

1974

Simple Reaction Time of Ipsilateral and Contralateral Hand to Monaurally Presented Tones of Different Pitch with Binaural White Noise

Peter G. Aitken
The College at Brockport

Follow this and additional works at: http://digitalcommons.brockport.edu/psh_theses

 Part of the [Psychiatry and Psychology Commons](#)

Repository Citation

Aitken, Peter G., "Simple Reaction Time of Ipsilateral and Contralateral Hand to Monaurally Presented Tones of Different Pitch with Binaural White Noise" (1974). *Psychology Master's Theses*. 1.
http://digitalcommons.brockport.edu/psh_theses/1

This Thesis is brought to you for free and open access by the Psychology at Digital Commons @Brockport. It has been accepted for inclusion in Psychology Master's Theses by an authorized administrator of Digital Commons @Brockport. For more information, please contact kmyers@brockport.edu.

SIMPLE REACTION TIME OF IPSILATERAL AND
CONTRALATERAL HAND TO MONAURALLY PRESENTED TONES
OF DIFFERENT PITCH WITH BINAURAL WHITE NOISE

Peter G. Aitken

Submitted in partial fulfillment of the
requirements for the degree of Master of Arts
in Psychology

State University of New York College at Brockport

1974

Thesis committee:

Associate Professor Sachio Ashida, Chairman

Associate Professor William Riddell

Assistant Professor Frederick Gravetter

#9245718

Abstract

This study hypothesized that reaction times to monaural auditory stimuli are shorter with the ipsilateral hand than with the contralateral hand under binaural white noise stimulation, and that ipsi- and contralateral reactions do not differ in the absence of white noise. The relationship between the ipsilateral-contralateral reaction time difference and the frequency of the reaction signal was also determined. In experiment I, 10 male undergraduate students each performed 20 ipsilateral and 20 contralateral reactions to each of 6 signal frequencies (400, 800, 1200, 1600, 2000, & 2400 cps) under binaural white noise stimulation. In experiment II, 10 male undergraduate students each performed 20 ipsi- and 20 contralateral reactions, at one stimulus frequency, under white noise on and white noise off conditions. The results support both hypotheses ($p < .001$), and also indicate that signal frequency has a significant effect on contralateral reactions ($p < .001$) but not on ipsilateral reactions. Close agreement was obtained with results of other callosal transmission studies, and support provided for the theory that the ear asymmetry effect is caused in part by the occlusion of ipsilateral auditory connections by contralateral ones. The results also suggest that the effect of signal frequency on contralateral reactions is related to the mechanism limiting the frequency at which binaural beats are perceived.

Preface

A word of explanation is in order about the format of this paper. A thesis is broader in scope and function than a scientific article. To facilitate submission of this study for publication, and to gain experience in writing a journal article, the author, at the suggestion of Dr. Sachio Ashida, structured this paper as a journal article with supplementary appendices. The appendices, which contain material inappropriate for publication, are referred to as needed within the article.

The author would like to express his thanks and appreciation to the members of his thesis committee for their help and guidance in the preparation of this thesis. In addition to their more general assistance, thanks go to Dr. Frederick Gravetter for his advice on matters of experimental design and statistical analysis, and to Dr. William Riddell for his comments on the style and structure of this paper. Special thanks go to Dr. Sachio Ashida who, in addition to his assistance in every phase of this study, provided a year of guidance, teaching, and friendship that has had a great influence on my development as a scientist and teacher.

Contents

Abstract -----	1
Preface -----	111
List of appendices -----	v
Introduction -----	1
Method (Experiment I) -----	5
Results (Experiment I) -----	6
Method (Experiment II) -----	7
Results (Experiment II) -----	8
Discussion -----	9
References -----	11
Tables -----	13
Figures -----	15
Appendices -----	18
References for appendices -----	25
Data -----	28

List of Appendices

Appendix I (Supplemental to introduction) ----- 18
Appendix II (Supplemental to method) ----- 22
Appendix III (Supplemental to discussion) ----- 23

SIMPLE REACTION TIME OF IPSILATERAL AND
CONTRALATERAL HAND TO MONAURALLY PRESENTED TONES
OF DIFFERENT PITCH WITH BINAURAL WHITE NOISE

Peter G. Aitken

State University of New York, College at Brockport

The complete structural symmetry and almost complete functional symmetry of the hemispheres of the human brain have allowed the design of a number of studies that use reaction time (RT) measurements to draw inferences about the structure and function of the nervous system (e.g. Filbey & Gazzaniga, 1969; Jeeves, 1965). One basis for many of these studies was the belief that the voluntary muscles of each side of the body are under the total control of the contralateral motor cortex; thus, for a reaction to be made with the right hand, for example, neural excitation resulting from the input signal would have to reach the left motor cortex. The majority of these studies used visual stimuli (e.g. Berlucchi, Heron, Hyman, Rizzolatti, & Umiltà, 1971), as each half of the visual field (VF) is projected onto the contralateral cortex. When a stimulus is presented to one VF, a reaction with the ipsilateral hand (uncrossed reaction) would involve an interaction between the visual and motor areas of one hemisphere, while a reaction with the contralateral hand (crossed reaction) would involve an interaction between the two hemispheres. Interhemispheric transmission of information would be

expected to take longer than intrahemispheric transmission, resulting in crossed reactions taking longer than uncrossed reactions.

