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Research Paper

Examining the Relationship Between the Dominant Eye and the Dominant Hand

Mohammad Almasi[1], Ali Mirzajani[1*], Jamile Abolghasemi[2], Saeed Rahmani[3]

1. Department of Optometry, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.
2. Department of Biostatistics, School of Health, Iran University of Medical Sciences, Tehran, Iran.
3. Department of Optometry, School of Rehabilitation Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran.

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Conflict of interest

The authors declared no conflict of interest.

ABSTRACT

Background and Objectives: This study aims to determine the relationship between hand dominance and ocular dominance (OD) using different test formats of handedness and ocular dominance.

Methods: Three OD test formats were administered to 74 healthy young adult subjects, hole-in-card test for sighting dominance, near-point-of-convergence (NPC) test for motor dominance, and +1.50 to blur test for sensory dominance. All of these tests were performed while the best correction was in front of the subject's eyes. An interview for preferred dominance and a finger-tapping test for performance dominance were administered to determine the dominant hand.

Results: Right eye dominance was indicated in 66.2% with the hole-in-card test, 56.8% with the NPC test, and 51.4% of cases with the +1.50-to-blur test. Statistically, a significant nonrandom relationship was observed between the results of hole-in-card and NPC tests (P=0.000), hole-in-card and +1.50-to-blur tests (P=0.003), and also between the results of NPC and +1.50-to-blur tests (P=0.003). In addition, it was found that in 52.7% of the cases, all three dimensions of eye dominance (sighting, sensory, and motor) are not in the same eye and do not have pure eye dominance. In examining the dominant hand, the majority of subjects were right-handed both in the preference (62 of 74 [83.8%]) and in the performance dimension (63 of 74 [85.1%]). Statistical analysis shows a significant nonrandom relationship between the pure dominant hand and the pure dominant eye (P=0.000). In addition, the pure dominant hand (0.813) and pure dominant eye (P=0.126) are independent of gender.

Conclusion: Determining the OD, similar to determining the hand dominance based on their different dimensions, can have different results. According to the results, in all dimensions of ocular and hand dominance, both the dominant eye and the dominant hand are more on the right side of people. Furthermore, the pure dominant eye and pure dominant hand are not independent of each other.
Keywords: Dominance, Handedness, Ocular dominance (OD)

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*** Corresponding Author:**
Ali Mirzajani, PhD.
Address: *Department of Optometry, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.*
Tel: *+98 (21) 22228052*
E-mail: *mirzajani.a@iums.ac.ir*

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What is "already known" in this topic:

Performance-based measurements are not predictors of preferred hand. Combining the questionnaires and performance test results can be the best predictor of the preferred hand. Thus, these results show that the use of several different methods can predict the dominant hand more accurately. Also, regarding eye dominance, different methods can be used to determine the dominant eye.

What this article adds:

According to the available facilities and the results of past studies, this study aims to obtain a more accurate and comprehensive laterality of them, considering all the dimensions of hand and eye dominance.

Introduction

Although the human anatomy is symmetrically arranged around a central vertical axis, most people use one side of their body with greater frequency, ease, and skill than the other [1]. It is also the case with the eyes. Porta first proposed ocular dominance (OD) in 1953 [2]. Ocular dominance refers to the tendency of the visual system to prefer the processing of input signals from one eye to the other eye [3]. The concept of ocular dominance has been studied for many years in optometry, ophthalmology, and psychology. Clinically, ocular dominance has been used for a variety of applications, including monovision contact lens wear, cataract surgery, sports performance, military marksmanship, and education and learning disorders [4]. Depending on the operational definition and specific measurements, ocular dominance could be classified into sighting, motor, and sensory dominance. Sighting dominance refers to the preferential use of one eye over the fellow eye in fixating on a target. In motor dominance, the dominant eye is less likely to lose fixation at the near point of convergence, and the state of the extraocular muscles with their innervational patterns may play a role in determining motor dominance. Sensory dominance occurs when the perception of a stimulus presented to one eye dominates over the other in retinal rivalry conditions [3].

Qiu et al [5] showed that when OD was determined using the hole-in-the-card test, right OD was present in 75.7% of subjects, and left OD was present in 24.3%. The worth 4-dot (sensory) test indicated right OD in 40.7%, left OD in 39.3%, and 20.0% had undetermined ocular dominance. Another study [1] showed that using the hole-in-card test and +1.50 to blur (sensory) test, 71% of subjects with the hole-in-card test and 54% of subjects with the +1.50 to blur test had right-eye dominance, which had a statistically significant difference.

