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University of Pretoria
Faculty of Humanities
Department of Speech-Language Pathology and Audiology

The Effect of Self-Reported Handedness on Auditory Binaural Integration and Separation

In fulfilment of the requirements for the degree BA Audiology in the Department of Speech-Language Pathology and Audiology, Faculty of Humanities, University of Pretoria.

Authors	**Student number**
Angelina da Silva	u22511980
Emma de Lange	u22495658
Cheryl Jones	u21480232
Tyler Marais	u21474983

Supervisor/s:
Prof L Pottas
Prof T le Roux

UNIVERSITY OF PRETORIA
FACULTY OF HUMANITIES
DEPARTMENT OF SPEECH-LANGUAGE PATHOLOGY AND AUDIOLOGY

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Full name: Angelina da Silva, Emma de Lange, Cheryl Jones, Tyler Marais
Student Number: U22511980, U22495658, U21480232, U21474983
Degree/Qualification: BA Audiology (KMP 481)

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

ADD – Attention Deficit Disorder

ADHD – Attention Deficit-Hyperactivity Disorder

APD – Auditory Processing Disorder

ART – Acoustic Reflex Threshold

CAPD – Central Auditory Processing Disorder

DDT – Dichotic Digits Test

dB HL – Decibels Hearing Level

LEA – Left Ear Advantage

LI – Laterality Index

PTA – Pure Tone Average

REA – Right Ear Advantage

SD – Standard Deviation

ABSTRACT

This study examined the influence of self-reported handedness on auditory binaural integration and separation performance using the Dichotic Digits Test (DDT) in normal-hearing young adults. Dichotic listening tasks provide insight into hemispheric lateralization and auditory processing, yet the specific contribution of handedness to auditory laterality remains unclear. A quantitative, cross-sectional comparative design was employed, including twenty-eight participants aged 19-24 years (16 right-handed, 12 left-handed). Although the sample size was modest, determined by feasibility constraints rather than power sufficiency, the results provide preliminary evidence that handedness modulates auditory performance. Participants completed the DDT under three conditions: binaural integration, directed attention separation, and undirected attention separation. Laterality indices were calculated, and t-tests compared ear advantage within and between groups. No significant ear advantage was observed within groups ($p > 0.05$); however, between-group analyses revealed significant effects, with right-handed participants demonstrating a right-ear advantage during undirected attention ($p = 0.02$) and integration ($p = 0.005$), while left-handed participants showed a left-ear advantage during integration ($p = 0.04$). These findings suggest that handedness influences auditory lateralization, particularly under higher cognitive or attentional demand. Findings may inform the clinical interpretation of dichotic listening assessments, highlighting the importance of considering handedness in evaluating auditory processing and hemispheric asymmetry.

1. INTRODUCTION

Dichotic listening refers to the brain's ability to simultaneously process different auditory stimuli presented to each ear, resulting in a unified perception of sound (Tawfik & Shafik, 2022). This process is essential for speech comprehension in noisy environments, sound localization, and overall auditory perception. Two primary processes that contribute to dichotic listening include binaural integration and binaural separation. Binaural integration refers to the ability to process and synthesize auditory information presented simultaneously to both ears (Reynard et al., 2023). In contrast, binaural separation involves the ability to selectively attend to auditory input from one ear while suppressing or disregarding competing input presented to the other (Reynard et al., 2023). The Dichotic Digits Test (DDT) is used to evaluate these two primary processes by simultaneously presenting different digits to each ear, requiring the listener to attend to and repeat what they hear (Moncrieff, 2002).

Hugdahl et al. (2010) highlighted the importance of the dichotic listening paradigm as a tool for evaluating hemispheric laterality regarding language dominance, particularly through the Right Ear Advantage (REA). According to Kimura (1961), auditory information is transmitted more efficiently via contralateral pathways, with stronger projections from each ear to the opposite hemisphere. This explains the REA, as right ear input reaches the typically left-lateralized language hemisphere more directly, while a Left Ear Advantage (LEA) may occur in individuals with right-hemispheric language dominance. As a result, individuals showing typical left-hemispheric language dominance may perform better on dichotic listening tasks when stimuli are presented to the right ear (Kimura, 1961). Kimura's structural model emphasises the dominance of contralateral over ipsilateral projections and forms part of the theoretical basis for using dichotic listening tests, such as the DDT, to identify the language-dominant hemisphere. Therefore, the DDT is valuable in research and in evaluating auditory processing abilities and hemispheric dominance in individuals (Richard, 2013). However, because hemispheric dominance is not uniform across all individuals, other factors such as handedness may also influence ear advantage patterns observed in dichotic listening tasks, warranting further consideration.

While research has explored the influence of hemispheric dominance on dichotic listening tasks, the role of handedness in these auditory processing tasks has not been conclusively established. Moncrieff (2006) identified four hemispheric dominant response patterns in DDT, with varying degrees of interaural differences. The first pattern reflects generally strong performance in both ears, with a slight weakness in the opposing ear to the language-dominant hemisphere. The second pattern shows poor performance in both ears with only a slight interaural difference, often linked to brain lesions, language or memory difficulties, attention deficits, or fatigue. The third pattern is marked by a large interaural difference, with strong performance from the ear contralateral to the language-dominant hemisphere and weaker performance from the other ear. The fourth pattern combines poor performance in both ears with a large interaural difference, suggesting the influence of multiple underlying factors. Handedness has been proposed as a potential factor influencing these patterns, particularly in individuals with atypical hemispheric dominance (Fallow and Voyer, 2013). Although hemispheric dominance is frequently examined in relation to dichotic listening, limited studies have addressed how individual differences in handedness specifically may influence binaural integration and separation performance (Fallow and Voyer, 2013).

