Uludağ Üniversitesi Tıp Fakültesi Dergisi
Journal of Uludağ University Medical Faculty
51 (3) 373-377, 2025
DOI: https://doi.org/10.32708/uutfd.1722028

ORIGINAL RESEARCH

Auditory Reaction Times and Hand Asymmetry Under Blindfolded Conditions: A Gender-Based Analysis of Averaged Motor Performance

Murat Cenk ÇELEN, Engin SAĞDILEK

Bursa Uludag University, Faculty of Medicine, Department of Biophysics, Bursa, Türkiye.

ABSTRACT

This study aimed to evaluate the effects of hand dominance and gender on auditory reaction times under blindfolded and randomized conditions, while also examining bilateral motor coordination through simultaneous response evaluation. Twenty-eight healthy participants (16 female, 12 male) completed auditory reaction time tasks under three conditions: dominant hand, non-dominant hand, and simultaneous bilateral responses. Each condition was repeated 10 times. Mean and standard deviation (SD) values were calculated from all trials. Paired and independent t-tests were used for statistical comparison. The dominant hand produced significantly faster responses than the non-dominant hand ($p = 0.022$) and also exhibited lower intra-individual variability ($p = 0.030$), indicating higher consistency. Gender had no significant effect on reaction time ($p = 0.249$). Interestingly, in the simultaneous condition, the mean difference in reaction time between hands was −1.44 milliseconds, with the non-dominant hand often responding faster—a result that challenges conventional assumptions about motor asymmetry. Auditory reaction time is influenced by hand dominance in both speed and consistency. The surprising dominance of the non-dominant hand during simultaneous responses raises important questions about interhemispheric coordination and sensorimotor integration and warrants further neurophysiological investigation.

Keywords: Auditory Reaction Time. Hand Dominance. Motor Asymmetry. Sensorimotor Integration. Simultaneous Response.

Gözlerin Kapalı Koşullarda İşitsel Reaksiyon Süresi ve El Dominansı: Cinsiyet Temelli Bir Değerlendirme

ÖZET

Bu çalışma, gözler kapalı ve rastgeleleştirilmiş koşullarda el baskınlığı (dominantlık) ve cinsiyetin işitsel reaksiyon süresi üzerindeki etkilerini değerlendirmeyi; ayrıca eş zamanlı yanıt ölçümleri yoluyla bilateral motor koordinasyonu incelemeyi amaçlamaktadır. Çalışmaya 28 sağlıklı gönüllü (16 kadın, 12 erkek) katılmıştır. Katılımcılar, baskın el, baskın olmayan el ve eş zamanlı çift el yanıtı olmak üzere üç farklı koşulda işitsel reaksiyon süresi görevini tamamlamıştır. Her koşul 10 tekrar halinde uygulanmıştır. Tüm tekrarlar üzerinden ortalama ve standart sapma (SS) değerleri hesaplanmıştır. İstatistiksel karşılaştırmalar için eşleştirilmiş ve bağımsız örneklemler t-testleri uygulanmıştır. Baskın el, baskın olmayan ele kıyasla anlamlı düzeyde daha hızlı tepki vermiştir ($p = 0,022$) ve daha düşük birey içi değişkenlik göstermiştir ($p = 0,030$), bu da daha tutarlı bir yanıt profiline işaret etmektedir. Cinsiyetin reaksiyon süresi üzerinde anlamlı bir etkisi saptanmamıştır ($p = 0,249$). Eş zamanlı koşulda ise el reaksiyon süreleri arasındaki ortalama fark −1,44 milisaniye olarak bulunmuştur; bu durum, baskın olmayan elin daha hızlı yanıt verdiği örneklerin çoğunlukta olduğunu göstermektedir ve motor asimetriye ilişkin geleneksel varsayımlara meydan okuyan bir bulgu olarak dikkat çekmektedir. İşitsel reaksiyon süresi, hem hız hem de tutarlılık açısından el baskınlığından etkilenmektedir. Eş zamanlı yanıt koşullarında baskın olmayan elin beklenmedik performans üstünlüğü, interhemisferik koordinasyon ve duyu-motor entegrasyon mekanizmaları hakkında yeni sorular doğurmakta ve daha ileri nörofizyolojik araştırmaları gerekli kılmaktadır.

