) than older participants; $M = 0.61 \pm 0.21$ μV, $F(1, 42) = 4.29, p < .045$. As with the P100, standard errors were larger for occipital ($M = 0.75 \pm 0.30$ μV) than temporal sites ($M = 0.68 \pm 0.26$ μV), main effect of site, $F(1, 42) = 22.81, p < .0009$. However, this effect held only for younger participants; Age Group × Site interaction, $F(1, 42) = 13.87, p < .001$. The standard error of the ipsilateral N160 was larger than for the contralateral waveform; main effect of

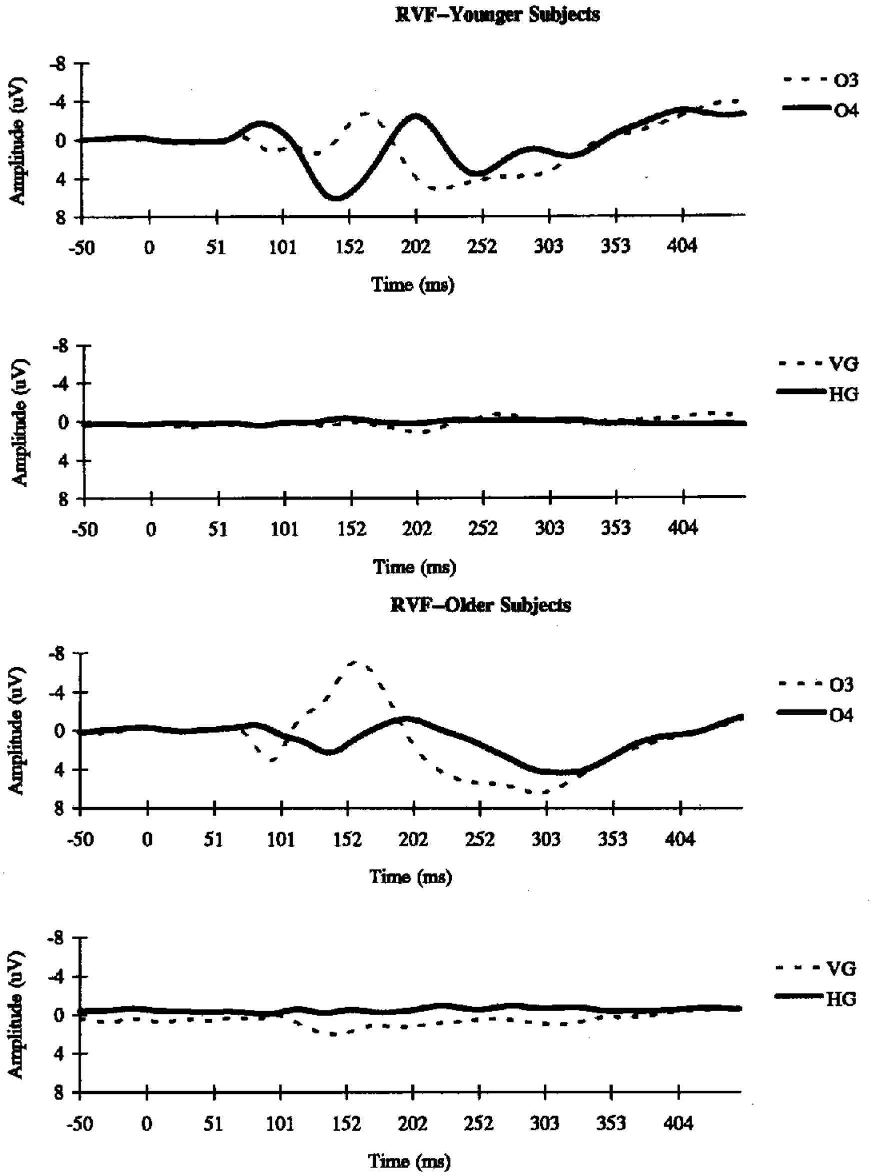

Figure 2. Grand average waveforms for right visual field (RVF) stimuli. Top: Younger participants. Bottom: Older participants. VG = vertical electrooculogram (EOG); HG = horizontal EOG. Amplitude expressed in microvolts. O3 and O4 indicate respectively left and right occipital electrode sites.

side, $F(1, 42) = 10.06, p < .003$, although this effect was larger for younger participants than older ones; Age Group × Side interaction, $F(1, 42) = 5.40, p < .025$.

Discussion

The major finding in this study was that older participants showed a reduction in the amplitude of their ipsilateral waveform. These results confirmed the prediction that older participants would show reduced activity over ipsilateral sites consistent with reductions in the quality of interhemispheric transfer and represent, to our knowledge, the first data to show such an effect in older participants. The effect occurred only for amplitudes; there was no age effect for latency.