Handedness, defined as the inclination to use one hand over the other, impacts several cognitive functions, including auditory processing. An exception to this inclination includes ambidextrousness (doing equally well with both hands) and mixed-handedness (using various hands for different tasks). The majority of the Western population (85%-90%) is predominantly right-handed (MedlinePlus, 2022); however, the strength of handedness, not only direction, has been linked to differences in time perception and auditory processing. Fallow and Voyer (2013) discovered that individuals with stronger hand dominance may have less efficient interhemispheric communication, potentially affecting tasks that require integration of information from both ears, such as binaural auditory processing.

Ear preference in auditory tasks may also be influenced by handedness. Seidman et al. (2013) found that left-handed individuals also tend to use their left ear for phone conversations, while right-handed individuals prefer their right ear. This behavioural tendency may reflect a relationship between hand preference and auditory lateralization, but it should not be interpreted as direct evidence of hemispheric dominance (Seidman et al., 2013). Furthermore, Broca's rule states that most individuals have left-hemisphere linguistic dominance, where certain left-handed individuals may have right-hemisphere dominance (Knecht et al., 2000). This difference can affect binaural integration and separation; atypical hemispheric dominance may implicate the degree and manner in which auditory information from each ear is processed and interpreted during dichotic listening tasks (Moncrieff, 2006).

Directed attention (the ability to focus on auditory stimuli from one ear) may be affected by handedness during auditory processing. Foundas et al. (2006) reported that right-handed individuals showed greater performance shifts on DDT when attention was directed to the left ear, whereas left-handed individuals exhibited greater performance shifts when attending to the right ear. These findings are relevant because directed auditory attention is critical in everyday listening situations, such as following a conversation in a noisy classroom, understanding instructions in multi-speaker environments, or localizing sounds in daily life. The influence of handedness on performance shifts suggests that ear preference and attentional control can vary across individuals, affecting how efficiently they process competing auditory information in real-world listening.

Dichotic listening and handedness highlight the complexity of neural organization and its influence on human behaviour. Evidence suggests that handedness can affect dichotic listening performance, particularly concerning binaural integration, separation, and directed auditory attention (Foundas et al., 2006). However, limited empirical evidence exists regarding the extent to which handedness modulates these auditory processing mechanisms, and how these effects manifest across different listening contexts. Further research is needed to clarify the magnitude and functional significance of handedness-related differences in dichotic listening, which may have implications for understanding variability in real-world auditory processing.

This study aimed to investigate whether handedness influenced performance in binaural integration and binaural separation tasks using the DDT. The findings will enhance understanding of the role of individual neurocognitive profiles in auditory processing and inform research on hemispheric lateralization and auditory attention.

2. METHODOLOGY

2.1 Research aim

This study aimed to determine the effect of self-reported handedness by comparing binaural integration and separation performance between left-handed and right-handed normal-hearing young adults using a dichotic paradigm.

2.2 Research design

This study adopted a quantitative, cross-sectional, comparative design to investigate the effect of reported handedness on auditory binaural integration and separation. A quantitative approach was employed to enable the collection and statistical analysis of numerical data, facilitating the description of characteristics and examination of potential associations within the sample (Manchaiah et al., 2020). As the study aimed to evaluate and compare auditory performance between left-handed and right-handed participants at a single point in time, a cross-sectional design was appropriate (Wang & Cheng, 2020). Furthermore, the comparative design supported the identification of similarities and differences between the two groups (Iranifard & Latifnejad Roudsari, 2022).

2.3 Participants

Participants were recruited using convenience, purposive, and snowball sampling, based on availability and specific inclusion criteria (Brink, 2004). Furthermore, snowball sampling was utilised to improve access to left-handed participants, who are a minority group (~10% of the population). Initial recruitment included friends and family of the researchers, with additional participants obtained through referrals to achieve the required sample size (Manchaiah et al., 2020). Participants underwent selection procedures before data collection.

A priori power analysis using G*Power for an independent-samples t-test with an expected large effect size ($d = 0.80$), an alpha level of 0.05, and desired power of 0.80 indicated that a minimum of 21 participants per handedness group was required. Due to data collection constraints, the final sample comprised 12 left-handed and 15 right-handed participants. Accordingly, the results should be interpreted with consideration of the reduced sample size and its potential impact on statistical power and generalisability.

Inclusion Criteria

Eligible participants were between 18 and 26 years old, an age range selected to minimize potential confounding effects of age-related cognitive decline, particularly in temporal processing and listening effort (Health, 2023; Bao et al., 2020; Stroud et al., 2015). A handedness score was determined using a self-report questionnaire and the *Edinburgh Handedness Inventory - Short Form* (Veale, 2014), with only individuals consistently identifying as left- or right-handed included.

Participants were required to have normal hearing thresholds of ≤15 dB HL bilaterally at 125–8000 Hz (Swanepoel & Laurent, 2025). Normal peripheral hearing is necessary for performing well on the central auditory test because peripheral hearing loss compromises the assessment's reliability (Ahn et al., 2020). Additionally, hearing sensitivity is affected by middle ear pathologies, as well as central auditory processing abilities (Swanepoel & Laurent, 2025). To obtain accurate and reliable results, participants were required to have normal middle ear functionality (Type A tympanograms in both ears). Furthermore, acoustic reflexes had to be present and within normative limits (70-100dB suprathreshold) at 1000Hz bilaterally to determine the integrity of the auditory nerve pathway (British Society of Audiology, 2024).

Exclusion Criteria

Participants were excluded if they reported ambidexterity or mixed-handedness, as the study specifically focused on left- and right-handed individuals. Those with a history of auditory cortex lesions were excluded, given the associated poor performance on dichotic listening tasks (Musiek & Chermak, 2013). To minimize the influence of undiagnosed auditory processing disorders, only participants who successfully passed the initial Dichotic Digits Integration Test were included, as this test is highly sensitive to detecting auditory processing difficulties (Musiek & Chermak, 2013). In addition, individuals with documented language or learning delays, as well as those with diagnosed academic or learning disabilities, were excluded due to the potential impact of these conditions on auditory integration and separation performance (Musiek & Chermak, 2015). Participants with a diagnosis of attention deficit disorder (ADD) or attention deficit hyperactivity disorder (ADHD), and/or those currently taking medication for ADHD, were also excluded, as previous research has demonstrated significantly poorer Dichotic Digits Test performance in these populations (Dige et al., 2010).