Anahtar Kelimeler: İşitsel Reaksiyon Süresi. El Baskınlığı. Motor Asimetri. Duyu-Motor Entegrasyonu. Eş Zamanlı Yanıt.

Date Received: 18.June.2025
Date Accepted: 18.September.2025

Dr. Murat Cenk ÇELEN
Bursa Uludag University, Faculty of Medicine,
Department of Biophysics, Bursa, Türkiye
E-mail: muratcenkelen@uludag.edu.tr

AUTHORS' ORCID INFORMATION
Murat Cenk ÇELEN: 0000-0003-0727-0110
Engin SAĞDILEK: 0000-0001-8696-4035

Auditory reaction time (ART) serves as a critical measure in cognitive neuroscience, reflecting the efficiency of the sensorimotor system in processing auditory stimuli and executing motor responses[1,2]. It encompasses the duration between the presentation of an auditory stimulus and the initiation of a motor response, serving as an index of neural processing speed and coordination. In addition, some studies suggest that auditory stimuli may not significantly affect reaction times[3].

Hand dominance significantly influences ART[4–6]. Dominant limbs typically exhibit faster and more consistent responses due to more refined motor control and greater cortical representation[7]. This asymmetry is attributed to the lateralization of motor functions in the brain, where the dominant hemisphere exerts more precise control over the preferred hand[8].

Gender differences in ART have also been documented, though findings are controversial. Some studies report males could have faster ARTs, potentially due to differences in muscle mass and neural conduction velocity, but findings do not support these predictions[9]. Conversely, other research indicates negligible differences between genders, suggesting that factors such as task complexity and stimulus modality may mediate these effects.

Simultaneous bilateral tasks introduce additional complexity, engaging interlimb coordination and revealing asymmetries in motor control. Research indicates that during such tasks, the dominant limb often leads, while the non-dominant limb follows, highlighting a hierarchical organization in bimanual movements[10]. This phenomenon underscores the importance of understanding interlimb dynamics, particularly in contexts requiring precise coordination[11]. Despite extensive research on ART, gaps remain in the understanding of how hand dominance and gender interact to influence auditory RTs (Reaction Time), especially under conditions that mimic real-world scenarios, such as blindfolded tasks requiring simultaneous bilateral responses. Existing studies often focus on visual stimuli or unimanual tasks, leaving a paucity of data on auditory RTs in bimanual contexts.

To address this gap, the present study investigates the effects of hand dominance and gender on auditory RTs under blindfolded conditions, incorporating simultaneous bilateral response tasks. By analyzing RTs across dominant, non-dominant, and simultaneous conditions, this research aims to elucidate the interplay between lateralization, gender, and sensorimotor integration. The findings are expected to contribute to a more comprehensive understanding of motor asymmetry and inform the development of training protocols and rehabilitation strategies that account for individual differences in hand dominance and gender.

Material and Method

Participants

This study was granted ethical approval by Bursa Uludağ University Faculty of Medicine Clinical Research Ethics Committee (approval no: 2025-4-10). 28 healthy volunteers (16 females and 12 males) aged between 18 and 40 yearsparticipated voluntarily. Participants were recruited through announcements made in student organizations and clinical units of Bursa Uludağ University Faculty of Medicine, as well as via online platforms. All participants provided written informed consent prior to inclusion. Eligibility criteria required individuals to be free from hearing loss or neurological/motor disorders that could affect auditory processing or motor performance. Those with uncorrected visual impairments, psychiatric or neurological conditions, or under psychoactive medication were excluded from the study. Handedness was determined using the Edinburgh Handedness Inventory[5,12].

