·Clinical Research·

Study on dominant eye measurement

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Abstract

• AIM: To examine a new performance test for detecting eye dominance by testing and re-testing with two different methods of the same subjects for comparing and discussing the reliabilities of these tests.

• METHODS: A total of 179 university students (mean± SD: 19.37± 1.62 years) were voluntarily participate in this survey consisting of 110 females (61.5%) and 69 males (38.5%). Eye dominances were determined by two different methods which were named McManus and a Gündoğan tests. The reliability of the survey was examined using a test-retest method.

• RESULTS: Without sex difference, right eyes were found dominant in 128 (71.5 %) participants by McManus test. The same subjects were re-tested by Gündoğan method, the right eye dominance were found in 110 (61.5%) subjects. The results of these two methods were related significantly by Fisher exact test(P<0.01), with an agreement score(κ=0.256, P<0.001). In females, the right eye dominance was found in 74 (67.3%) and left eye was found in 36 (32.7%) by McManus test. When the same subjects were re-tested by G ndo an method, the right eye dominance was found in 62 (56.4%) and the left eye dominance was found in 48 (43.6%) subjects.McManus and Gündoğan methods results for females were related significantly by Fisher exact test (P<0.05), with a weak agreement score (κ=0.239, P<0.01). In males, the right/left eye dominances were found respectively 54 (78.3%), 15(21.7%) by McManus test as they were found 48 (69.6 %), 21 (30.4 %) in the same participants when they were re-tested by Gündoğan method.χ^2 test and Fisher exact test were used for the analysis of categorical data. The agreement between different methods was analyzed with Kappa statistics. Comparison of proportions was made by two proportions z test. P value less than 0.05 was considered as significant.

• CONCLUSION: Without gender difference and also in both

females and males marked right eye dominance is observed. The right eye dominance is considering functional laterality may due to the dominance of left hemisphere instead of right hemisphere. It is an important topic for future research in laterality, and it may well become an important model system for future research.

• KEYWORDS: dominant eye; dominant eye measurement; functional asymmetry; laterality

INTRODUCTION

In humans, the right cerebral hemisphere is dominant in visuospatial and nonverbal function such as art, architecture, geometry and mathematics, whereas the left cerebral hemisphere is dominant in recent verbal functions such as rhetoric, literature, and poetry [1-4]. Many theorists, particularly in the area of education, have focused on cerebral functional asymmetry called cerebral laterality, was diagnosed by hand preference. But various times, the educational system has strongly encouraged all children to write with their right hand. Although manifested handedness may be altered by training, but no attempts are made to change the eye dominance for detecting laterality and many authors have seen that dominant eye as a more fundamental measure of underlying cerebral laterality[5-8].

Despite having been written about for at least 400 years [9], and probably recognized much earlier, little is known about the functional origins of eye dominance [10]. Although many researchers would agree with the position of Peters [11] that just bilateral brain is likely to have problems in co-coordinating the rapid movements of the larynx and vocal cords in producing speech, so bilateral control will also be ineffective in eye movements, where "medial rectus of one eye has to be coordinated with lateral rectus muscle of the other eye" so that process may be better controlled by single, unilateral control mechanism which will give a reliable clue on the subject of the functional laterality of cerebral hemisphere [10]. Dominant eye is associated with hand preference which is most conventionally assessed in

terms of the hand used for writing. However, precise numerical nature of the relationship is extremely difficult to explain, and in a recent meta-analysis of the literature it was found that about 35% of right-handers and about 57% of left-handers were left eye dominant [10]. The principal problem of the association of handedness and eye dominance is suggested to be asymmetrical distribution of the proportions (35% and 57%) are themselves asymmetrically distributed to either side of a value of 50% which can be regarded as the biological baseline for laterality [12]. This fluctuating asymmetry between right and left eyes aroused a question in our mind: Could it be related to methodological errors? Could it be contaminated by hand preference? Which method could be more reliable for dominant eye measurement without hand contaminations? In order to clarify the role of methodological diversity in fluctuating asymmetry between the right and left eye dominances, we establish a new measurable eye dominance performance method which will depend on objective criterions for assessing dominant eye.

MATERIALS AND METHODS

Participants This study was performed in accordance with the ethical standards of the Declaration of Helsinki 1994 which was approved by the local Ethics Committee of Başkent University (KA06/04). A total of 179 healthy students with normal visual acuity (69 males, 38.5%, 110 females, 61.5%) were investigated by assessing dominant eye. The age of all participants varied between 16 to 24 years (M =19.37 years SD±1.62). The ethnic origin was Caucasian. Informed consent was obtained from each participant.

