Ear advantage, handedness and telephone usage: Away with structural models.

Stephen M. Williams, D.Phil., February 2007, Colchester, Essex, UK.

Dichotic testing is noninvasive and atraumatic. For these reasons many have worked hard to turn it into a means of determining hemispheric functional specialisations. The efforts remain at best dubiously successful, however. The dichotic right-ear advantage (REA) in normals is more readily understood as (i) a component of a general skewed awareness and (ii) a correlate of ear preference in telephone conversation. The relevant research literature is extensive and some moderating variables, in particular age and ecological validity, have not been adequately evaluated. An empirical study of ear preference in mobile (cell) phone use is presented. Right ear use was observed in 64% of a sample of 500.

Definition of "structural model"

It was Kimura (1961) who announced the right ear advantage (REA) for dichotic speech. She put it down to "favoured access" of that ear to the (left) speech hemisphere, a type of explanation that has become known as a "structural" model. "Dichotic" speech means different messages to either ear – simultaneously (using stereophonic equipment). The efficacy of dichotic presentation in revealing ear advantages was put down to "functional" decussation. I have previously argued at length (Williams, 1987a) that "functional decussation" is too committal as to the structural counterpart of the behavioural evidence.

From an early stage Kinsbourne (*e.g.* 1975) took a theoretical view that is usually contrasted with the structural models, emphasising an influence of *attention* on ear advantages. Nonetheless his explanation of the rightward skew of attention was in terms of left-hemisphere "spreading activation" and remains, as I am using the term, a partially *structural* model. And to this day (*eg*, Di Stefano *et al,* 2004), that comprehends a substantial weight of researcher opinion on the REA. In the next section I deconstruct one recurring argument for a structural model of the REA. Then I go on to portray the REA as (i) a component of a general skewed awareness and (ii) a correlate of ear preference in telephone conversation.

In surveying the literature it needs to be remembered that the experimental stimuli are sometimes consonant-vowel syllables, sometimes words or specifically digit-words or fused rhyming words. Also the age of the participants may be important. Furthermore, *advantage* and *preference* for one side or other are two easily confused concepts in the handedness literature, and account needs to be taken of this distinction regarding earedness as well. Towards the end of this article is a description of an empirical study I have conducted that adds to understanding of ear preference in telephone conversation.

The argument I want to deconstruct depends on the good evidence of a reduction in the REA when the participants are left-handed (Azanon-Gracia & Sebastian-Galles, 2005; Bryden, 1988a; Cowell & Hugdahl, 2000; Curry, 1967; Curry & Rutherford, 1967; Dawe & Corballis, 1986; Hiscock *et al*, 2000; Hugdahl & L Andersson, 1984; Jänke, 2002; Mondor, 1994; Satz *et al*, 1965; Satz *et al*, 1967; Wilson & Leigh, 1996; Zatorre, 1989; for a review see Bryden, 1988b). There is unequivocal (and direct - *e.g.,* with unilateral lesions or Wada amytal testing) work indicating left-handers do not as a group show the same degree of left-hemisphere specialisation for speech as right-handers do (Hardyck & Petrinovich, 1977). Consequently the reduction in the REA for left-handers has frequently been put down to this structural difference. In other words, it is said to be a consequence of greater hemispheric equipotentiality for left-handed subjects.

However, with time the popularity of this interpretation has been receding. It will surely strike the reader less in the hold of a neurological mindset that the structural interpretation of handedness interactions could be superfluous (Mondor, 1994). There are now some strong advocates of attentional as opposed to hard-wiring accounts (see Hiscock & Stewart, 1985; Hiscock *et al*, 2005; Voyer & Ingram, 2005). And a lateral attentional skew could cross modalities. Indeed a right-hander showing a REA could simply be exhibiting two different aspects of a consistent skew towards the right - regardless of how it is mediated, whether by attention or something else, perhaps even unconscious.