Design and Procedure

The study was conducted at the Biophysics Laboratory of the Department of Biophysics, Faculty of Medicine, Bursa Uludağ University. The design was a cross-sectional experimental protocol approved by the institutional ethics committee. Each participant underwent ART testing under blindfolded conditions to eliminate visual cues. Auditory stimuli (1000 Hz tones) were delivered via headphones in a sound-attenuated room, while participants were seated alone to minimize distractions.

The experiment comprised three conditions:

1. Dominant hand reaction time
2. Non-dominant hand reaction time
3. Simultaneous bilateral response condition

Each participant was exposed to 10 randomized auditory stimuli in each condition. In each trial, the auditory stimulus was presented after a randomized delay (between 1–3 seconds). Participants were instructed to press a predefined response button as quickly as possible upon hearing the sound using the specified hand. For the simultaneous condition, both hands were required to respond at once, and the difference in reaction times between the two hands was recorded.

Reaction times were recorded in milliseconds using a custom-built response box interfaced with a digital timing system. For the dominant and non-dominant hand conditions, the average and standard deviation were calculated across all 10 trials. For simultaneous responses, the latency difference between hands (Dominant – Non-Dominant) was used as the primary measure.

Data Analysis

Data were analyzed in RStudio (version 2024.04.2+764, R version 4.4.1) using the stats and car packages. Paired-sample t-tests were used to compare reaction times between the dominant and non-dominant hands. Independent t-tests were used to assess gender effects. Intra-individual variability was

examined via standard deviation comparisons. The latency differences in the simultaneous condition were evaluated using descriptive statistics. The significance threshold was set at $p < 0.05$.

Results

The results of this study were analyzed across three primary conditions: dominant hand responses, non-dominant hand responses, and simultaneous bilateral responses. Reaction time (RT) values were averaged over 10 trials per condition for each participant, and intra-individual variability was quantified using standard deviation (SD). Statistical analyses assessed the effect of hand dominance, gender, and within-subject variability on auditory RT.

Dominant vs. Non-Dominant Hand Reaction Time

As shown in Figure 1, auditory RTs recorded from the dominant hand were significantly faster than those from the non-dominant hand. The mean RT for the dominant hand was 0.188 ± 0.021 seconds, while the non-dominant hand yielded a mean of 0.198 ± 0.027 seconds. A paired-sample t-test confirmed the significance of this difference ($p = 0.022$), thereby suggesting a clear advantage associated with hand dominance.

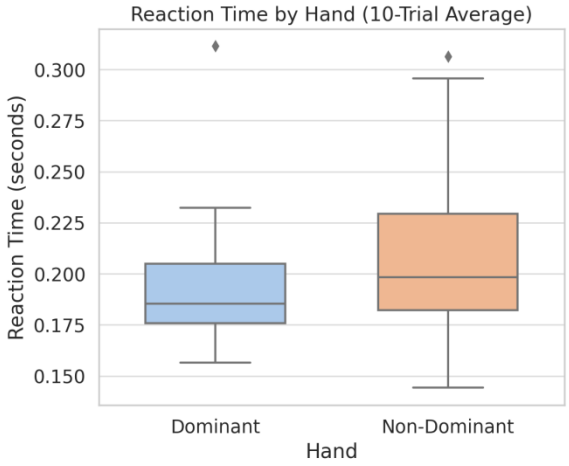

Figure 1:
Boxplot of auditory reaction times by hand (10-trial average). Mean reaction times recorded from the dominant and non-dominant hands are compared. Dominant hands showed significantly faster responses ($p = 0.022$). The box shows the interquartile range (IQR), the line indicates the median, whiskers extend to 1.5 × IQR, and individual outliers are marked.