Recruitment of the Students We explain to the students that if they have personal interest in the subject of cerebral laterality they should contact with us for participating voluntarily in the survey.

Procedure

McManus test´s Eye dominance assessed by monocular procedure, in which sighting was primarily with a single eye chosen by participants. All subjects were tested individually in the day lightened laboratory room during 12.00-13.00 with adequate instruments. Eye dominance was assessed by performance measurement according to McManus test in which there were three items for eye sighting such as: looking through a narrow opening into a dark bottle, looking through keyhole, looking down monocular microscope [13-15]. This test was performed twice. The eye that was unequivocally preferred in this situation was scored on a

point scale 1=always left, 2=either, 3=always right. Dominant eye was accepted to be the left eye if the average score < 2 and to be the right eye if total score was ≥2 [15]. Participants who had either eye dominant and who were aware of having a difference in acuity of more than two dioptres in their eyes were excluded.

Gündoğan test's The same subjects were re-tested in the same laboratory conditions by means of the near-far alignment test. The subject has to align two reference points in the horizontal eye-level plane. The line running through the two targets intersects the interocular axis at mid point between the eyes. The intersection can be imagined as the fictive vantage point from which the two targets appear in the same direction. Two equal size black round shape reference points were used. The first point as a near point (NP) was on the middle of the fixed transparent thin glass board 0.4m away from the eyes which had two centimeter schedule were placed on both sides. The second reference point was a mobile far point (FP) 3.0m away from the eyes on the wall (Figure 1A and Figure 2A). The subjects were asked to place their jaws and foreheads on the jaw support and headrest, and an elastic band was gently secured in order to avoid head movements. Then the subjects were asked to focus both eyes on the FP as the examiner move the FP till it comes at the same line with the reference NP. When the two points were overlapping in the same line, the subject was then directed to close one eye without moving his or her head and eyes. The examiner questioned whether points were shifting or not. If the reference NP shifted from the FP in the horizontal plane when one eye was closed, examiner asked the subject to read the shifting distance between two points from the transparent board where centimeter schedule was placed on the two sides of the reference NP (Figure 1B, 2B). The same procedure was repeated for the other eye. The eye representing minimum shifting distance between two points was accepted to be dominant. Some subjects who have very slight mismatches of shifting distance for both eyes were considered as two of them were dominant and these few subjects were excluded. Dominant eye measurement was illustrated by Figure 2.

Statistical Analysis Data were shown as n (%). χ^2 test and Fisher exact test were used for the analysis of categorical data. The agreement between different methods was analyzed with Kappa statistics. Comparison of proportions was made by two proportions z test. P <0.05 was considered as significant. Statistical analysis was performed using the SPSS 11.5 and MINITAB 13.0 for Windows.
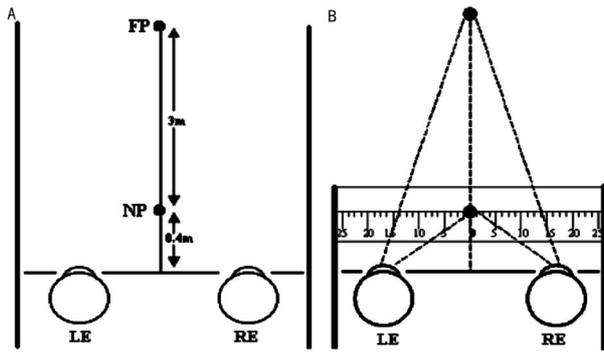
Figure 1 Ocular dominance was determined by means of the near-far alignment test for right eye (RE) and for left eye (LE) A: The distance between near point (NP) and the far point (FP) from the eyes is seen; B: The centimeter schedule was placed on the two sides of the NP on the fixed transparent glass board for measuring shifting distance

Figure 2 Eye dominance was measured by Gündoğan performance method in the laboratory A: Picture shows reference FP which has mobile ability, according to the direction of subject; B: Picture shows the subject's NP on the transparent glass in front of the eye level and also it can be seen hands and head fixation positions

RESULTS

Gündoğan method depends on the measurement of shifting distance between NP and FPs on the horizontal plane for each eye when one of eyes was closed. Without gender difference the mean values of shifting distance for all participants were (2.16±2.44)cm for the right eye, (3.35± 2.47)cm for the left eye, the difference was significant ($P <$ 0.01). Among females the mean values of shifting distance were (2.38±2.38)cm for the right eye, (3.05±2.41)cm for

the left eye, the difference was also significant ($P<0.01$). In males the mean values of shifting distance were (1.81± 2.51)cm for right eye, (3.83 ±2.50)cm for left eye, the difference was not significant. It was remarkable that minimum and maximum values were exactly similar in all groups for both of two eyes (Table 1).