Poffenberger (1912) found just that, reporting crossed reactions an average of 6 msec. slower than uncrossed reactions. These results were, however, contradicted by a later study (Smith, 1938). Although Jeeves (1965) reported results agreeing with those of Poffenberger, the rationale behind these studies was thrown into question by Gazzaniga's (1967) report that each hemisphere of the brain has motor control over either side of the body. This has since been shown to be true except for the fingers, which are controlled solely by the contralateral motor cortex (Moscovitch & Catlin, 1970). Thus, finger reactions to lateralized visual stimuli should be faster when uncrossed than when crossed. This has been convincingly shown by Berlucchi et al. (1971) who found uncrossed reactions an average of 2.7 msec. faster than crossed reactions.

While it is well established that more time is required for a response involving transmission of information between hemispheres, reports on the length of time required vary: e.g., 10 to 35 msec. (Bremer, 1958; Teitelbaum, Sharpless, & Byck, 1968), 30 msec. (Filbey & Gazzaniga, 1969), and 10 msec. (Moscovitch & Catlin, 1970) (see Appendix I, Part A).

The contralateral cortical projection of the visual fields has made vision the most widely used sensory input for studies of cerebral dominance and interhemispheric information transmission. The results obtained with visual stimulation might not be predicted with

auditory stimulation, as neural inputs from each ear project to the auditory areas of both hemispheres. Simon (1967) found no difference between crossed and uncrossed RT to monaural auditory stimuli. An ear asymmetry effect has been found, however, with the right ear superior for verbal tasks, and the left for nonverbal tasks.

Bryden (1963) found the right ear superior in a task requiring the recall of pairs of digits, and Kimura (1964) found the left ear superior in the perception of melodies (see Appendix I, Part B).

The left and right hemispheres of the brain being dominant, respectively, for verbal and nonverbal functions, the ear asymmetry effect implies that signals from each ear are being transmitted almost solely to the contralateral hemisphere. The ear asymmetry effect is generally noticed only under conditions of binaural stimulation, and Dirks (1964) has related this to Rosenzweig's (1951) finding that there is greater evoked cortical response to contra- rather than to ipsilateral auditory stimulation, and that under binaural stimulation, ipsilateral connections are partially occluded by contralateral ones. Under binaural stimulation, therefore, crossed pathways are accentuated, and the auditory pathways function, to an extent, as if inputs from each ear projected solely to the contralateral cortex. In a simple RT task, if the signal stimulus is presented to one ear while some other stimulus (e.g., white noise) is presented to the other ear, crossed reactions would be expected to take longer than uncrossed reactions.

Another area of investigation that has provided information on

the neural processing of auditory input is the study of binaural beats (Oster, 1973) (see Appendix I, Part C). The perception of binaural beats is limited by both upper and lower stimulus frequency boundaries, the lower being approximately 90 cps (Oster, 1973), the upper being reported by various investigators from 750 cps to 2500 cps (Perrott & Nelson, 1969). Licklider, Webster, and Hedlund (1950) have proposed that the perception of binaural beats is related to the precision with which the neural input follows the sinusoidal stimulus input, and that the upper frequency limit for perception of binaural beats is due to a loss of synchrony between neural input and signal. Licklider et al. (1950) further propose that this loss of synchrony is the result of a limit in the number of peripheral neurons available for volley rotation. It is possible that the occlusion of ipsilateral auditory pathways by contralateral ones under binaural stimulation (Rosenzweig, 1951) would vary as a function of the proportion of the available peripheral neurons involved in signal transmission. Following the model proposed by Licklider et al. (1950), such occlusion would be a maximum at or near the upper frequency limit for the perception of binaural beats. At this frequency, therefore, a significant variation in the difference between crossed and uncrossed reactions might be expected.

To recapitulate, available evidence suggests that crossed and uncrossed RTs to monaural auditory stimuli under binaural white noise will differ, and that this difference may vary as the stimulus frequency is raised above the frequency limit for binaural beat perception. The present study hypothesized that crossed reactions would take longer than uncrossed reactions. The relationship between this difference and

signal frequency was also determined.

Experiment I

Method

Subjects. Ten male undergraduate students with normal hearing.

Apparatus. White noise was from a Grason-Stadler model 901B noise generator, and signal tones from a Tektronics model SG-502 oscillator. Stimuli were switched with a home built integrated circuit timed switch, and presented through Koss model K-6 stereo earphones. RT was measured with a Berkeley model 554 EPUT meter.

Procedure. Each S was seated in a straight backed chair at a table in an otherwise empty 5 by 8 foot soundproof room. Air temperature was 70°, and room illumination was subdued (approximately 2 foot-candles). Each hand was positioned near a reaction switch, which was operated horizontally by holding the switch in (toward the midline) and releasing it upon hearing the reaction signal. The S was informed whether to react with his right or left hand on a given trial by a small red light above each switch. The lights did not serve as a warning - one or the other was always on, changing, when needed, immediately following a trial.