Gender-Based Comparison of Reaction Time

When separated by gender, female participants tended to exhibit slightly faster RTs compared to male participants in both hand conditions, although the differences were not statistically significant. Figure 2 illustrates the distribution of RTs by gender and hand. In the dominant hand condition, the mean RTs for females and males were 0.184 s and 0.192 s, respectively. An independent-sample t-test revealed no significant gender effect in the dominant condition ($p = 0.249$), and a similar trend was observed for the non-dominant hand. These results indicate that while gender may influence auditory motor response trends, it was not a significant factor in this sample.

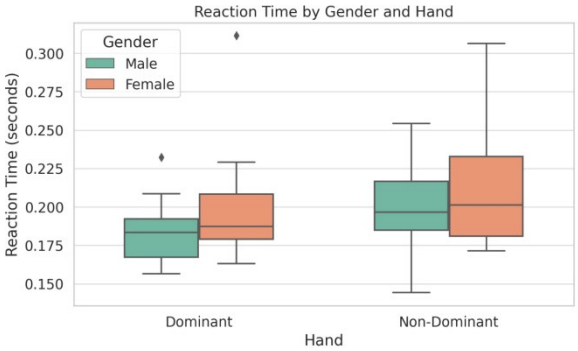

Figure 2:
Auditory reaction times by hand and gender. Reaction time distribution is shown separately for male and female participants across dominant and non-dominant hands. While females showed slightly faster average responses in the dominant hand, no statistically significant gender difference was observed ($p = 0.249$). Outliers are shown as dots.

Intra-individual Variability Across Hands

To assess the consistency of responses, the standard deviation of RTs across the 10 trials was compared between hands. Figure 3 demonstrates that the dominant hand exhibited lower intra-individual variability (mean SD = 0.059 s) compared to the non-dominant hand (mean SD = 0.064 s). A paired-sample t-test showed this difference to be statistically significant ($p = 0.030$), indicating that the dominant hand not only responds faster but also more reliably.

Simultaneous Bilateral Response Differences

The latency difference between hands in the simultaneous response condition was calculated by subtracting non-dominant hand RTs from dominant hand RTs (Dominant − Non-Dominant). As shown in Figure 4, the distribution of these differences was centered slightly below zero, with a mean value of −1.44 milliseconds and a standard deviation of 8.79 ms. Although no inferential test was applied due to the directional nature of the metric, the data suggest a slight tendency for the non-dominant hand to respond faster in simultaneous conditions—an unexpected finding that may reflect complex interhemispheric dynamics or compensatory mechanisms in bimanual tasks.

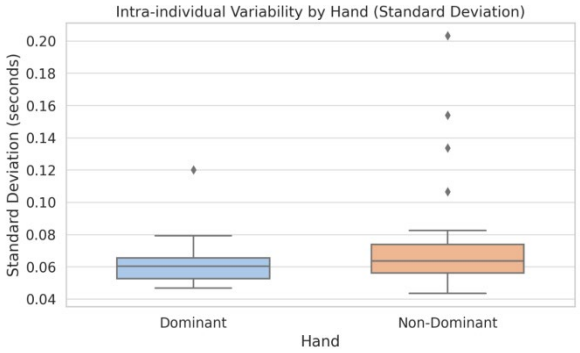

Figure 3:
Intra-individual variability in auditory reaction times (standard deviation) by hand. Standard deviations (SD) across 10 trials are plotted for each participant by hand. Dominant hands exhibited significantly lower variability than non-dominant hands ($p = 0.030$), indicating more consistent performance.