For a left-hander a REA would not be consistency of skew. But s/he would not necessarily show a diametric reversal - a left-ear advantage (LEA) of similar magnitude. For one thing left-handers form a minority living in a world designed for the majority - right-handers. For another it has long been known that self-described left-handers are often in fact strictly speaking mixed-handed - writing and throwing, say, with different hands. However in some studies (*e.g.,* Hugdahl & L Andersson, 1984; Hugdahl & Franzon, 1987; Jänke, 2002), left-handers *do* show a LEA for speech, and this poses considerable difficulty for a pure structural model. For left-handers as a group do remain left-hemisphere specialised for speech - just less so.

Some researchers (see Day and MacNeilage, 1996) now put greater emphasis on footedness rather than handedness as the primary asymmetry. However, since there is good evidence of a close lateral concordance of preferred foot and preferred hand, this may not affect the basic issue.

Warrington and Pratt (1981) investigated the effects of unilateral electro-convulsive therapy for depressed patients. This direct evidence gave them a different sort of opportunity to compare the structural model with consistency of skew as explanations of ear advantage for speech. They opted unequivocally against the structural model. Another type of direct evidence - sodium amytal (Wada) testing - is better known. But it could be argued that this evidence is not so good, since the participants are generally *neurological* patients, usually with epilepsy and whose condition is often of long standing, so that their hemispheric specialisation cannot be presumed to be typical. In any case some researchers deny that dichotic word testing is a valid predictor of amytal-assessed cerebral language dominance (Lee *et al*, 1994).

The relevance of telephone usage

Strong support for a telephone account of the dichotic speech REA was presented by Williams (1982). What I found (though only when the direction of attention was under looser experimental control) was a correlation ($r = 0.60$, $p < .05$) between a university student's individual REA and his ear preference for telephone usage (as ascertained by questionnaire). The significance level is low because there were only 16 subjects in each condition of the study, but Strauss and Goldsmith (1986) with 197 students found a similar positive association. They too determined ear preference by questionnaire.

My study could be said to be atypical in that some of the stimuli were sentences. This is more like the telephone situation than is a dichotic words task. The latter in turn is more akin to the telephone situation than is a dichotic consonant-vowels (CV) task. In this respect the digit-words and fused rhyming-words tasks look intermediate between ordinary words and CVs.

In proposing a telephone account it has never been my intention to deny any clinical utility for dichotic testing. That utility does not hang only on the hope of identifying the "language hemisphere" but also on the well-established "lesion effect" of impaired performance at the ear contralateral to hemispheric damage. Despite all the advances in neuro-imaging double simultaneous stimulation in any modality can reveal previously unnoticed impairments (especially unilateral neglects).

There are obvious objections to a simple consistent-skew model. For *non-verbal* stimuli (including music), *left* ear advantages have been found in right-handers, though LEAs are less substantial and robust as a body of evidence than REAs. Also with children too young to have used the telephone, reports of REA (and there have been many) require a different account. Even left-handed children appear to show a REA (Hugdahl & B Andersson, 1989).

Relating dichotic ear advantages to telephoning is part of an enduring tradition in laterality that sees consistency of sidedness as the more natural state. Researchers in this tradition tend to keep hemispheric specialisation on the back-burner and appraise (some subset of) the *behavioural* manifestations of sidedness for hand, foot, ear and eye. Starting with their belief that consistent-skew is typical and adaptive, they may describe its absence as "lateral confusion" and see that as a likely cause of pathologies (such as dyslexia). One reason for inconsistent-skew is left-handers shifting, under social pressure, to their "wrong" hand for writing (Searleman & Porac, 2001) and such shifts by themselves might be an origin of pathology.

Partly because much of this work has been with children, telephoning has not generally been the aural activity studied; instead, it has been such situations as listening at a closed door or a wall. With such Mounsey and Peterson (1944) found hand-ear lateral concordance in 65.4% (17 out of 26) of participants. Porac and Coren (1981) reviewed substantial published empirical work of their own on this question and also considered a *positive* association of ear skew with hand skew to be established (p. 63, p. 241). This was also the tenor of the work of Bakker (*e.g.*, 1970) and his co-workers. Both teams were taking eye and foot preference into account as well.