2.4 Equipment and Materials

Participant selection and data collection materials utilized in this study are outlined in Table 1 below:

Table 1. Equipment and materials used for participant selection and data collection

Equipment and materials for participant selection	
Equipment or Materials	**Description**
Demographic questionnaire	The demographic questionnaire (Appendix A) was used to assess participants' self-reported hand preference and identify any contraindications to the inclusion criteria, such as concentration-enhancing medications, the presence of ADHD and/or diagnosed academic delays that would exclude them from the study.
Welch Allyn Pocketscope ™ with reusable specula	Designed for visual inspection of the tympanic membrane and external ear canal.
GSI Tympstar - Comprehensive Middle Ear Tympanometry	Performing diagnostic tympanometry and acoustic reflex testing, the device evaluates middle ear function and the integrity of the auditory nerve pathway.
GSI 61 - Two Channel Clinical Audiometer	By obtaining air conduction pure tone thresholds at 125Hz, 250Hz, 500Hz, 1000Hz, 2000Hz, 4000Hz, and 8000Hz, it was used to determine participants' hearing sensitivity to ensure normal peripheral hearing.
Dichotic Digits Test (Musiek et al., 1991)	The Dichotic Digits Test (DDT) is an auditory evaluation tool designed to measure binaural integration abilities, which involve processing and combining sounds presented to both ears simultaneously (Musiek et al., 1991). This test is particularly useful in identifying central auditory system lesions, including those in the brainstem and cortex (Musiek et al., 1991). It serves as a valuable screening method for detecting central auditory processing disorders (CAPD). Individuals over 12 years should obtain a score of 90% in both the left and right ears for the DDT (Musiek, 2019).
Equipment and materials for data collection	
Equipment or Material	**Description**
GSI 61 - Two Channel Clinical Audiometer	The Dichotic Digits Test stimuli (DDT) was presented through the GSI 61 - Two Channel Clinical Audiometer to the participants in the soundproof booth. Ear specific information was obtained and recorded on a recording sheet (Appendix B).
Dichotic Digits Test (Musiek et al., 1991)	This test was utilised to assess binaural integration and separation, along with directed auditory attention.

2.5 Participant Selection Procedures

Participants first received an informational letter outlining the purpose and procedures of the study (Appendix C). After receipt, an electronic demographic questionnaire was completed (Google Form) (Appendix A), which included questions regarding self-reported hand preference and eligibility criteria as well as a printed informed consent slip (Appendix D). Audiological screening was performed by means of otoscopy, acoustic immittance measurements, and pure tone audiometry to ensure normal auditory function. Visual otoscopic examination of the tympanic membrane and external ear canal was conducted using a Welch Allyn Pocketscope™with reusable specula. Diagnostic tympanometry, and acoustic reflex testing using a GSI TympStar to assess middle ear function and auditory nerve pathway integrity. Air conduction pure-tone thresholds were measured using a GSI 61 Two-Channel Clinical Audiometer at 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz.

2.6 Data Collection Procedures

Eligible participants completed the Dichotic Digits Test (DDT) (Musiek et al., 1991) using a GSI 61 Two-Channel Clinical Audiometer in three conditions:

1. *Screening for auditory processing disorders:* Participants listened to 20 numerical stimulus presentations (80 digits total; 40 per ear) presented simultaneously via headphones and repeated all digits heard. Stimuli were presented at 55 dB SL above the participant's pure-tone average (PTA) (Musiek, 1983). The first five presentations served as practice, followed by 20 scored presentations. Each ear was scored separately (out of 40), and participants achieving <90% (<36/40) in either ear were excluded (Moncrieff & Musiek, 2002). Right-ear advantage was evaluated due to typical left-hemisphere dominance in speech processing (Hugdahl, 2003).
2. *Binaural separation with directed attention:* The 20 numerical stimuli were presented again. Participants were instructed to repeat only the digits heard in a specified ear for the first ten stimuli, then the other ear for the next ten. Correct repetitions were recorded as scores out of ten for each ear.
3. *Binaural separation with undirected attention:* Participants listened to four-digit stimuli presented simultaneously and were instructed to repeat ear-specific digits without prior knowledge of which ear to attend to. This procedure was

repeated 20 times, using one of three pre-randomized lists for ear selection. To minimize order effects, the three lists were rotated across participants so that each list consisted of a different presentation order, ensuring balanced exposure to right- and left-ear targets. Correctly repeated digits were recorded as separate scores out of ten for each ear.

All testing was conducted in a controlled environment and was non-invasive, ensuring participant comfort and safety. Each participant's session lasted approximately 30 minutes, including consent, audiologic screening, and all DDT procedures.

2.7 Data Analysis

Descriptive statistics were employed to systematically summarize and organize the collected data, using methods that describe the essential features of the dataset and provide insights into patterns and trends (Field, 2023). All test results were recorded in and analysed using Microsoft Excel 2024. Key metrics such as minimum and maximum scores, mean scores, and standard deviations were calculated to understand the distribution of the data. Visualizations such as histograms, bar charts, and scatter plots were used to further illustrate how the data was distributed and whether there were visible differences between groups (Spriestersbach et al., 2009). Given these descriptive statistics, it was determined that the best way to represent the results was by calculating a Laterality Index (LI) for each participant as it quantifies ear advantage and allows for universal interpretation and analysis of data (Hugdahl et al., 2010). This index was computed as:

$$LI = \frac{R_{Ear\ Score} - L_{Ear\ Score}}{R_{Ear\ Score} + L_{Ear\ Score}} X100$$

This formula resulted in a positive value when an individual had a right-ear advantage, a negative value when there was a left-ear advantage, and a value of zero when no ear advantage was observed (Hugdahl et al., 2010). The purpose of calculating LI was to obtain a continuous measure that could be used in inferential statistical tests, rather than relying only on frequency counts. This supported the application of inferential statistics from descriptive analysis, giving conclusions more weight.