The reduction in the amplitude of the ipsilateral waveform may be parsimoniously attributed to a disruption of interhemispheric interaction. It cannot be the result of some property of elementary visual function because the contralateral N160 is larger in older participants than it is in younger participants. Rugg et al. (1985) and Mangun et al. (1991) showed that the appearance of the ipsilateral waveform in response to visual stimulation is contingent on the integrity of the corpus callosum. Analyses on the intraindividual variance in peak amplitude show that these effects could not be due to increased latency jitter in older participants, as in general older participants had smaller intraindividual standard errors than younger participants. Thus, reduction in the amplitude of the ipsilateral waveform in older participants suggests a disruption in the quality of interhemispheric interaction, as opposed to IHTT.

Table 3
Mean Latencies (in Milliseconds) for P100 and N160 Peaks by Visual Field and Younger and Older Age Groups

	Younger								Older							
	P100				N160				P100				N160			
Visual field	Contralateral		Ipsilateral		Contralateral		Ipsilateral		Contralateral		Ipsilateral		Contralateral		Ipsilateral	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Left	114.0	19.2	137.9	16.4	165.8	21.0	188.0	20.4	111.0	16.6	131.0	19.4	163.6	13.0	179.8	25.1
Right	111.5	17.2	137.6	17.9	158.2	19.2	192.1	20.8	109.2	16.3	133.9	16.3	159.0	14.0	179.2	24.1

Note. Latencies averaged across temporal and occipital sites. For the contralateral P100 to right visual field stimuli, 25 younger participants showed a peak at temporal sites, whereas 24 showed a peak at occipital sites. Otherwise the number of participants showing peaks was identical for temporal and occipital sites.

The reason for this disruption is unclear at present. The failure to observe a robust ipsilateral waveform in older participants might be the result of decreased signal intensity through the callosal channel, increased "noise" in callosal fibers, and/or decreased responsivity of cortical sites to incoming callosal input. There likely are other possibilities as well. The lack of an age effect of IHTT is inconsistent with the idea that callosal axons shrink with aging, as is the case in other brain regions (e.g., Terry, DeTeresa, & Hansen, 1987). We are aware of no histological or physiological studies of neuronal aging in the CC.

The finding of site-specific effects warrants some discussion. The shorter latency of P100 peaks over contralateral occipital than over temporal sites is expected on the basis of neuroanatomy of the visual system and the presumed source of the P100 in extrastriate cortex (e.g., Maier et al., 1987). These areas are connected by callosal fibers, although striate cortex receives only afferent callosal fibers (Clarke & Miklossy, 1990). Thus, it is unlikely that the longer IHTTs seen at occipital sites are due simply to a lack of callosal connectivity between the source generators of the P100s. The difference in IHTTs may be the result of between-region differences in the caliber of callosal fibers. Thus, there may be more large fibers in regions of the CC connecting homologous lateral temporal sites than in regions of the CC connecting lateral occipital sites. An autopsy study by Aboitiz, Scheibel, Fisher, and Zaidel (1992) lends support to this notion. Although this effect was statistically significant, it was small in magnitude and thus awaits replication. The larger peak-to-peak amplitude for occipital sites also may reflect the source localization of the P100 and N160 peaks.

Another finding that warrants comment is that N160 amplitudes were larger at contralateral sites in older than in younger participants, whereas P100s were larger at ipsilateral sites in younger than in older participants. It may be that there is differential aging in the generators of these peaks. The larger contralateral N160s may reflect stimulus disinhibition similar to that noted in earlier occurring peaks among patients with frontal lesions (see Knight, 1991, for a discussion). In this context, it should be noted that in the present sample, older participants performed more poorly than younger ones on cognitive tasks sensitive to frontal lobe damage (Hoptman & Davidson, 1996). The lack of a comparable finding for the contralateral P100 peak may reflect the differential influences of prefrontal activity on each of these components.

Similarly, the lack of an age difference for the ipsilateral N160 may reflect the different neural influences on this component compared with the P100. If there is greater disinhibition at N160, that might be reflected in a smaller age-related reduction in the ipsilateral N160. However, it should be noted that the ipsilateral N160 peak was nonsignificantly smaller in older than in younger participants, suggesting that statistical power may have been insufficient to detect this difference.