In this study, the relationship between hand-eye dominance is investigated. According to the definition, the dominant hand performs better, faster, and more accurately than the other [6]. Handedness is a multidimensional motor function that identifies the hand one prefers to use for a variety of unimanual tasks (i.e. preference) and the ability to perform more effectively with one hand (i.e. performance) [7]. Therefore, preference and performance dimensions should be considered in determining the handedness to choose it more accurately. Hand dominance is strong and pure when the preference and performance in one hand are significantly preferable to the other [8]. Based on studies [9, 10], cultural and biological factors may influence the dominant hand. In the early twentieth century, significant pressures were found to switch the writing hand from left to right to avoid the religious and social stigmas of being left-handed. It was believed that left-handed individuals were at a physical and psychological disadvantage compared to right-handers. In addition to forced hand switching, inherent environmental constraints exist that a left-handed individual must adapt to living in a world designed for right-handers. In addition to these pressures, due to the design of devices for right-handers, left-handers people have to adapt and get used to this type of design, which, in turn, can affect the accurate recognition of whether people are left-handed or right-handed [11]. As a result, environmental factors can affect the preference and performance dominance of the hand, and it is impossible to determine the dominant hand by performing one test that evaluates only one of the dimensions. Because a person may have left-hand dominance, and the preference is changed to the right hand due to parental compulsion, the left hand still performs better. Only a few studies have paid attention to the effect of these factors, which may affect the

results of studies. In past classifications, typically, hand dominance was determined unidimensionally (such as a person's self-report of their dominant hand). Recently, multidimensional hand dominance has been considered, as its one-dimensionality seemed ambiguous. According to the study conducted by Corey et al [12], if considered alone, performance-based measurements are not predictors of preferred hand. Combining the questionnaires and performance test results can be the best predictor of the preferred hand. Thus, these results show that the use of several different methods can predict the dominant hand more accurately. Also, regarding eye dominance, different methods can be used to determine the dominant eye. Therefore, investigating the effect of the method of determining the dominance in the eye and its relationship with the dominance of the hand can bring new results. Therefore, this study aims to obtain a more accurate and comprehensive laterality of them, considering all the dimensions of hand and eye dominance, according to the available facilities and the results of past studies.

Materials and Methods

This research was conducted by convenience sampling method in Qom City, Iran in 2022. People without physical defects in the upper limbs and with normal vision (at least visual acuity of 20/20 measured by the Snellen e-chart) between the ages of 17 and 35 years whom we got access to, were invited to participate in the study if they had the conditions to enter the research. In this study, information, such as a history of eye surgery, and history of eye trauma, was collected by asking questions in the form of an interview. The person's refractive error was obtained objectively by auto refractometer Topcon model AR 8000 and then subjectively with an end-point of maximum plus for better distance visual acuity. With the best correction, the subject's visual acuity was measured with a Snellen e-chart placed at 6 meters from the participant. The amount of eye deviation was measured first at a distance of 6 meters and then at a distance of 40 cm using an accommodative target with the alternate prism cover test. Stereopsis was measured with the Titmus Fly test. Sighting ocular dominance was determined with the hole-in-card test (to find out which eye was used for fixation), motor ocular dominance with the near-point-of-convergence (NPC) test (to find which eye is less likely to lose fixation at the near point of convergence), and sensory ocular dominance with +1.50 to blur test (to find out which eye feels more blur by adding +1.50 sphere to the best optical correction).

To determine the performance dominance of the hand, the finger-tapping test was used. We used the finger-tapping test software, version 3.5 (Sybu Data) that can be installed on the mobile phone. In this method, the participant was asked to tap the index finger in the box specified in the software as fast as possible for ten s while his/her palm was on the table. This task was repeated three times for each hand and the average tap number was recorded. The hand with the higher average tap number was considered the dominant performance hand. Preference for hand dominance was also determined by asking several questions in the form of an interview, and the preferred hand for writing, throwing, using a spoon, brushing, and combing was questioned. Finally, according to the results of the tests, the dominant hand and dominant eye were determined and recorded.

Statistical analysis

All data were analyzed using SPSS software, version 27 (SPSS Inc., Chicago, IL). The chi-square test has been used to evaluate the relationship between variables. In all statistical tests, $P<0.05$ was considered significant.

Results

The subject group (74 people, mean age 22.7±2.3 years) included 36 men (48.6%) (mean age 22.9±2.3 years) and 38 women (51.4%) (mean age 22.6±2.3 years). Age distributions of the genders were not statistically significantly different (P=0.597).

Table 1 presents the OD outcomes recorded with the three dominance test formats across the study group. As can be seen, 66% (49 of 74) of individuals were identified as right-eye dominant using the sighting test, 51% (38 of 74) of persons were right-eye dominant with the sensory test, and 57% (42 of 74) of persons were right-eye dominant with the motor test. Also, with the sighting test, all participants had clear ocular dominance, while 14 participants (18.91%) had undetermined OD with motor and sensory tests. This represents a statistically significantly different outcome between the sighting and motor tests (P=0.000), between sighting and sensory tests (P=0.003), and between motor and sensory tests (P=0.003).