To formally test whether the mean LI differed significantly from zero (indicating no ear advantage), a one-sample t-test was used for each group and condition. The t-distribution used in t-tests is a probability distribution that accounts for variability in small samples, making it appropriate when the population standard deviation is unknown and the sample size is limited (Serdar, 2021). It allows for the comparison of the observed mean to a hypothesized mean (in this case, 0) while considering sample variability. Although the assumption of normality was not formally tested, visual inspection of the data distributions suggested no substantial deviations from normality.

The null hypothesis for each test was:

$H0: \mu LI = 0$ (no ear advantage)

Versus the alternative hypothesis:

$H1: \mu LI \neq 0$ (significant left or right ear advantage)

This was a two-tailed t-test, which means both possible directions of difference were measured (right-ear advantage or left-ear advantage).

It was suspected that group differences might still exist, therefore, independent-samples (two-sample) t-tests were conducted to compare right- and left-handed participants' scores directly. A one-tailed test was selected as the research hypothesis specified a directional expectation, that right-handed participants would demonstrate higher right-ear scores (positive LI) than left-handed participants. Using a one-tailed test is appropriate when the hypothesis predicts the direction of the effect, as it increases statistical power by concentrating the critical region in one tail of the distribution (Liang et al., 2025). Statistical significance was set at $p < 0.05$ (Spriestersbach et al., 2009).

2.8 Ethical Considerations

Prior to data collection, ethical clearance was obtained from the Research and Ethics Committee of the Department of Speech-Language Pathology and Audiology at the University of Pretoria (Appendix E). In line with established ethical principles for research involving human participants (Leedy & Ormrod, 2015; Mantzorou et al., 2023), the study ensured protection from harm, voluntary and informed participation, and confidentiality. All participants were treated with respect and provided with clear information regarding the study's purpose, procedures, voluntary nature, right to withdraw without consequence, and data confidentiality. Written informed consent was obtained from each participant prior to data collection (Appendix D). Only non-invasive procedures were conducted, and participants who did not pass the initial hearing screening or any other test were referred for further diagnostic hearing evaluation via a referral form to ensure appropriate follow-up care (Appendix E). Confidentiality was safeguarded by securing all personal data and research records within the Department for a minimum of 15 years, with participants' identities and responses remaining undisclosed in the research report. To further ensure validity and reliability, standardized procedures, instructions, and scoring methods were consistently applied across participants, and assessments were conducted in a controlled environment to minimize researcher bias.

3. RESULTS

The demographic distribution of the sample population for each group is illustrated in Table 2:

Table 2. Description of sample population for each group

	Age (years)				Handedness score				
Handedness	Mean	(SD)	Min	Max	Mean	(SD)	Min	Max	N
Right	21.7	(1.16)	20	24	94.17	(11.44)	62.5	100	16
Left	21.33	(1.37)	19	23	-96.88	(5.65)	-100	-87.5	12
All participants	21.6	(1.25)	19	24	9.26	(97.17)	-100	100	28

As shown in Table 2 above, the sample consisted of 28 participants, divided into 16 right-handed and 12 left-handed individuals. The mean age of the right-handed group was 21.7 years (SD = 1.16, range = 20–24 years), while the left-handed group had a mean age of 21.3 years (SD = 1.37, range = 19–23 years). Handedness scores reflected strong group differences, with right-handers showing a positive mean score of 94.17 (SD = 11.44, range = 62.5–100) and left-handers showing a negative mean score of -96.88 (SD = 5.65, range = -100 to -87.5). Across all participants, the overall mean age was 21.6 years (SD = 1.25), with handedness scores spanning the full scale from -100 to 100.

Table 3 demonstrates the mean percentage of dichotic listening responses reported in each ear, per condition:

Table 3. Means for all conditions and all subgroups for percent of dichotic listening responses that were reported for each ear

		Ear in which reported stimulus was heard							
		Right (%)				Left (%)			
Condition	Handedness	Mean	(SD)	Min	Max	Mean	(SD)	Min	Max
Directed Attention Separation	Right	94	(9.12)	70	100	97.33	(4.58)	90	100
	Left	98.33	(3.89)	90	100	95.83	(6.69)	80	100
Undirected Attention Separation	Right	56	(20.28)	20	90	64	(23.84)	10	100
	Left	69.17	(13.79)	50	90	65.83	(18.32)	40	100
Integration	Right	94	(3.87)	90	100	94.47	(3.12)	90	97.5
	Left	97.5	(2.61)	92.5	100	97.04	(3.34)	90	100

Across dichotic listening conditions shown in Table 3, both right- and left-handed participants demonstrated high accuracy in the directed attention tasks, with mean correct responses exceeding 94% in both ears, indicating near-ceiling performance and minimal group differences. In the undirected attention condition, performance was more variable, right-handers reported an average of 56% (SD = 20.28, range = 20–90) in the right ear and 69.17% (SD = 13.79, range = 50–90) in the left ear, while left-handers reported 64% (SD = 23.84, range = 10–100) in the right ear and 65.83% (SD = 18.32, range = 40–100) in the left ear. The mean differences in this condition suggest a small-to-moderate effect, reflecting subtle handedness-related variation in ear advantage. Integration tasks yielded the highest and most consistent performance across groups, with right-handers averaging 94%–97.5% and left-handers 94.47%–97.04% across ears, showing minimal variability and negligible effect sizes, indicating comparable performance between groups under reduced attentional demands.