Reaction signals were monaurally presented pure sinusoidal tones of 400, 800, 1200, 1600, 2000, & 2400 cps, of 250 msec. duration, at 70 db. SPL. Binaural white noise at 70 db. SPL onset 1 to 5 sec. prior to the signal, and offset 1 sec. after the signal offset. For the duration of each signal tone, the white noise was turned off in the channel that carried the tone.

Each S received 10 trials under each of the 24 experimental conditions (2 hands, 2 ears, 6 frequencies). The trials were randomly ordered within each of 10 blocks, each block containing every condition once. The time by which the white noise anticipated the signal tone was randomly assigned to the trials with the restrictions that (a) the 10 trials of each condition had each duration of anticipation (1, 2, 3, 4, & 5 sec.) assigned twice, and (b) for each block of trials the average anticipation was between 2.5 and 3.5 sec. The intertrial interval averaged 15 sec. for each block, randomly assigned between 10 and 20 sec. SS were given 24 practice trials, and 5 minutes rest after 3 and 6 blocks were run.

RT was recorded to the nearest millisecond in an adjoining room. Anticipatory ($RT < 100$ msec.) and delayed ($RT > 250$ msec.) responses were discarded and the trial repeated. (see Appendix II).

Results

The results of experiment I are summarized in figure 1. Each data point represents the mean of 200 responses, 20 by each S under that condition. Overall, uncrossed reactions were an average of 9.63 msec. faster than crossed reactions.

Insert figure 1 about here

The data were averaged across trials and analyzed in a two factor repeated measures ANOV, summarized in table 1. The simple effect

of frequency for crossed reactions was significant ($F = 12.50$, $df = 5, 45$, $p < .001$), and the simple effect of frequency for uncrossed reactions was nonsignificant ($F = 2.04$, $df = 5, 45$).

Insert table 1 about here

Four of the Ss volunteered the subjective impression that they had reacted slower for the lower frequencies.

Experiment II

The results of experiment I could not be properly interpreted without determining whether the difference between crossed and uncrossed reactions is due to the white noise. Although Simon (1967) reported no difference between crossed and uncrossed reactions in the absence of white noise, it was deemed desirable to replicate these results under the specific experimental conditions of the present study. Simon (1967) employed a 1000 cps signal tone; a 1600 cps signal tone was used in experiment II, as it was at this frequency that the greatest mean difference between crossed and uncrossed reactions was obtained in experiment I.

Method

Subjects. Ten male undergraduate students with normal hearing.

Apparatus. Same as in experiment I.

Procedure. Identical to experiment I with the following exceptions. Only one stimulus frequency, 1600 cps, was used. White noise

on trials were identical to trials in experiment I. White noise off trials consisted of a 1 sec. pulse of white noise followed by a 1 to 5 sec. delay and the 250 msec. signal tone. Each S received 10 trials under each of the 8 conditions (white noise on or off, 2 hands, 2 ears). The trials were randomly ordered within each of 5 blocks, each block containing each condition twice. Intertrial intervals and the white noise to signal delay were assigned as in experiment I. 24 practice trials were given, and the 80 trials run without interruption.

Results

The results of experiment II are summarized in figure 2. Each data point represents the mean of 200 responses, 20 by each S under that condition. Under the white noise on condition, uncrossed reactions were an average of 13.57 msec. faster than crossed reactions.

Insert figure 2 about here

The data were averaged across trials and analyzed in a two factor repeated measures ANOV, summarized in table 2. The simple effect of white noise for crossed reactions was significant ($F = 34.3$, $df = 1, 9$, $p < .001$), and the simple effect of white noise for uncrossed reactions was nonsignificant ($F = 0.14$, $df = 1, 9$). The simple effect of crossed or uncrossed reaction was significant for the white noise on condition ($F = 46.4$, $df = 1, 9$, $p < .001$) and nonsignificant for the white noise off condition ($F = 0.95$, $df = 1, 9$).

Insert table 2 about here

Discussion

The average time by which the present study found uncrossed reactions to be faster than crossed reactions is in close agreement with the times reported in other studies (Berlucchi, et al., 1971; Filbey & Gazzaniga, 1969; Moscovitch & Catlin, 1970) as the time needed for information to be transmitted between the hemispheres. These other studies all used visual stimulation; support of their results using auditory stimulation suggests that these times are a generally applicable value for interhemispheric information transmission and are not limited to transfer of information originating in the visual system (see Appendix III, Part A).

The finding that crossed and uncrossed RTs differ with white noise, and do not differ without white noise, is in accord with the proposed explanation of the ear asymmetry effect (Dirks, 1964; Rosenzweig, 1951) discussed in the introduction. A study which determined the relationships between the crossed-uncrossed RT difference and the relative amplitudes and temporal relations of the signal tone and white noise might provide inferences about the mechanism of occlusion of ipsilateral auditory pathways by contralateral ones.