More recent studies with a similar thrust and also assigning earedness with situations other than telephoning include Mandal *et al* (1992) using five tests of ear preference, who also found a *right*-sided skew :- no fewer than 74% of a random sample were right-sided. Since about 90% of any random sample are right-handed, this amounts to evidence for hand-ear lateral concordance. Also Reiss and Reiss (1999) with *N* of 912 parents and their (young adult) children found non-right-earedness in just 37%. Dane and Gumustekin (2003) too found a positive association of ear laterality with handedness. They measured ear *advantage* not preference, with the Rinne tuning fork test (a part of standard audiometry).

A study of Noonan and Axelrod (1981), however, stands out for the thoroughness with which they investigated the lateral concordance of hand with ear (including in telephoning), and for being an investigation using experiments. They determined ear preference for listening to a suspended earphone, and a stopwatch on a table, as well as for using a telephone - which was symmetrically constructed and displayed. They point out that the standard design of corded fixed-line handset has the cord on the left, and modified their own telephone so that the cord was central. In other ways too they took special care to remove environmental lateral asymmetries, for example the entrance door to the laboratory cubicle was hinged at the top. They did indeed find that non-telephone ear preference was strongly influenced by seemingly minor environmental asymmetries. This may account for the failure of some published monaural ear differences to replicate (Williams, 1985). They found ear laterality for the suspended earphone and the stopwatch were *not* associated with telephone habits.

A substantial sample of 373 normal young adults participated in five experiments measuring earedness. Non-telephone earedness was concordant with handedness in 74% of right-handers and 65% of left-handers. It did not vary with putatively hemisphere-specific stimulus types (music and speech). Experiment II was the one that included investigation of telephone ear, with very interesting results. 74% of 53 left-handers used a left-ear/left-hand combination; 49% of 102 right-handers used a right-ear/right-hand combination. However this lack of concordance (or discordance) in the case of right-handers was wholly explicable when an additional controlled factor was taken into account :- the presence or absence of a writing table. Without the table present 62% of the right-handers and 88% of the left-handers used their preferred hand and ipsilateral ear. With the table present, only 35% of right-handers used that combination. The three-way interaction was easily significant statistically. No participant used a crossed ear-hand combination to answer the phone, though when actually asked to write, some participants did switch to a crossed ear-hand combination.

A puzzle

So there is a *prima facie* case for a role of telephone ear in explaining dichotic ear advantage. But now the work of Surwillo (1981) needs to be considered. For with a sample unselected for handedness (and therefore mainly right-handers) he reported that they tended to use their *left* ear on the telephone. He did assign handedness (though by self-classification, the inaccuracy of which will have added noise to the data). Hand-ear lateral concordance was only 41% (136 out of 333 participants). The sample was not young adults

as in Noonan and Axelrod (1981), Williams (1982) and Strauss and Goldsmith (1986) but an aggregation of secretaries and of people chosen randomly from the telephone directory.

Each participant was actually telephoned and asked what ear s/he was using *at that moment*, a good feature methodologically except that there is no indication in the report of how many people were approached but declined to cooperate. There was an additional question about habitual ear preference in telephoning. The explanation presented for the lack of concordance was that the right-handers were more likely to hold the receiver to the left ear to free the preferred hand for writing, dialling or smoking. One might expect on this hypothesis that heavy use of the phone would be associated with less hand-ear lateral concordance - but there was no sign of this.

When I did a related study myself (Williams, 1987b), the results were very different. Hand-ear lateral concordance was 73% (96 out of 132). The paid volunteer sample of young adults was unselected for handedness, which was determined at the end of ear advantage experiments by one or other of two standard British inventories. Response rate in this study was 100%. Ear preference in telephoning as in my 1982 report was assigned on the basis of additional questions added to handedness inventories. Funch *et al* (1996) similarly, found a positive correlation (though at 0.15 a weak one) between handedness and ear preference in telephoning of 1127 “portable or handheld phone users”. This study too used questionnaire methodology. The Funch work suggests a new type of data source that might help to resolve these issues - mobile (cell) phone users. Funch *et al*’s sample was similar to part of Surwillo’s :- a random one using telephone company documentation.