The LI scores for all conditions are outlined in Table 4, per handedness group:

Table 4. Laterality index score for all conditions for each group

	Handedness							
	Right				Left			
Condition	Mean	(SD)	Min	Max	Mean	(SD)	Min	Max
Directed Attention Separation	-0.02	(0.05)	-0.13	0.05	0.01	(0.05)	-0.05	0.11
Undirected Attention Separation	-0.06	(0.28)	-0.50	0.67	0.03	(0.20)	-0.33	0.38
Integration	-0.004	(0.02)	-0.04	0.03	0.003	(0.01)	-0.03	0.03

LI results from Table 4 indicate minimal ear preference across conditions for both right- and left-handed participants. In the directed attention separation task, right-handers demonstrated a near-neutral mean LI of -0.02 (SD = 0.05, range -0.13 to 0.05), while left-handers showed a similarly balanced mean of 0.01 (SD = 0.05, range -0.05 to 0.11), reflecting negligible effect sizes between groups. Greater variability was observed in the undirected attention separation condition, with right-handers averaging -0.06 (SD = 0.28, range -0.50 to 0.67) and left-handers averaging 0.03 (SD = 0.20, range -0.33 to 0.38). This increased spread suggests a small-to-moderate effect and likely reflects the higher cognitive load and task complexity associated with undirected attention, highlighting subtle handedness-related differences in auditory processing. In the integration condition, both groups again showed almost no lateral bias, with means near zero (right-handers: -0.004; left-handers: 0.003) and narrow ranges, indicating minimal practical differences.

The results from the initial t-test, determining whether there is a significant ear advantage per handedness group, are illustrated in Table 5 below:

Table 5. Ear advantage determined by t-test 1

Condition	Handedness	p-value
Directed Attention Separation	Right	0.13
	Left	0.33
Undirected Attention Separation	Right	0.43
	Left	0.59
Integration	Right	0.56
	Left	0.40

An independent-samples t-test was conducted to determine whether there was a significant ear advantage. As shown in Table 5, results indicated no statistically significant ear advantage across any listening conditions for either handedness group. In the directed attention separation task, right-handers ($p = 0.13$) and left-handers ($p = 0.33$) showed no significant difference between ears, reflecting negligible effect sizes. Similarly, in the undirected attention separation task, differences remained non-significant for right-handers ($p = 0.43$) and left-handers ($p = 0.59$), indicating minimal practical differences between ears despite some variability in performance. In the integration condition, no significant ear effect was observed for right-handers ($p = 0.56$) or left-handers ($p = 0.40$), suggesting balanced performance and negligible effect sizes across ears. These non-significant findings should be interpreted cautiously, as the modest sample size may have limited statistical power, potentially reducing the ability to detect subtle ear differences.

Whether an ear advantage was present during t-test 2, where groups were compared directly (Table 6):

Table 6. Ear advantage for t-test 2 when comparing groups directly

Handedness	Condition	p-value
Right	Directed Attention Separation	0.06
	Undirected Attention Separation	0.02*
	Integration	0.005*
Left	Directed Attention Separation	0.26
	Undirected Attention Separation	0.41
	Integration	0.04*

***** $p < 0.05$**

Results from the second set of independent-samples t-tests examined whether right-handers performed better in the right ear compared to left-handers, and whether left-handers performed better in the left ear compared to right-handers. Right-handers were hypothesised to show a right-ear advantage, which was confirmed in the integration condition ($p = 0.005$) and the undirected attention separation condition ($p = 0.02$), with effect sizes likely reflecting small-to-moderate practical differences. The directed attention separation condition approached significance ($p = 0.06$), suggesting a trend toward a right-ear advantage with a small effect size. For left-handers, no significant differences were found in the directed ($p = 0.26$) or undirected ($p = 0.41$) attention separation conditions, indicating minimal effect sizes, but a significant effect emerged in the integration condition ($p = 0.04$), suggesting a small-to-moderate effect.

These findings indicate that ear advantage in relation to handedness may be condition-specific, particularly evident in integration and undirected attention tasks, and highlight that the magnitude of differences varies across conditions.

4. DISCUSSION

This study aimed to identify whether handedness influences performance in binaural integration and binaural separation tasks using the DDT and the significance of this effect. Overall, the results indicate that neither right- nor left-handed participants showed a statistically significant ear advantage when considered independently (Table 5). However, when comparing groups, right-handed individuals showed a significant right-ear advantage over left-handed individuals in the undirected attention condition ($p = 0.02$; Table 6). Between-group comparisons of laterality indices showed a greater right-ear advantage in right-handers for undirected separation ($p=0.02$; Table 6) and integration ($p=0.005$; Table 6), and a greater left-ear advantage in left-handers for integration ($p=0.04$; Table 6). These findings suggest an association between handedness and auditory lateralisation, particularly under undirected attention and integration conditions where cognitive/attentional demands are higher.

The REA observed in dichotic listening reflects left-hemisphere dominance for language, as stronger contralateral projections allow access to left-hemispheric language areas when right-ear stimuli is presented (Kimura, 1961). Carey et al. (2025) suggests that handedness correlates with cerebral lateralisation, as right-handers typically show stronger left-hemisphere dominance, compared to left-handers demonstrating greater variability in lateralisation. The present results align with this literature where the pronounced REA in right-handers likely reflects more consistent left-hemisphere dominance, while the LEA among left-handers indicates more bilateral or right-hemisphere involvement.

The broader literature affirms the robustness of the REA, reflecting left-hemisphere dominance, but highlights that its magnitude varies with task design and participant characteristics (Rimol et al., 2024; Hugdahl et al., 2003). These two factors may explain the handedness effects observed. First, performance relies primarily on bottom-up processing in undirected conditions, revealing intrinsic hemispheric dominance patterns. This may account for the stronger REA among right-handers when attention was not directed. Second, integration tasks place heavier demands on working memory and interhemispheric communication, as listeners must combine information from both ears. These processes engage bilateral cortical networks and the corpus callosum, amplifying individual differences in lateralisation (Zhang et al., 2023). Consequently, left-handers, who often show greater interhemispheric connectivity, may perform better for left-ear stimuli under such conditions (Zhang et al., 2023). Neuroimaging research similarly indicates that integration activates both temporal lobes and frontal control regions to a greater extent than separation tasks (Zhang et al., 2023; Rimol et al., 2024).