It is more difficult to interpret the finding that the delay of crossed reactions varies with signal frequency. If this variable delay occurs in the afferent auditory pathways, it would be expected that uncrossed RT would vary significantly as a function of signal

frequency as well, which it did not in the present study (It should be noted that while the effect of frequency for uncrossed reactions was nonsignificant, the curves plotting crossed and uncrossed RT as a function of signal frequency, in figure 1, are largely parallel except for one point on the graph). The alternative is that this variable delay occurs at some point in the transfer of information between hemispheres. Information on the interhemispheric connections which integrate auditory activity in one hemisphere with motor activity in the other hemisphere is, however, too sparse at the present time to allow even tentative conclusions to be drawn (see Appendix III, Part B).

References

- Berlucchi, G., Heron, W., Hyman, R., Rizzolatti, G., & Umiltà, C.
Simple reaction times of ipsilateral and contralateral hand
to lateralized visual stimuli. Brain, 1971, 94, 419-430.
- Bremer, F. Physiology of the corpus callosum. Research Publica-
tions of the Association for Research in Nervous and Mental
Disease, 1958, 36, 424-428.
- Bryden, M. P. Ear preference in auditory perception. Journal of
Experimental Psychology, 1963, 65, 103-105.
- Dirks, D. Perception of dichotic and monaural verbal material and
cerebral dominance for speech. Acta Otolaryngologica, 1964,
58, 73-80.
- Filbey, R. A., & Gazzaniga, M. S. Splitting the brain with reaction
time. Psychonomic Science, 1969, 17, 335-336.
- Gazzaniga, M. S. The split brain in man. Scientific American,
1967, 217, 24-29.
- Jeeves, M. A. Psychological studies of three cases of congenital
agenesis of the corpus callosum. Ciba Foundation Study Groups,
1965, 20, 73-94.
- Kimura, D. Left-right differences in the perception of melodies.
Quarterly Journal of Experimental Psychology, 1964, 16, 355-358.
- Licklider, J. C. R., Webster, J. C., & Hedlund, J. M. On the frequen-
cy limits of binaural beats. Journal of the Acoustical Society
of America, 1950, 22, 468-473.

- Moscovitch, M., & Catlin, J. Interhemispheric transmission of information: Measurement in normal man. Psychonomic Science, 1970, 18, 211-213.
- Oster, G. Auditory beats in the brain. Scientific American, 1973, 229, 94-101.
- Perrott, D. R., & Nelson, M. A. Limits for the detection of binaural beats. Journal of the Acoustical Society of America, 1969, 46, 1477-1483.
- Poffenberger, A. T. Reaction time to retinal stimulation with special reference to time lost in conduction through nerve centers. Archives of Psychology, 1912, New York, No.23.
- Rosenzweig, M. R. Representations of the two ears at the auditory cortex. American Journal of Physiology, 1951, 167, 147-214.
- Simon, J. R. Ear preference in a simple reaction time task. Journal of Experimental Psychology, 1967, 75, 49-55.
- Smith, F. O. An experimental study of the reaction time of the cerebral hemispheres in relation to handedness and eyedness. Journal of Experimental Psychology, 1938, 22, 75-83.
- Teitelbaum, H., Sharpless, S. K., & Byck, R. The role of the somatosensory cortex in the interhemispheric transfer of tactile habits. Journal of Comparative and Physiological Psychology, 1968, 66, 623-632.

TABLE 1
 Analysis of Variance: Experiment I

Source	<u>df</u>	<u>MS</u>	<u>F</u>
Crossed or Uncrossed (C)	1	2776.52	180.17**
Frequency (F)	5	217.44	11.02**
Subjects (S)	9	2163.06	
C x F	5	69.68	7.13**
C x S	9	15.41	
F x S	45	19.73	
C x F x S	45	9.76	