In examining the pure dominant eye, a significant change was observed (Table 2) so that only 35% (26 of 74) of subjects were pure right-eyed (all three sighting, motor, and sensory dominance were present in the right eye simultaneously), and 53% (39 of 74) of persons all three dimensions of OD were not present in one eye simultaneously, in other words, they did not have pure ocular dominance.

Table 1. Distribution of ocular dominance by test formats

Dominant Eye	No. (%)			Total No.
	Dominance Test Format			
	Sighting	Motor	Sensory	
Right	49(66.2)	42(56.8)	38(51.4)	129
Left	25(33.8)	18(24.3)	22(29.7)	65
Undetermined	0(0.0)	14(18.9)	14(18.9)	28
Total	74	74	74	222

Table 2. Distribution of pure ocular dominance

Pure Dominant Hand	No. (%)
Right	59(79.7)
Left	4(5.4)
Undetermined	11(14.9)
Total	74(100)

Table 3 presents the distribution of the pure dominant hand (in other words, both dimensions of performance dominance and preference dominance are in the same hand). When the pure dominant hand was analyzed, 80% (59 of 74) of subjects were right-handed.

Table 4 presents the results of the two hand dominance format tests. According to the results, most participants were right-handed both in the preference test (84%, 62 of 74) and in the performance test (85%, 63 of 74). Based on these results, a significant non-random relationship is observed between preference and performance tests of hand dominance (P=0.003).

Table 3. Distribution of pure handedness

Pure Dominant Eye	No. (%)
Right	26(35.1)
Left	9(12.2)
Undetermined	39(52.7)
Total	74(100)

Table 4. Distribution of handedness by test format

Dominant Hand	Dominance Test Format		Total No.
	Preference	Performance	
Right	62	63	125
Left	5	5	10
Undetermined	7	6	13

Table 5. Distribution of pure handedness and ocular dominance

Pure Dominant Eye	Pure Dominant Hand			Fisher-exact Value	P
	Right	Left	Undetermined		
Right	25	1	0	23.946	0.000
Left	2	3	4		
Undetermined	32	0	7		
Total	59	4	11		

Table 5 presents the frequency distribution and comparison of net dominant hand and eye, and based on that, out of a total of 59 people whose right hand was dominant, 23 people (39.0%) had the right eye, and 4 people (6.8%) had the left eye. Also, among the right-handed people, 32 people (54.2%) did not have a specific dominant eye; in other words, all 3 dimensions of eye dominance were not observed in one eye. Also, out of 4 people whose left hand was dominant, 1 person (0.25%) had the right eye, and 3 person (0.75%) had the left eye. Of the 11 people who did not have a clear dominant hand, none were right-eyed, but either their left eye was dominant (36.4%), or they did not have a clear eye dominance in the eye (63.6%). Based on statistical analysis, a significant non-random relationship is observed between pure dominant hand and eye dominance (P=0.000). It is worth noting that the pure dominant hand (0.813) and pure dominant eye (P=0.126) are independent of gender.

Discussion

Based on the results of this study, a non-random relationship is observed between the pure dominant eye and the pure dominant hand. In other words, the pure hand and the pure eye dominance are not independent. However, in a study conducted by Jagadamba [13], it was pointed out that no significant relationship is observed between the dominant hand and the eye. The relationship between sighting dominance and the preferred dominant hand has been investigated in that study. However, if the relationship between these two cases is considered according to the data in the present study, in that case, a significant non-random relationship is observed between sighting dominance and the preferred dominant hand (P=0.034). With simple definitions regarding the dominance of eye and hand, that is, if the dominant eye, observational eye, and the dominant hand, handwriting are considered, the relationship between the eye and the dominant hand becomes significant (P=0.040).

The current study found that when each of the different dimensions of eye dominance is considered alone, the frequency of right eyes is higher in all three dimensions. Dominant eye in few people is relatively undetermined, which can be found in various studies [1, 5, 13]. Nevertheless, the result is very different when all dimensions are considered together, and we define the dominant eye as having all 3 dimensions of eye dominance in that eye. It is observed that most people (52.7%) have all the dimensions of dominance not in one eye, and do not have a pure dominant eye. The results show a significant relationship between the results of all three tests used to determine eye dominance in this study. Now the question may arise that in clinical conditions when one-sided eye treatment is to be done, which of the dimensions of eye dominance is a better indicator of the dominant eye? Given that the human visual system is usually binocular, are tests that allow some degree of binocular vision to be maintained during testing desirable? Even in many people with the normal visual system in sensory and motor tests, no clear dominant eye is observed; clinical decision-making based on the results of these tests may not be a correct basis.