Moreover, attentional modulation plays a critical role, Elyamany et al. (2024) demonstrated that directing attention can shift or diminish ear advantages through top-down control mechanisms. Our data support this interpretation, as handedness differences emerged primarily under undirected attention, where spontaneous lateralisation dominates. Collectively, these findings reinforce that the REA is robust but context sensitive. It varies not only with task structure but also with participant characteristics such as handedness and attentional control.

The findings from the initial t-test should be interpreted with caution, given the small sample size, which limits impact and increases the chance of Type II error, which is failing to detect real differences (Serdar et al., 2021). The first set of t-tests used smaller group-specific sample sizes (n = 16 and n = 12), whereas the second set of t-tests used between-group comparison, with a total sample of n = 28. Between-group comparisons may have been better powered for detecting group differences in LI than the within-group one-sample tests for detecting non-zero LI, given different variance structures (Serder et al., 2021). This may partly explain why significant results were observed in the second set of tests. As a result, a REA was observed during the undirected attention separation condition for right-handed individuals. Additionally, during the integration condition, a REA and an LEA were observed for right-handed and left-handed participants, respectively. This suggests that some of the non-significant results from the first tests could be due to insufficient statistical power rather than the absence of a real effect (i.e. Type II errors). Future studies with larger samples would help confirm these findings and reduce the likelihood of Type II errors.

The findings could have practical implications for interpreting DDT results in clinical audiology. As ear advantage patterns may vary systematically with handedness, clinicians should consider handedness as an influencing factor when evaluating DDT performance. A LEA in a left-hander may reflect normal neurocognitive variability rather than a central auditory processing deficit. Moreover, since integration tasks appear more sensitive to interhemispheric and cognitive factors, they may provide valuable insights into higher-level auditory processing. Clinicians should therefore interpret DDT outcomes by considering both handedness and task conditions. Future studies should explore the use of normative datasets to ideally include stratification by handedness. Incorporating these factors could enhance diagnostic precision and reduce misinterpretation in the assessment of CAPD, as a LEA in a left-hander may be typical but should be interpreted alongside other CAPD measures and the individual's case history, rather than considered in isolation.

5. CONCLUSION

This study indicates that self-reported handedness can affect auditory binaural separation and integration, which supports the idea that handedness can influence dichotic listening performance, particularly under both undirected separation and integration conditions. Effects are subtle, variable, and best understood within frameworks that integrate hemispheric asymmetry, attentional shifts, and task-specific demands. Replication with larger samples and complementary neurophysiological methods is needed to clarify the mechanisms underpinning these differences.

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7. APPENDICES

7.1 APPENDIX A – Demographic Participant Questionnaire

7.2 APPENDIX B – Recording Sheet

7.3 APPENDIX C – Participation Information Form

7.4 APPENDIX D – Informed Consent Slip

7.5 APPENDIX E – Ethical Clearance

7.6 APPENDIX F – Referral Letter

7.1 APPENDIX A

Demographic Participant Questionnaire

Participant Form

Hello, and thank you for participating in our research study!

We are students currently enrolled at the University of Pretoria and are conducting a research study. The purpose of this form is to gather information needed regarding hand dominance, as well as other aspects required for our research study

We look forward to working with you!

*Indicates required question

1. Email*

____

2. Dear Participant*

We are final-year Audiology students—Emma de Lange, Tyler Marais, Cheryl Jones, and Angelina da Silva—from the Department of Speech-Language Pathology and Audiology at the University of Pretoria. We are conducting a research study to explore the relationship between handedness (hand preference) and the way individuals process sounds.

The title of our study is: *The Effect of Self-Reported Handedness on Auditory Binaural Integration and Separation.*

We are investigating whether hand dominance influences how people listen to sounds presented to each ear. The findings may contribute to a better understanding of auditory processing and its neurological underpinnings.

Before deciding whether to participate, please take a moment to read through the study details below.

What participation involves:

As part of the study, you will be asked to complete the following procedures (should take about 1 and a half hours:

Questionnaire: To determine your hand preference.

Otoscopy: A visual examination of your ear canal and eardrum using an otoscope.

Tympanometry: To assess middle ear function and the integrity of the auditory nerve pathway.

Pure Tone Audiometry: To measure your hearing sensitivity across frequencies ranging from 125 Hz to 8000 Hz.

Dichotic Digit Test: You will listen to different digits presented simultaneously to each ear and repeat what you hear. This test evaluates auditory integration, separation, and selective auditory attention.

Your Rights as a participant:

- Participation is entirely voluntary.
- You may withdraw from the study at any time without any negative consequences.

Confidentiality

All data obtained will be treated with confidentiality and identifying information will not be disclosed. An alpha-numeric code will be assigned to each participant and will be utilised for data interpretation and analysis.

Data storage

All data will be securely stored—both electronically and in hard copy— for a period of 15 years within the Department of Speech-Language Pathology and Audiology at the University of Pretoria.

Contact details

Should you have any questions, please do not hesitate to contact us:

- **Emma de Lange**: +27 83 270 4848
- **Tyler Marais**: +27 72 525 9461
- **Cheryl Jones**: +27 81 558 7644
- **Angelina da Silva**: +27 71 624 4942

Department of Speech-Language Pathology and Audiology address:

Communication Pathology Building
University of Pretoria
Private Bag X20, Hatfield 0028, South Africa
Tel: +27 (0)12 420 4280
Fax: +27 (0)12 420 3517

If you agree to take part in this research project, please select all options you agree to below.

Thank you for considering your participation. Feel free to contact us should you have any questions or concerns.