**p < .001.

TABLE 2

Analysis of Variance: Experiment II

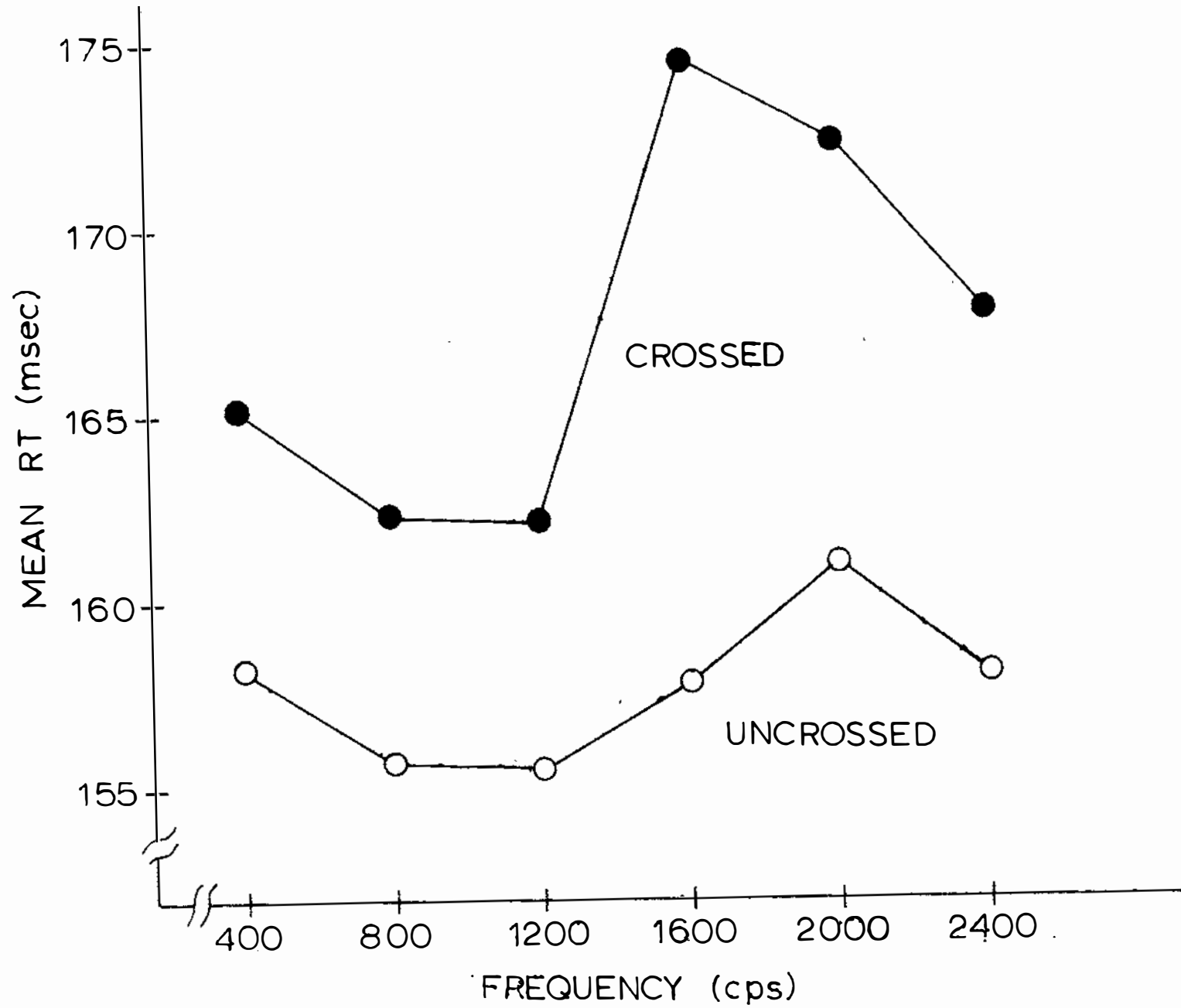
Source	<u>df</u>	<u>MS</u>	<u>F</u>
Crossed or Uncrossed (C)	1	334.44	16.75*
White Noise (W)	1	495.34	15.47*
Subjects (S)	9	486.06	
C x W	1	605.59	93.88**
C x S	9	19.96	
W x S	9	32.01	
C x W x S	9	6.45	