Table 4
Mean Peak-to-Peak Amplitudes (in Microvolts) for Left and Right Visual Field (VF) Stimuli by Site and Younger and Older Age Groups

	Younger								Older							
	Left VF				Right VF				Left VF				Right VF			
	Contralateral		Ipsilateral		Contralateral		Ipsilateral		Contralateral		Ipsilateral		Contralateral		Ipsilateral	
Site	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Temporal																
P100	3.7	2.3	4.2	2.8	2.9	2.0	5.3	2.8	4.4	1.8	2.9	1.6	3.2	1.8	3.9	2.2
N160	−5.2	2.8	−2.0	2.3	−4.6	2.6	−3.2	3.5	−7.0	2.8	−2.6	2.0	−7.4	2.8	−2.7	2.5
Peak-to-peak	9.0	3.5	6.2	3.5	7.5	3.1	8.6	5.1	11.0	3.1	5.4	2.7	10.3	3.3	6.3	3.4
Occipital																
P100	4.6	3.6	5.4	4.2	4.3	2.6	6.3	5.1	4.3	2.0	3.0	1.9	3.5	2.3	3.4	2.3
N160	−5.8	3.6	−2.7	2.7	−5.6	3.3	−4.1	4.4	−6.6	3.3	−2.4	2.4	−8.5	3.9	−2.0	2.4
Peak-to-peak	10.4	4.3	8.0	5.6	9.8	4.0	10.5	7.2	10.5	4.3	5.3	2.7	11.8	4.9	5.2	2.9

Note. P100 and N160 peaks are baseline corrected, and peak-to-peak values do not equal the difference of the P100 and N160 because they are not baseline corrected and there were differences in the numbers of participants providing each peak. For the contralateral P100 to right VF stimuli, 25 younger participants showed a peak at temporal sites, whereas only 24 younger participants showed a peak at occipital sites. Otherwise, the number of participants showing peaks was identical for temporal and occipital sites.

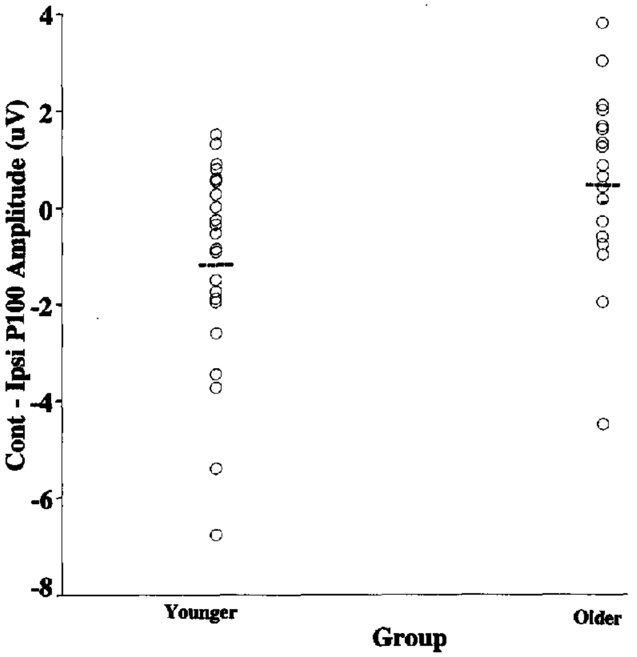

Figure 3. Contralateral (Cont) minus ipsilateral (Ipsi) amplitude for the P100 peak (in microvolts) of each younger and older participant collapsed across site, visual field, and response hand. Dashed lines indicate group means.

It is probable that information carried in VEPs transfers in posterior loci of the CC (Pandya & Seltzer, 1986; see Hoptman & Davidson, 1994, for a discussion). Thus, the finding of reductions in ipsilateral VEP amplitude is especially interesting in light of data suggesting that anterior CC regions are especially reduced in age (e.g., Cowell et al., 1992). It may be that other kinds of information (e.g., somatosensory EPs) that probably transfer more anteriorly (e.g., see Pandya & Seltzer, 1986) might be even more influenced by age than the VEPs. It would be of special interest to investigate interhemispheric transfer in other modalities across the lifespan.

Because of the large individual differences that occur in normal aging (Schaie, 1993), it would be important to examine intraindividual changes in interhemispheric transfer by studying subjects longitudinally. It also would be of interest to determine the extent to which variations in interhemispheric transfer in older age predicts pathologies of aging. For instance, it may be that such changes are markers for cognitive decline. However, such questions can only be examined in prospective longitudinal studies. Furthermore, work is necessary to relate anatomical changes in CC anatomy to the psychophysiological data reported here. Such work would entail MRI or autopsy data so that area measurements and/or cytological indexes can be obtained on a within-subjects basis. Finally, it would be important to examine the functional significance of a decline in interhemispheric interaction. For example, interhemispheric interaction is beneficial under more difficult task conditions (e.g., Banich, 1995). It remains to be seen whether age-related declines in interhemispheric interaction predict age-related reductions in demanding task paradigms.

Evoked potentials are relatively easy to obtain, give highly reliable estimates of interhemispheric interaction (Saron & Davidson, 1989a), are noninvasive, and require little output from the participants. These methods are therefore ideally suited for the study of interhemispheric interaction across the lifespan.

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