In the current study, the interview method was used to determine the preferred dominant hand, so it is possible that some people refused to give real answers and gave unrealistic answers. Also, the large number of experiments and tests caused the participant's fatigue and errors in the results of the tests. This study was conducted in the age range of 19-29 years. Therefore, it cannot be generalized to the whole of society.

Ethical Considerations

Compliance with ethical guidelines

The Ethics Committee of the Iran University of Medical Sciences approved this study (Code: IR.IUMS.REC.1400.329) .

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Authors' contributions

Conceptualization: Saeed Rhmani, Ali Mirzajani and Mohammad Almasi; Methodology and writing the original draft: Mohammad Almasi and Ali Mirzajani; Investigation: Mohammad Almasi; Data analysis: Mohammad Almasi and Jamileh Abolghasemi; Review and editing: All authors; Supervision: Ali Mirzajani.

Conflict of interest

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مقاله پژوهشی

آیا افراد راست‌دست، راست‌چشم هستند؟

محمد الماسی[1]، *علی میرزاجانی[1]، جمیله ابوالقاسمی[2]، سعید رحمانی[3]

۱. گروه بینایی سنجی، دانشکده علوم توانبخشی، دانشگاه علوم پزشکی ایران، تهران، ایران.
۲. گروه آمار زیستی، دانشکده بهداشت، دانشگاه علوم پزشکی ایران، تهران، ایران.
۳. گروه بینایی سنجی، دانشکده علوم توانبخشی، دانشگاه علوم پزشکی شهید بهشتی، تهران، ایران.

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چکیده

مقدمه این مطالعه با هدف تعیین رابطه بین دست غالب و چشم غالب با استفاده از ابعاد مختلف غالبیت دست و چشم انجام شد.

مواد و روش‌ها در این پژوهش ۷۴ نفر شرکت کردند. برای چشم غالب، از روش‌های NPC ، Hole-in-card و ۱/۵۰+ to blur به‌ترتیب برای تعیین چشم غالب مشاهده‌ای، حرکتی و حسی و برای تعیین دست غالب از مصاحبه و تست finger-tapping به‌ترتیب برای مشخص کردن دست غالب ترجیحی و عملکردی استفاده شد. تمامی روش‌های تعیین چشم غالب در حالی انجام شد که بهترین اصلاح جلوی چشم‌های شرکت‌کننده قرار داشت.

یافته‌ها با تست غالبیت مشاهده‌ای در ۶۶/۲ درصد، با تست غالبیت حرکتی در ۵۶/۸ درصد و با تست غالبیت حسی در ۵۱/۴ درصد از موارد، چشم راست غالب بود. ازنظر آماری میان نتایج تست‌های مشاهده‌ای و حرکتی (P=۰/۰۰۰)، تست‌های مشاهده‌ای و حسی (P=۰/۰۰۳) و همچنین میان نتایج تست‌های حرکتی و حسی (P=۰/۰۰۳)، هماهنگی غیرتصادفی معناداری وجود دارد. به‌عبارت‌دیگر ازنظرآماری نتایج تست‌های غالبیت چشم از یکدیگر مستقل نیستند. علاوه‌براین مشخص شد در ۵۲/۷ درصد از موارد هر ۳ بعد مشاهده‌ای، حسی و حرکتی در یک چشم نیستند و غالبیت چشمی خالصی ندارند. در بررسی دست غالب، اکثر افراد شرکت‌کننده هم در بعد ترجیحی (۶۲ نفر از ۷۴ نفر (۸۳/۸ درصد)) و هم در بعد عملکردی (۶۳ نفر از ۷۴ نفر (۸۵/۱ درصد)) راست دست بودند. براساس تحلیل‌های آماری، میان دست غالب خالص و چشم غالب خالص همراهی غیرتصادفی معنادار وجود دارد (P=۰/۰۰۰). از سوی دیگر، ارتباط معناداری میان دست غالب خالص (۸۱۳/۰) و همچنین چشم غالب خالص (P=۰/۱۲۶) با جنسیت مشاهده نشد.

نتیجه‌گیری تعیین غالبیت چشم، همانند تعیین غالبیت دست براساس ابعاد مختلف می‌تواند نتایج متفاوتی داشته باشد. براساس یافته‌های مطالعه حاضر در تمام ابعاد، هم چشم غالب و هم دست غالب بیشتر در سمت راست افراد قرار دارد. همچنین، غالبیت چشم و دست غالب خالص از هم مستقل نیستند.

کلیدواژه‌ها:
غالبیت، غالبیت چشم، غالبیت دست

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* نویسنده مسئول:
دکتر علی میرزاجانی
نشانی: تهران، دانشگاه علوم پزشکی ایران، دانشکده علوم توانبخشی، گروه بینایی سنجی.
تلفن: ۲۲۲۲۸۰۵۲ (۲۱) ۹۸+
رایانامه: mirzajani.a@iums.ac.ir