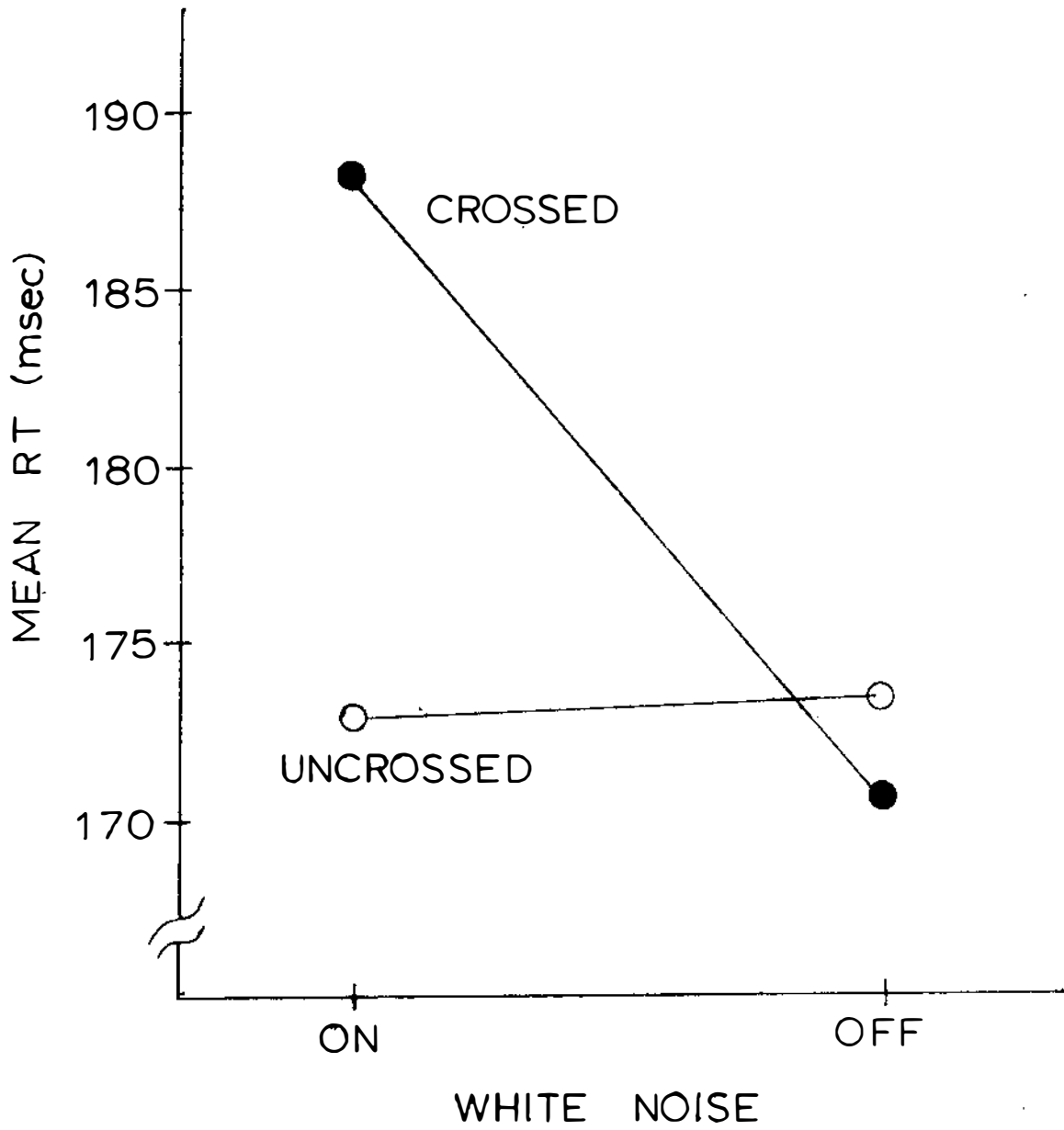
*p < .005. **p < .001.

Figure Captions

Figure 1. Experiment I: mean crossed and uncrossed RT as a function of stimulus frequency.

Figure 2. Experiment II: mean crossed and uncrossed RT with and without white noise.





Appendix I

Part A

The localization of verbal function in the left hemisphere for most individuals provides a clear picture of interhemispheric information transmission, and has been the basis for several studies using RT measurements. Filbey & Gazzaniga (1969) presented Ss with either a dot or a blank in one VF. Ss responded verbally, saying yes or no to the presence or absence of the dot. This verbal RT was an average of 30 msec shorter for stimulus presentation in the right VF. Similarly, Moscovitch & Catlin (1970) had Ss name a letter presented in the right or left VF, and reported verbal RT an average of 10 msec. shorter for right VF presentation. Information presented to the right VF, being projected to the left visual cortex, would reach the speech centers faster than would information presented to the left VF.

Dimond (1970) and Davis and Schmit (1971) reported similar findings that might not have been predicted on the basis of other callosal transmission studies. In the Davis and Schmit study, for example, Ss were presented with two visual stimuli, one in each VF or both in the same VF, and had to make a finger response indicating whether the two stimuli were the same or different. RT was 15 to 25 msec. slower when the stimuli were in the same VF. The authors propose the explanation that when one stimulus is received by each hemisphere, it can be analyzed without any interference

from the other stimulus, and that this time saving more than makes up for the callosal transmission time needed to compare the two stimuli and make a response. The possibility of such more or less independent functioning of the cerebral hemispheres has been suggested by some of the split brain studies (e.g. Gazzaniga, 1967), and invites further experimentation.

The 1 to 7 msec. difference between crossed and uncrossed reactions reported by Berlucchi et al. (1971) is considerably shorter than the 10 to 35 msec. reported as the time needed for information to cross between hemispheres by other studies (Bremer, 1958; Filbey & Gazzaniga, 1969; Moscovitch & Catlin, 1970; Teitelbaum et al., 1968). These studies used more complex tasks than the simple RT used by Berlucchi et al. (1971), and the shorter time difference reported in this latter study could be the result of the less complex information being transmitted between hemispheres via the pathways in the superior colliculus, which would be shorter, and perhaps involve fewer synaptic connections, than pathways in the corpus callosum. The collicular pathways have been shown to be involved in reflex behavior (Deutsch & Deutsch, 1973, p. 104); whether they are involved in any voluntary actions has not been established.

Part B

The dominance of the right cerebral hemisphere for nonverbal functions has been further supported by Shankweiler (1966), who studied the perception of melodies in people who had suffered

damage to one of their temporal lobes. Left temporal lobe damage resulted in significantly less interference with the perception of melodies than did right temporal lobe damage.

Murphy and Venables (1970) investigated the ear asymmetry effect using simple and disjunctive RT tasks. No ear difference was found for simple RT, while the left ear was superior for performance of a disjunctive RT task. This indicates that the right hemisphere is superior in the discrimination of nonverbal stimuli.