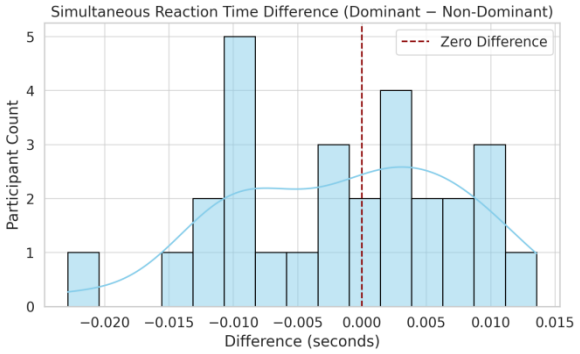

Figure 4:
Histogram of latency differences in simultaneous bilateral responses (Dominant − Non-Dominant). The histogram displays the difference in reaction times between hands for simultaneous responses. Negative values indicate faster responses from the non-dominant hand. The mean latency difference was −1.44 milliseconds, with several participants responding more quickly with their non-dominant hand. The dashed line represents zero difference.

Discussion and Conclusion

This study investigated the influence of hand dominance and gender on auditory reaction times (ART) under blindfolded conditions, incorporating simultaneous bilateral response tasks to assess motor coordination. The findings revealed that dominant hands exhibited significantly faster and more consistent responses compared to non-dominant hands, aligning with existing literature that attributes superior motor performance to the dominant limb due to enhanced cortical representation and refined motor control[4,5]. The lack of significant gender differences in ART suggests that, under the specific conditions of this study, gender may not be a determining factor in auditory-motor processing speed, corroborating findings from previous research indicating minimal gender effects on simple reaction tasks[13].

The unexpected observation that the non-dominant hand often responded faster during simultaneous bilateral tasks challenges traditional notions of motor asymmetry. This phenomenon may be explained by the concept of interhemispheric inhibition, where the dominant hemisphere exerts inhibitory control over the non-dominant hemisphere during unilateral tasks, but such inhibition may be reduced during bilateral movements, allowing the non-dominant hand to respond more swiftly[14]. Additionally, the central nervous system's strategy for integrating proprioceptive information from both limbs during bimanual tasks may favor the limb with superior sensory acuity, potentially leading to the observed performance of the non-dominant hand in certain contexts[15].

These findings underscore the complexity of sensorimotor integration during bilateral tasks and suggest that hand dominance may not uniformly predict performance across different motor activities. The results have implications for the design of rehabilitation programs and athletic training, where understanding the nuanced interplay between limb dominance and motor coordination can inform more effective interventions. Future research should explore the neural mechanisms underlying these observations, potentially utilizing neuroimaging techniques to elucidate the cortical dynamics involved in bilateral motor tasks.

This study provides compelling evidence that hand dominance significantly influences auditory reaction times (ART), both in terms of response speed and intra-individual consistency, under blindfolded and randomized testing conditions. Participants demonstrated faster and more stable responses with their dominant hand, a finding that supports longstanding theories of lateralized motor control and cortical efficiency in the dominant hemisphere[4,5]. While no significant gender effect was observed, subtle trends suggest that sex-based factors may still modulate motor performance under specific conditions and merit further exploration.

Unexpectedly, the simultaneous bilateral condition revealed a mean latency difference favoring the non-dominant hand. This contradicts conventional assumptions regarding dominant limb superiority and aligns with emerging research on interhemispheric inhibition[14] and task-specific sensorimotor integration[15]. These findings highlight the context-dependent nature of motor asymmetry, particularly in tasks involving bilateral coordination.

Taken together, the results underscore the importance of considering task dynamics and interlimb

interactions when assessing motor performance. Future research should delve deeper into the neurophysiological underpinnings of such asymmetries, possibly integrating neuroimaging or electrophysiological approaches to examine real-time interhemispheric dynamics during auditory-motor tasks. Additionally, the observed patterns hold translational value for clinical assessment protocols and training designs in sports and neurorehabilitation, where individualized strategies based on hand dominance and bilateral coordination could optimize outcomes.