Seeman & Surwillo (1987) followed up Surwillo (1981) with a new kind of sample :- airline reservations agents. Again hand-ear lateral concordance was *below* chance at 44.4% (127 out of 286). The phone was a headset, so unlike the groups of Surwillo (1981), these participants had their hands free when on the phone. However they were wearing their headsets for eight hours a day - is it possible that over the course of a working day it was sometimes desirable, when there was a lot of noise in the environment or the line was bad, to hold the earpiece to the ear? Then it would still be better for the right hand to be free. It is reported that those listening with the left ear had more experience using the headsets (mean 8.6 years) than those listening with the right ear (mean 6.4 years).

In both of Surwillo’s studies there was even greater left-ear preference among left-handers than among right-handers. This does not fit his hypothesis about keeping the preferred hand free since that ought to make *left*-handers use their *right* ear for listening.

Another group of researchers have taken an interest in ear preference, mainly as a factor in the prediction of personality and sales performance of telesales staff, who also use headsets. Their data contradict Seeman and Surwillo (1987). They find preponderant *right* ear preference with the headset (Jackson, Furnham & Miller, 2001). Despite their primary focus not being to establish norms for ear preference, I can find no reason to implicate systematic error in their data. It was also found that headset ear was generally the same as the ear used to answer the telephone (Furnham, Richardson & Miller, 1997). Ear preference was

recorded objectively and without the participants being aware of it. The ratio of left-ear to right-ear preferrers was 75:101 with 27 participants using stereo (both-ear) headsets. Thus left-ear prevalence was 42.6%, far enough from 50% to explain a REA for speech. These workers do not believe that amount of telephoning affects ear preference (though within a heavy-user sample). Their research programme is ongoing (Jackson, 2005).

An empirical study

Do the discrepancies with the results of Surwillo arise from differences in methodology (over and above any transatlantic cultural differences)? In the hope of reconciling the evidence, I have been observing outdoor users of mobile phones (cell phones). This sample, like headset wearers, did not need to keep a hand free to write. There was no independent evidence as to handedness of the unobtrusively observed 500 mobile phone users.

179 (35.8%) left-ear users were counted. Obviously this is different from the data of Surwillo (1981) and Seeman and Surwillo (1987), from 50% and from the one-in-ten prevalence of left-handedness - statistical significance does not require demonstration.

Not uncommonly, when someone at a distance *appeared* to be using a mobile phone it was not possible to be sure. The count for one or other ear was incremented *only* if (i) a visual identification of a phone was made **or** (ii) the hand was to the ear, the putative mobile user was talking and there was nobody else around **or** (iii) the putative mobile user was observed for at least a quarter of a minute with the hand to one ear. Counting took place between December 2004 and May 2005 on a total of 134 separate days. Most observations were made in Colchester – in the streets or at the town's supermarkets - and central London; but 169 observations were made in other East Anglian (Cambridge, Southend, Chelmsford, Ipswich, Halstead and Letchworth) or West Country (Bath, Frome and Swindon) towns. Observations of people in cars (7) as well as observations from my own car (31) were included.

A few of the mobile phone users were observed at the University of Essex and six out of the 22 (27.3%, *cf.*, Williams, 1987b, above) were using the left ear - that is, these young adults showed a rather greater deviation from 50% than the complete sample. The mobile users in London were counted on a single visit when 30 left-ear users out of 71 (= 42.3 %, a *smaller* deviation from 50% than for the complete sample) were noted. It could well be that walking amidst the stimulus overload of a city centre creates an added incentive to keep the preferred hand free. Crossing the hand to hold the phone at the contralateral ear was observed just twice.

Since completing this study I have discovered a similar one by Sanchez *et al*. (undated) who so far as I know have published it only on the Internet. Out of 432 people they observed using a mobile phone, 172 (39.8%) used the left ear. Plainly, this figure is far closer to mine than to Surwillo's. It is worth noting that in both this study and mine the unobtrusiveness of the observing means demand characteristics were excluded.