Kind regards,

Angelina, Emma, Tyler & Cheryl, and our study supervisors: Prof le Roux & Prof Pottas

Please read through and select all that are applicable

I have read and understood the information provided in the information letter ☐

I have been granted the opportunity to ask questions concerning the research study ☐

I hereby give my consent to participate in the research study titled "The effect of handedness on binaural integration and separation." ☐

I understand that my participation is voluntary, and I may withdraw at any time during the study ☐

I acknowledge that the data collected will be for research purposes ☐

3. Name*

____

4. Surname*

____

5. Contact Number *

____

6. Birth date *

____

Example: 7 January 2019

7. Age *

____

8. Do you have any diagnosed learning disabilities? If so, please specify*.

____

____

____

____

9. Have you had a hearing test before? If so, please state when and the results*.

____

____

____

____

10. Do you take any medication for attention disorders? If so, please specify*.

____

____

____

____

11. Please indicate your preference in the use of hands in the following activity/object*

1. Writing

<u>Mark only one box</u>

☐ Always right

☐ Usually right

☐ Both Equally

☐ Usually left

12. Please indicate your preference in the use of hands in the following activity/object*

2. Throwing

<u>Mark only one box</u>

☐ Always right

☐ Usually right

☐ Both equally

☐ Usually left

13. Please indicate your preference in the use of hands in the following activity/object*

3. Toothbrush

Mark only one box

☐ Always right

☐ Usually right

☐ Both equally

☐ Usually left

14. Please indicate your preference in the use of hands in the following activity/object*

4. Spoon

Mark only one box

☐ Always right

☐ Usually right

☐ Both equally

☐ Usually left

7.2 APPENDIX B

Recording Sheet

Participant Recording Sheet

Participant Name ______________________________

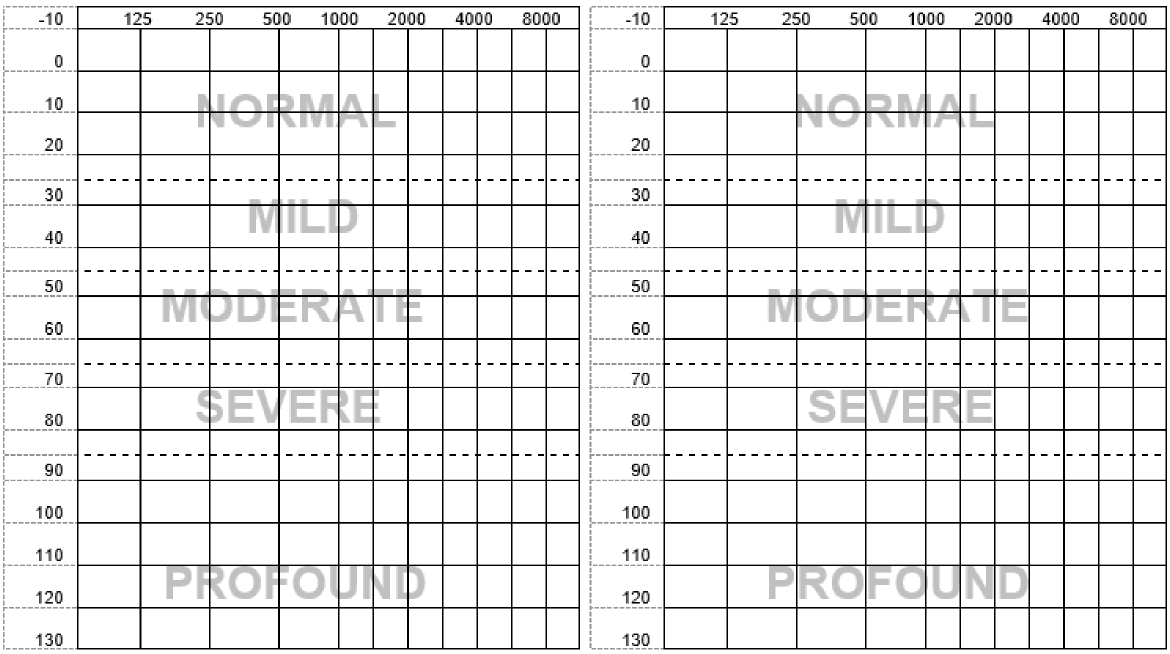
Hand Preference: **Right** ☐ **Left** ☐

Otoscopy	
R:	L:
Acoustic Reflex Screening	
R:	**L:**

Tympanometry	
R-Type:	**L-Type:**
ECV:	**ECV:**
Compliance:	**Compliance:**
Pressure:	**Pressure:**

Suiwertoonoudiogram / Pure Tone Audiogram

Regteroor / Right Ear **Linkeroor / Left Ear**



Maskering / Masking

LG/AC							
BG/BC							

Maskering / Masking

LG/AC							
BG/BC							

Integration %		Separation Directed Attention %		Separation Undirected Attention %	
R	L	R	L	R	L

2 – Pair Digits (Track 3)	
Left Ch	**Right Ch**
4, 3	**1, 6**
3, 1	**9, 10**
9, 6	**1, 5**
2, 10	**6, 8**
4, 8	**6, 9**
9, 1	**10, 2**
2, 4	**9, 10**
1, 9	**8, 6**
2, 4	**3, 9**
1, 4	**10, 5**
2, 5	**1, 3**
4, 5	**2, 6**
3, 10	**5, 6**
4, 1	**9, 5**
4, 5	**3, 8**
9, 5	**4, 1**
4, 5	**10, 2**
9, 8	**3, 4**
9, 10	**8, 5**
8, 6	**4, 1**
6, 8	**10, 2**
9, 1	**2, 8**
6, 9	**3, 1**
1, 2	**3, 9**
5, 3	**2, 1**

Integration			
Left		**Right**	

Separation (undirected)		
List 1	**List 2**	**List 3**
L	**R**	**R**
L	**R**	**L**
R	**R**	**R**
L	**L**	**R**
R	**L**	**L**
R	**R**	**L**
L	**L**	**L**
L	**R**	**R**
L	**R**	**R**
R	**L**	**R**
L	**R**	**R**
L	**L**	**L**
R	**R**	**L**
R	**L**	**R**
R	**R**	**R**
R	**R**	**L**
L	**L**	**L**
R	**L**	**R**
L	**L**	**L**
R	**L**	**L**
L: **R:**	**L:** **R:**	**L:** **R:**

Separation (Directed)	
L	**R**

7.3 APPENDIX C

Participation Form

Dear Participant,

We are final-year Audiology students—Emma de Lange, Tyler Marais, Cheryl Jones, and Angelina da Silva—from the Department of Speech-Language Pathology and Audiology at the University of Pretoria. We are conducting a research study to explore the relationship between handedness (hand preference) and the way individuals process sounds. The title of our study is: *The Effect of Self-Reported Handedness on Auditory Binaural Integration and Separation*.