Part C

Binaural beats are distinct from monaural beats, which occur when one or both ears receive two tones of slightly different frequency and the perceived amplitude varies at a frequency equal to the difference between the frequencies of the two tones. Monaural beats are produced by wave interference occurring outside the body, the total amplitude at any instant being equal to the algebraic sum of the amplitudes of the two tones. A common use of this phenomenon is in tuning a guitar, two strings being tuned to the same pitch when they are plucked together and no beat is heard. Binaural beats occur when two tones of slightly different frequency are presented one to each ear through earphones. Again, a modulation in perceived amplitude is present, at a frequency equal to the difference between the frequencies of the two tones. Binaural beats are the result of interactions within the nervous system (Oster, 1973).

It is probable that this interaction takes place in the superior

olivary complex. Wernick and Starr (1968) made field potential recordings from the superior olivary complex of the cat under appropriate binaural stimulation, and found both following responses and slow potentials with a periodicity equal to the frequency difference between the two stimulus tones.

Some facts about binaural beats are mentioned by Oster (1973). If one of the tones is at a clearly audible loudness, but the other is well below the threshold of perception (minus 20 db), the beats are still perceived. The brain is apparently able to detect and process stimulus input that cannot be consciously perceived. Oster also notes that while most sounds are masked by an interfering noise, the perception of binaural beats is enhanced by noise. If, along with two tones that produce binaural beats, white noise is presented at an intensity that completely masks the tones, the white noise is perceived as modulated in amplitude by the beats. This may be related to the previously mentioned observation (Rosenzweig, 1951) that under binaural stimulation, ipsilateral connections are partially occluded by contralateral ones. Contralateral connections must be involved in binaural beats, and the binaurally presented white noise would accentuate these connections, enhancing the perception of the beats.

Appendix II

To establish cut off values for RT above and below which a reaction would be considered delayed or anticipatory was not possible from examination of previous literature. Typical mean RT values under conditions similar to those in the present study ranged from 110 msec. (Kling & Riggs, 1971, p.309) to 275 msec. (Borwinick & Storandt, 1972). As the data in the present study were to be averaged across trials, the relatively wide range of 100 to 250 msec. was established.

Borwinick and Storandt (1972), using auditory stimuli ranging in amplitude from 55 to 85 db., found that simple RT was shorter for the louder stimuli. It is known that subjective loudness varies with stimulus frequency, and the different tones used in experiment I, while of equal objective loudness, might have differed enough in perceived loudness to influence the results. An examination of equal loudness curves for pure tones (Robinson & Dadson, 1956) indicated that this worry was unjustified. For frequencies between 400 and 2400 cps, the variation in subjective loudness is a maximum of 4 db. SPL. The Borwinick and Storandt (1972) data indicate that this variation is not enough to cause any variation in RT.

Appendix III

Part A

Berlucchi et al. (1971) discuss the question of which callosal fibers are involved in the interhemispheric transmission of information required for a crossed response to be made to a lateralized visual stimulus. Their results included the observation that the delay between crossed and uncrossed reactions is constant, independent of the degree of laterality of the stimulus. Berlucchi et al. (1971) also mention evidence that in humans (Whitteridge, 1965) as well as animals (e.g., Wilson, 1968; Zeki, 1969) "...both the origin and termination of callosal fibers joining the visual cortices are restricted to those areas connected with the parts of the visual field bordering the central vertical meridian" (Berlucchi et al., 1971). Thus, they conclude, the callosal connections between the visual cortices do not play a major role in crossed reactions, and note that this conclusion is in accord with Lehman's (1968) report that in monkeys, callosal fibers not originating in the occipital lobe are involved in interhemispheric visual-motor cortex interactions.

Part B

A much more speculative explanation of this finding involves the possibility that the occlusion of ipsilateral pathways by contralateral ones varies in effect as a function of the stimulus frequency, and assumes that a reaction to an auditory stimulus is a voluntary action requiring conscious awareness that a signal has

been presented. At lower signal frequencies (400 through 1200 cps.) the occlusion of ipsilateral pathways might be incomplete, allowing an attenuated signal to reach the ipsilateral hemisphere. The attenuation of the signal delays awareness of it, and therefore delays the reaction. At these lower signal frequencies, therefore, inter-hemispheric transmission is not required. At the higher signal frequencies (above 1300-1400 cps.) the occlusion of ipsilateral pathways is complete, or at least effective enough to require that for a crossed reaction to be made, information is transmitted from one hemisphere to the other, resulting in the greater delay of crossed reactions found at signal frequencies above 1600 cps.