Sanchez *et al* were interested in reconciling conflicting reports of an association between mobile phone use and various medical disorders, the most serious being brain tumours. There were six observers, which has advantages, though agreeing criteria of the kind I have listed above will have been important to the accuracy of the results. They observed only six people crossing the hand to hold the phone to the contralateral ear.

Age and ear advantages

So even in random samples a right ear preference in telephoning remains the possible direction. But the disparate nature of Surwillo's findings may hinge as well on the age of samples. Young adult students may be atypical in their telephone-ear habits. Their lives are less regimented, and in the 1980s as now many of them would not have had their own fixed-line phone during term-time. Many of them may simply not yet have come round to keeping their preferred hand free to write or dial or smoke when on the phone, whether fixed-line or mobile. Therefore they are mainly right-eared for telephoning. Putting this together with the fact that they have made up the samples for very many of the dichotic REA experiments, a non-structural explanation of REAs is compelling.

Data of Meyers *et al* (2002) lend strong support to this idea. On a single-pair dichotic words test, dividing 336 normal volunteers into age groups, 83 of them aged 40-59 years showed as a group a *left* ear advantage. Though not tested for significance, the table of means and standard deviations shows the difference to be no smaller than the REAs at other ages.

With 62 volunteers older still the right side went back to being the better one, but those participants included the very oldest group (70-79 years) who were markedly different from all others - with poorer total performance and greater variability. With participants old enough to have suffered age-related hearing loss, these three findings of Meyers *et al* have received substantial confirmation. First, numerous studies have confirmed that the dichotic listening performance of the really old is worse (Borod & Goodglass, 1980; Carter & Wilson, 2001; Clark & Knowles, 1973; Hatta *et al*, 1984; Inglis *et al*, 1968; Inglis & Tansey, 1967; Martini *et al*, 1988; Richardson *et al*, 1994; Roup *et al*, 2006; Schonfield *et al*, 1972). This makes valid comparison of the magnitude of their ear advantages with those of people at other ages far from straightforward (Chapman & Chapman, 1988). Second, Davis & Friedrich (1982) confirm the greater variability of the old as do Richardson *et al* (1994) for old *men* specifically. Third, that old people show a REA (and that it is due to deterioration of performance on the left ear) is a frequent finding (Borod & Goodglass, 1980; Carter & Wilson, 2001; Clark & Knowles, 1973; Johnson *et al*, 1983; Nebes *et al*, 1983; Panek & Rush, 1981; Roup *et al*, 2006). For this though there are contrary reports :- Alden *et al* (1997) and Martini *et al* (1988). Hugdahl *et al* (2001) is also contrary but the "old" group was only 50-70 years.

In the present context it is the Meyers *et al* finding that the middle-aged are atypically left-skewed that is more interesting. If true it would mean that the age curve of ear advantage is non-monotonic and simple correlations of age with ear will be misleading - the analyses should be testing for a quadratic trend.

Comparable studies offer little support for *this* finding, but there are always major differences weakening the comparability. Data of Richardson *et al* (1994) with a very similar task and 275 volunteers had only one-fifth of the sample older than 40 years. They found REA in all age groups and an interaction with sex. Older women showed a smaller REA, older men a larger one. The same Sex x Age interaction was found by Cowell and Hugdahl (2000) with an *N* of 57. These statements are not based upon inferential testing. Gootjes *et al* (2004) with an *N* of 56 compared younger and older adults on a dichotic digits task, and found identification errors increased with age more on the *left* ear. Though in most studies performance is measured in terms of stimulus identification it is also possible to measure stimulus localisation (left or right) and there have been suggestions (Gootjes *et al*, 2004; Hiscock *et al*, 2005) that this is dissociated from identification. Hugdahl *et al* (2001) with *N* of 240 on dichotic CVs tasks (the study was a statistical aggregation of data collected by different researchers and in different laboratories) found left-ear advantages only in conditions where attention was forced to the left. But the REAs in free-recall and forced-right conditions will have been exaggerated by requiring all participants to be right-handed. In a German sample with *N* of 912 Reiss and Reiss (1999) found no real difference between parents and their children (who were young adults) in the prevalence of non-right-eared *preference* - but they were asking only about non-telephone activities, which Noonan and Axelrod (1981) found to be uncorrelated with telephoning in terms of laterality.