We are investigating whether hand dominance influences how people listen to sounds presented to each ear. The findings may contribute to a better understanding of auditory processing and its neurological underpinnings.

Before deciding whether to participate, please take a moment to read through the study details below.

What participation involves:

As part of the study, you will be asked to complete the following procedures (should take about 1 and half hours):
Questionnaire: To determine your hand preference.
Otoscopy: A visual examination of your ear canal and eardrum using an otoscope.
Tympanometry: To assess middle ear function and the integrity of the auditory nerve pathway.
Pure Tone Audiometry: To measure your hearing sensitivity across frequencies ranging from 125 Hz to 8000 Hz.
Dichotic Digit Test: You will listen to different digits presented simultaneously to each ear and repeat what you hear. This test evaluates auditory integration, separation, and selective auditory attention.

Your Rights as a participant:
Participation is entirely voluntary.
You may withdraw from the study at any time without any negative consequences.

Confidentiality

All data obtained will be treated with confidentiality and identifying information will not be disclosed. An alpha-numeric code will be assigned to each participant and will be utilised for data interpretation and analysis.

Data storage

All data will be securely stored—both electronically and in hard copy—for a period of 15 years within the Department of Speech-Language Pathology and Audiology at the University of Pretoria.

Contact details

Should you have any questions, please do not hesitate to contact us:

Emma de Lange: +27 83 270 4848

Tyler Marais: +27 72 525 9461

Cheryl Jones: +27 81 558 7644

Angelina da Silva: +27 71 624 4942

Department of Speech-Language Pathology and Audiology address:

Communication Pathology Building

University of Pretoria

Private Bag X20, Hatfield 0028, South Africa

Tel: +27 (0)12 420 4280

Fax: +27 (0)12 420 3517

If you agree to take part in this research project, please select all options you agree to below.

Thank you for considering your participation. Feel free to contact us should you have any questions or concerns.

Kind regards,

Angelina, Emma, Tyler & Cheryl

And our study supervisors: Prof le Roux & Prof Pottas

7.4 APPENDIX D

Informed Consent Slip

Informed consent

Participation in research study entitled: *The Effect of Reported Handedness on Binaural Integration and Separation*

I, ______________________________, confirm that I have read and understood the information provided in the information letter and that I have been granted the opportunity to ask questions concerning the research study.

I hereby give my consent to participate in the research study titled "*The Effect of Handedness on Binaural Integration and Separation*." I understand that my participation is voluntary, and I may withdraw at any time during the study. Additionally, I acknowledge that the data collected will be used for research purposes.

_________________________ _________________________

Signature of the participant Date

7.5 APPENDIX E

Ethical Clearance

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Humanities 100. Since 1919

Department of Speech - Language Pathology and Audiology

20 February 2025

Dear Researchers,

Project: *The Effect of Self-Reported Handedness on Auditory Binaural Integration and Separation*

Researchers: Angelina da Silva (22511980); Emma de Lange (22495658); Cheryl Jones (21480232); Tyler Marais (21474983)

Supervisors: Prof Lidia Pottas and Prof Talita le Roux

Department: Department of Speech-Language Pathology and Audiology

Reference Number: SLPA 2025/01

Thank you for the application submitted to the Research Committee of the Department of Speech-Language Pathology and Audiology, Faculty of Humanities. Your application has been approved.

The approval is subject to the candidates abiding by the principles and parameters set out in the application.

We wish you success with the project.

Sincerely

Prof Lidia Pottas
Chair: Departmental Research Committee

Prof J van der Linde
HEAD: DEPARTMENT OF SPEECH-LANGUAGE PATHOLOGY AND AUDIOLOGY UNIVERSITY OF PRETORIA

Room 7.22, Level 7, Humanities Building
University of Pretoria, Private Bag X20
Hatfield 0028, South Africa

Email makone.maja@up.ac.za | www.up.ac.za

7.6 APPENDIX F

Referral Form

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Humanities 100. Since 1919

Dear: Date:

A hearing screening procedure was conducted on the _______________20__. During the evaluation it was noted that you should be referred for further assessment. For this reason, we would like to refer you to:

	Professional person:		Reason:
	Audiologist • Mandisa Shiceka Clinic • Kekana Gardens Clinic • Jubilee Hospital • Department of Speech, Language Pathology and Audiology, University of Pretoria - 012 420 2816 • You can also visit your nearest audiologist		Complete hearing evaluation recommended
	General practitioner (GP) and Audiologist **GP** • Mandisa Shiceka Clinic • Kekana Gardens Clinic • Jubilee Hospital • You can also visit your nearest GP practice		Further investigation of middle ear and hearing evaluation

The above-mentioned healthcare practitioners (audiologists and doctors) are only suggestions. You are welcome to visit other hearing healthcare professionals. However, we urge you to attend to this problem as soon as possible.

Kind regards,

Angelina da Silva, Emma de Lange, Cheryl Jones, Tyler Marais

4TH YEAR AUDIOLOGY STUDENTS

Room 3-25, Humanities Building
University of Pretoria, Private Bag X20
Hatfield 0028, South Africa
Tel +27 (0)12 420 3517 | Fax +27 (0)12 420 2490
Email Christine.louw@up.ac.za | www.up.ac.za/faculty-of-humanities