Researcher Contribution Statement:
Idea and Design: MCC., ES.; Data collection and processing: MCC., ES.; Analysis and interpretation of data: MCC., ES.; Writing of significant parts of the article: MCC., ES.
Support and Acknowledgement Statement:
The authors declared that this study has received no financial support.
Conflict of Interest Statement:
The authors of the article have no conflict of interest declarations..
Ethics Committee Approval Information:
Approving Committee: Bursa Uludağ University Faculty of Medicine Clinical Research Ethics Committee
Approval Date: 24.02.2025
Decision No: 2025-4-10

References

1. Andrade AN de, Sanfins MD, Skarzynska MB, Skarzynski PH, Gil D. Temporal Ordering and Auditory Resolution in Individuals with Sensorineural Hearing Loss. *Int Arch Otorhinolaryngol*. 2024;28(1):e122-e128. doi:10.1055/s-0042-1759748
2. Röder B, Rösler F, Neville HJ. Event-related potentials during auditory language processing in congenitally blind and sighted people. *Neuropsychologia*. 2000;38(11):1482-1502. doi:10.1016/s0028-3932(00)00057-9
3. Roche R, Wilms-Floet AM, Clark JE, Whitall J. Auditory and visual information do not affect self-paced bilateral finger tapping in children with DCD. *Hum Mov Sci*. 2011;30(3):658-671. doi:10.1016/j.humov.2010.11.008
4. Annett M. Handedness and Cerebral Dominance. *J Neuropsychiatry Clin Neurosci*. 1998;10(4):459-469. doi:10.1176/jnp.10.4.459
5. Oldfield RC. The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia*. 1971;9(1):97-113. doi:10.1016/0028-3932(71)90067-4
6. Sathiamoorthy A, Sathiamoorthy SS, Bhat SK, Hiremath S, Shenoy N. Influence of handedness on the visual and auditory reaction time. *Indian J Physiol Pharmacol*. 1994;38(4):297-299.
7. Karim Chouamo A, Griego S, Susana Martinez Lopez F. Reaction time and hand dominance. *The Journal of Science and Medicine*. Published online February 22, 2021. doi:10.37714/josam.v3i0.66
8. Dexheimer B, Przybyla A, Murphy TE, Akpinar S, Sainburg R. Reaction time asymmetries provide insight into mechanisms underlying dominant and non-dominant hand selection. *Exp Brain Res*. Published online September 6, 2022. doi:10.1007/s00221-022-06451-2
9. Goel V, Manjunatha S, Pai KM. Effect of red bull energy drink on auditory reaction time and maximal voluntary contraction. *Indian J Physiol Pharmacol*. 2014;58(1):17-21.
10. McCombe Waller S, Liu W, Whitall J. Temporal and spatial control following bilateral versus unilateral training. *Hum Mov Sci*. 2008;27(5):749-758. doi:10.1016/j.humov.2008.03.006
11. Rezaei Manesh S, Shetab boushehri N, shafeinia P, Doustan MR. Effect of foreperiod duration and dominant hand on simple and choice auditory reaction time. *Journal of Sport Management and Motor Behavior*. 2021;17(34):55-66. doi:10.22080/jsmb.2018.10620.2431
12. Atasavun Uysal S, Ekinci Y, Çoban F, Yakut Y. Edinburgh El Tercihi Anketi Türkçe güvenirliğinin araştırılması. *Journal of Exercise Therapy and Rehabilitation*. 2019;6(2):112-118. https://dergipark.org.tr/tr/pub/jetr/issue/48176/474884
13. Der G, Deary IJ. Age and sex differences in reaction time in adulthood: Results from the United Kingdom Health and Lifestyle Survey. *Psychol Aging*. 2006;21(1):62-73. doi:10.1037/0882-7974.21.1.62
14. Serrien DJ, Ivry RB, Swinnen SP. Dynamics of hemispheric specialization and integration in the context of motor control. *Nat Rev Neurosci*. 2006;7(2):160-166. doi:10.1038/nrn1849
15. Wong JD, Wilson ET, Kistemaker DA, Gribble PL. Bimanual proprioception: are two hands better than one? *J Neurophysiol*. 2014;111(6):1362-1368. doi:10.1152/jn.00537.2013