To repeat, it is likely that the closer the sentences we use in everyday speech, including on the telephone, to the experimental task stimulus, the more relevant the one is as an explanation of the other. As the stimulus becomes unrelated words, then single-pairs of words, then digit-words or fused rhyming words, then CVs, so the psychological distance from telephoning becomes greater, the ecological validity lessens and the less potent telephoning is as an explanatory variable. Epistemologically, mind and brain are two; nonetheless metaphysically (for monists), they are one. There is going to be some neurological counterpart of the observed behaviours, but in experiments with neurologically intact participants *its nature is not addressed*.

REFERENCES

Alden J D, Harrison D W, Snyder K A & Everhart D E (1997). Age differences in attention to left and right hemispace using a dichotic listening paradigm. *Neuropsychiatry, Neuropsychology & Behavioral Neurology* **10**(4), 239-242.

Azanon-Gracia E & Sebastian-Galles N (2005). Dichotic listening test in Spanish: Pairs of disyllabic words. *Revista de Neurologia* **41**(11), 657-663.

Bakker D J (1970). Ear-asymmetry with monaural stimulation: Relations to lateral dominance and lateral awareness. *Neuropsychologia* **8,** 103-118.

Borod J C & Goodglass H (1980). Lateralization of linguistic and melodic processing with age. *Neuropsychologia* **18**(1), 79-83.

Bryden M P (1988a). Correlates of the dichotic right-ear effect. *Cortex* **24,** 313-319.

Bryden M P (1988b). An overview of the dichotic listening procedure and its relation to cerebral organization. In K Hugdahl (Ed) *Handbook of Dichotic Listening: Theory, Methods and Research (*pp. 1-43). John Wiley.

Carter A S & Wilson R H (2001). Lexical effects on dichotic word recognition in young and elderly listeners. *Journal of the American Academy of Audiology* **12**(2), 86-100.

Chapman L J & Chapman J P (1988). Artifactual and genuine relationships of lateral difference scores to overall accuracy in studies of laterality. *Psychological Bulletin* **104(**1), 127-136.

Clark L E & Knowles J B (1973). Age differences in dichotic listening performance. *Journal of Gerontology* **28**(2), 173-178.

Cowell P & Hugdahl K (2000). Individual differences in neurobehavioral measures of laterality and interhemispheric function as measured by dichotic listening. *Developmental Neuropsychology* **18**(1), 95-112.

Curry F K W (1967). A comparison of left-handed and right-handed subjects on verbal and non-verbal dichotic listening tasks. *Cortex* **3,** 343-352.

Curry F K W & Rutherford D R (1967). Recognition and recall of dichotically presented verbal stimuli by right- and left-handed persons. *Neuropsychologia* **5,** 119-126.

Dane S & Gumustekin K (2003). Sex and handedness differences in hearing durations of the right and left ears in healthy young adults. *International Journal of Neuroscience* **113,** 411-416.

Davis D D & Friedrich D D (1982). Memory performance of young, middle, and old adults. *International Journal of Aging and Human Development* **16**(4), 311-324.

Dawe S & Corballis M C (1986). The influence of gender, handedness and head-turn on auditory asymmetries. *Neuropsychologia* **24,** 857-862.

Day L B & MacNeilage P F (1996). Postural asymmetries and language lateralization in humans *(Homo sapiens). Journal of Comparative Psychology* **110**(1), 88-96.

Di Stefano M, Marano E & Viti M (2004). Stimulus-dominance effects and lateral asymmetries for language in normal subjects and in patients with a single functional hemisphere. *Brain & Cognition* **56,** 55-62.

Funch D P, Rothman K J, Loughlin J E & Dreyer N A (1996). Utility of telephone company records for epidemiologic studies of cellular telephones. *Epidemiology* **7**(3), 299-302.