Appendix References

- Berlucchi, G., Heron, W., Hyman, R., Rizzolatti, G., & Umiltà, C.
Simple reaction times of ipsilateral and contralateral hand
to lateralized visual stimuli. Brain, 1971, 94, 419-430.
- Borwinick, J., & Storandt, M. Sensation and set in reaction time.
Perceptual and Motor Skills, 1972, 34(1), 103-106.
- Bremer, F. Physiology of the corpus callosum. Research Publica-
tions of the Association for Research in Nervous and Mental
Disease, 1958, 36, 424-428.
- Davis, R., & Schmit, V. Timing the transfer of information between
hemispheres in man. Acta Psychologica, 1971, 35, 335-346.
- Deutsch, J. A., & Deutsch, D. Physiological Psychology. (Rev. ed.)
Homewood, Ill.: Dorsey Press, 1973.
- Dimond, S. J. Hemispheric refractoriness and the control of reaction
time. Quarterly Journal of Experimental Psychology, 1970, 22,
610-617.
- Filbey, R. A., & Gazzaniga, M. S. Splitting the brain with reaction
time. Psychonomic Science, 1969, 17, 335-336.
- Gazzaniga, M. S. The split brain in man. Scientific American, 1967,
217, 24-29.
- Kling, J. W., & Riggs, L. A. Woodworth and Schlosberg's Experimental
Psychology. (3rd ed.) New York: Holt, Rinehart, & Winston, 1973.
- Lehman, R. A. W. Motor coordination and hand preference after lesions
of the visual pathway and corpus callosum. Brain, 1968, 91,
525-538.

- Moscovitch, M., & Catlin, J. Interhemispheric transmission of information: Measurement in normal man. Psychonomic Science, 1970, 18, 211-213.
- Murphy, E. H., & Venables, P. H. The investigation of ear asymmetry by simple and disjunctive reaction time tasks. Perception and Psychophysics, 1970, 8, 104-106.
- Oster, G. Auditory beats in the brain. Scientific American, 1973, 229, 94-101.
- Robinson, D. W., & Dadson, R. S. A redetermination of the equal loudness relations for pure tones. British Journal of Applied Physics, 1956, 7, 166-181.
- Rosenzweig, M. R. Representations of the two ears at the auditory cortex. American Journal of Physiology, 1951, 167, 147-214.
- Shankweiler, D. Effects of temporal lobe damage on perception of dichotically presented melodies. Journal of Comparative and Physiological Psychology, 1966, 62, 115-119.
- Teitelbaum, H., Sharpless, S. K., & Byck, R. The role of the somatosensory cortex in the interhemispheric transfer of tactile habits. Journal of Comparative and Physiological Psychology, 1968, 66, 623-632.
- Wernick, J. S., & Starr, A. Binaural interaction in the superior olivary complex of the cat. Journal of Neurophysiology, 1968, 31, 428-446.

Whitteridge, D. Area 18 and the vertical meridian of the visual field.

Ciba Foundation Study Groups, 1965, 20, 115-120.

Wilson, M. E. Cortico-cortical connexions of the cat visual areas.

Journal of Anatomy, 1968, 102, 375-386.

Zeki, S. M. The secondary visual areas of the monkey. Brain Research,

1969, 13, 197-226.

Data - Experiment I

Each number is the mean of the 20 responses made by that subject under the indicated experimental conditions, in msec.

Subject	Signal frequency						
	400	800	1200	1600	2000	2400	
Crossed	1	165.85	160.80	161.50	172.15	173.30	164.60
	2	152.30	146.10	150.50	167.60	154.20	155.30
	3	152.20	150.70	153.25	161.05	154.20	154.70
	4	184.41	190.58	178.16	198.83	196.41	191.50
	5	159.15	153.80	156.20	161.25	168.10	159.25
	6	160.18	152.18	142.06	160.00	162.68	159.56
	7	170.10	167.20	172.05	178.80	181.80	173.15
	8	155.50	158.70	161.05	170.75	169.45	164.40
	9	190.05	185.70	191.70	199.90	195.05	190.90
	10	162.33	159.00	157.00	170.20	168.20	164.20
Uncrossed	1	162.70	161.85	157.75	166.85	157.10	153.15
	2	144.90	144.55	139.60	146.90	146.75	148.65
	3	142.10	141.70	144.65	143.30	146.00	146.30
	4	184.16	177.83	170.58	175.58	169.50	174.08
	5	151.75	148.85	150.05	155.50	159.90	151.05
	6	145.31	138.81	138.18	137.50	159.50	152.18
	7	164.25	160.45	164.90	161.00	172.20	164.10
	8	149.90	150.85	153.30	154.95	158.20	156.25
	9	182.10	179.85	186.00	182.25	184.45	181.75
	10	155.20	152.30	150.20	154.30	156.50	154.20

Data - Experiment II

Each number is the mean of the 20 responses made by that subject under the indicated experimental conditions, in msec.

Subject	White noise on	White noise off	
Crossed	1	196.85	168.50
	2	199.85	187.35
	3	204.60	186.50
	4	185.40	177.90
	5	171.45	159.45
	6	170.85	155.05
	7	181.70	167.10
	8	181.35	163.00
	9	187.90	175.05
	10	185.25	177.10
Uncrossed	1	185.60	173.10
	2	188.00	185.80
	3	198.35	195.95
	4	176.20	173.80
	5	162.80	165.50
	6	155.50	157.50
	7	166.55	169.80
	8	168.30	168.71
	9	162.70	174.01
	10	165.55	172.82