Furnham A, Richardson S & Miller T (1997). Ear dominance and telephone sales. *Perceptual and Motor Skills* **85,** 541-547.

Gootjes L, van Strien J W & Bouma A (2004). Age effects in identifying and localising dichotic stimuli: A corpus callosum deficit? *Journal of Clinical and Experimental Neuropsychology* **26**(6), 826-837.

Hardyck C & Petrinovich L F (1977). Left-handedness. *Psychological Bulletin* **84,** 385-404.

Hatta T, Yamamoto M & Mito H (1984). Functional hemisphere differences in auditory and tactile recognition in aged people. [Japanese]. *Japanese Journal of Psychology* **54**(6), 358-363.

Hiscock M, Cole L C, Benthall J, Carlson V L & Ricketts J M (2000). Towards solving the inferential problem in laterality research: Effects of increased reliability on the validity of the dichotic-listening right ear advantage. *Journal of the International Neuropsychological Society* **6,** 539-547.

Hiscock M, Inch R & Ewing C T (2005). Constant and variable aspects of the dichotic listening right-ear advantage: A comparison of standard and signal detection tasks. *Laterality* **10**(6), 517-534.

Hiscock M & Stewart C (1984). The effect of asymmetrically focused attention upon subsequent ear differences in dichotic-listening. *Neuropsychologia* **21**(1), 337-351.

Hugdahl K & Andersson B (1989). Dichotic listening in 126 left-handed schoolchildren - ear advantages, familial sinistrality and sex differences. *Neuropsychologia* **27**(7), 999-1006.

Hugdahl K & Andersson L (1984). A dichotic listening study of differences in cerebral organization in dextral and sinistral subjects. *Cortex* **20,** 135-141.

Hugdahl K, Carlsson G & Eichele T (2001). Age effects in dichotic listening to consonant-vowel syllables: Interactions with attention. *Developmental Neuropsychology* **20**(1), 445-457.

Hugdahl K & Franzon M (1987). Dichotic listening performance to CVs between versus within groups. *Scandinavian Journal of Psychology* **28**(1), 26-34.

Inglis J, Ankua M N & Sykes D H (1968). Age-related differences in learning and short-term memory from childhood to the senium. *Human Development* **11**(1), 42-52.

Inglis J & Tansey C L (1967). Age differences and scoring differences in dichotic listening performance. *Journal of Psychology: Interdisciplinary and Applied* **66**(2), 325-332.

Jackson C J (2005). How preferred ear for listening moderates emotional cognitions in the prediction of personality. *Laterality* **10,** 305-320.

Jackson C J, Furnham A & Miller T (2001). Moderating effect of ear preference on personality in the prediction of sales performance. *Laterality* **6,** 133-140.

Jänke L (2002). Does "callosal relay" explain ear advantage in dichotic monitoring? *Laterality* **7**(4), 309-320.

Johnson R C, Green P, Ahern F M & Cole R E (1983). Cognitive correlates of hemispheric performance on dichotic tasks. *International Journal of Aging and Human Development* **18**(3), 186-195.

Kimura D (1961). Cerebral dominance and the perception of verbal stimuli. *Can. J. Psychol.* **15**, 166-171.

Kinsbourne M (1975). The mechanism of hemispheric control of the lateral gradient of attention. In P M A Rabbit & S Dornic (Eds) *Attention and Performance* **V (**pp 81-97). Academic Press.

Lee G P, Loring D W, Newell J R & Meador K J (1994). Is dichotic word listening a valid predictor of cerebral language dominance? *The Clinical Neuropsychologist* **8**(4), 429-438.

Mandal M K, Pandey G, Singh S K & Asthana H S (1992). Degree of asymmetry in lateral preferences: Eye, foot, ear. *Journal of Psychology* **126,** 155-162.

Martini A, Bovo R, Agnoletto M, da Col M, Drusian A, Liddeo M & Morra B (1988). Dichotic performance in elderly Italians with Italian stop consonant-vowel stimuli. *Audiology* **27**(1), 1-7.

Meyers J E, Roberts R J, Bayless J D, Volkert K & Evitts P E (2002). Dichotic listening: Expanded norms and clinical application. *Archives of Clinical Neuropsychology* **17**, 79-90.

Mondor T A (1994). Interaction between handedness and the attentional bias during tests of dichotic listening performance. *Journal of Clinical and Experimental Neuropsychology* **16,** 377-385.

Mounsey C & Peterson G E (1944). The relationship of ear preference to other laterality characteristics. *Journal of Speech Disorders* **9**, 121-123.

Nebes R D, Madden D J & Berg W D (1983). The effect of age on hemispheric asymmetry in visual and auditory identification. *Experimental Aging Research* **9**(2), 87-91.

Noonan M & Axelrod S (1981). Earedness (ear choice in monaural tasks): Its measurement and relation to other lateral preferences. *Journal of Auditory Research* **21,** 263-277.

Panek P E & Rush M C (1981). Simultaneous examination of age related differences in the ability to maintain and reorient auditory selective attention. *Experimental Aging Research* **7**(4), 405-416.

Porac C & Coren S (1981). *Lateral preferences in human behavior.* Springer.

Reiss M & Reiss G (1999). Earedness and handedness: Distribution in a German sample with some family data. *Cortex* **35**, 403-412.

Richardson E D, Springer J A, Varney N R & Struchen M A (1994). Dichotic listening in the clinic: New neuropsychological applications. *The Clinical Neuropsychologist* **8**(4), 416-428.

Roup C M, Wiley T L & Wilson R H (2006). Dichotic word recognition in young and older adults. *Journal of the American Academy of Audiology* **17**(4), 230-240.

Sanchez L, Ben-Tovim D, Dougherty M, Dunk P, Hodgman A, James S, Malone T & Smith A (n.d.). Ear preference and mobile phone use. *Internet publication from the School of Medicine, Flinders University, South Australia.*

Satz P, Achenbach K & Fennell E (1967). Correlations between assessed manual laterality and predicted speech laterality in a normal population. *Neuropsychologia* **5,** 295-310.

Satz P, Achenbach K, Pattishall E & Fennell E (1965). Order of report, ear asymmetry and handedness in dichotic listening. *Cortex* **1**, 377-396.

Schonfield D, Trueman V & Kline D (1972). Recognition tests of dichotic listening and the age variable. *Journal of Gerontology* **27**(4), 487-493.

Searleman A & Porac C (2001). Lateral preference patterns as possible correlates of successfully switched left hand writing: Data and a theory. *Laterality* **6**, 303-314.

Seeman J & Surwillo W W (1987). Ear preference in telephone listening. *Perceptual & Motor Skills* **65,** 803-809.

Strauss E & Goldsmith S (1986). Hand, foot, eye and ear preferences and performance on a dichotic-listening test. *Cortex* **22,** 475-482.

Surwillo W W (1981). Ear asymmetry in telephone-listening behavior. *Cortex* **17,** 625-632.

Voyer D & Ingram J (2005). Attention, reliability, and validity of perceptual asymmetries in the fused dichotic words test. *Laterality* **10**(6), 545-561.

Warrington E K & Pratt R T (1981). The significance of laterality effects. *Journal of Neurology Neurosurgery and Psychiatry* **44,** 193-196.

Williams S M (1982). Dichotic lateral asymmetry: The effects of grammatical structure and telephone usage. *Neuropsychologia* **20,** 457-464.

Williams S M (1985). Memory for unilateral speech. *Psychology* **22**, 47-70.

Williams S M (1987a). Over-creative neurologizing: the case of "functional decussation". *Social and Behavioral Sciences Documents* **17**, 43-44. MS #2819.

Williams S M (1987b). Handedness and preferred ear for telephoning. *Psychology* **24,** 62-65.

Wilson R H & Leigh E D (1996). Identification performance by right- and left-handed listeners on dichotic CV materials. *Journal of the American Academy of Audiology* **7,** 1-6.

Zatorre R (1989). Perceptual asymmetry on the dichotic fused words test and cerebral speech lateralization determined by the carotid amytal test. *Neuropsychologia* **27,** 1207-1219.