Without gender difference the incidence of right eye dominance was found in 128 subjects (71.5%) by McManus test and for the same population the right eye dominance was found in 110 subjects (61.5%) by Gündoğan test. The left eye dominance was found in 51 subjects (28.5%) by McManus test [15] and in 69 subjects (38.5%) by Gündoğan method ($P <0.05$, Table 2, Figure 3) for the same population. Totally, 128 subjects who were found with right eye dominant by McManus test, only 89 subjects of those were assessed with right eye dominance by Gündoğan method and the rest of 39 were assessed as they had left eye dominance. According to McManus method, 51 subjects were assessed as they had left eye dominance, but among those only 30 subjects assessed with left eye dominance according to Gündogan test method. The rest of 21 subjects were assessed as they had right eye dominance (Table 2). These two methods for detection of dominant eye were found to be related significantly according to Kappa test ($P<$ 0.001; κ =0.256). In females 74 subjects were found with right eye dominance and 36 subjects were found with left eye dominance by McManus test. But only 48 subjects of those were assessed with right eye dominance by Gündoğan method and the rest of 26 were assessed with left eye dominance. According to McManus method, 36 subjects were assessed as they had left eye dominance, but among those only 22 subjects were assessed with left eye dominance according to Gündoğan test method. The rest of 14 subjects were assessed as they had right eye dominance. According to Gündoğan test, 62 subject were found with right eye dominance, 48 subjects were found with left eye dominance (Table 3, Figure 4).

In males, 54 subjects were found with right eye dominance and 15 subjects were found with left eye dominance by McManus test. But only 41 subjects of 54 subjects were assessed with right eye dominance by Gündoğan method and the rest of 13 were assessed with left eye dominance. According to McManus [15] method, 15 subjects were assessed as they had left eye dominance, but among those only 8 subjects were assessed with left eye dominance according to Gündogan test method.

The rest of 7 subjects were assessed as they had right eye dominance. Accordıng to Gündoğan test, 48 subjects were found with right eye dominance, 21 subjects were found with left eye dominance (Table 4, Figure 5).

Table 1　Descriptive analyses(min-max)cm for measurements of shifting distance between two reference points for both eyes

(mean±SD) cm

Gündoğan method	n	Right eye	Left eye	P
Female	110	2.38±2.38 (0.00-6.50)	3.05±2.41 (0.00-6.50)	<0.01
Male	69	1.81±2.51 (0.00-6.50)	3.83±2.50 (0.00-6.50)	ns
Total	17	92.16±2.44 (0.00-6.50)	3.35±2.47 (0.00-6.50)	<0.01

Table 2　Without gender difference dominant eye results for two methods were compared　　　　　　　　　　　　n(%)

Gündoğan method	McManus method		
	Right eye	Left eye	Total
Right eye	89(49.7)	21(11.7)	110(61.5)
Left eye	39(21.8)	30(16.8)	69(38.5)
Total	128(71.5)	51(28.5)	179(100)

Table 3　Dominant eye results of two methods were compared for female subjects　　　　　　　　　　　　n(%)

Gündoğan method	McManus method		
	Right eye	Left eye	Total
Right eye	48(43.6)	14(12.7)	62(56.4)
Left eye	26(23.6)	22(20.0)	48(43.6)
Total	74(67.3)	36(32.7)	110(100)

Table 4　Dominant eye results of two methods were compared for male subjects　　　　　　　　　　　　n(%)

Gündoğan method	McManus method		
	Right eye	Left eye	Total
Right eye	41(59.4)	7(10.1)	48(69.6)
Left eye	13(18.8)	8(11.6)	21(30.4)
Total	54(78.3)	15(21.7)	69(100)
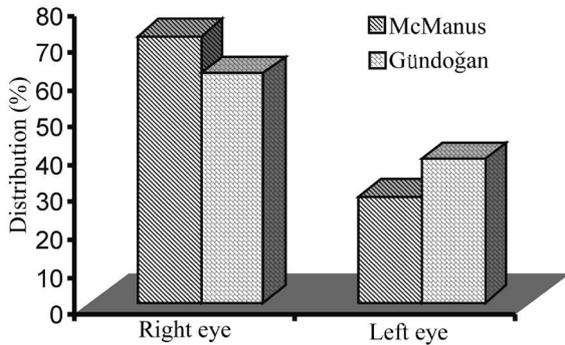
Figure 3　Without gender difference dominant eye results for two methods were compared

Figure 4　Dominant eye distributions among female students
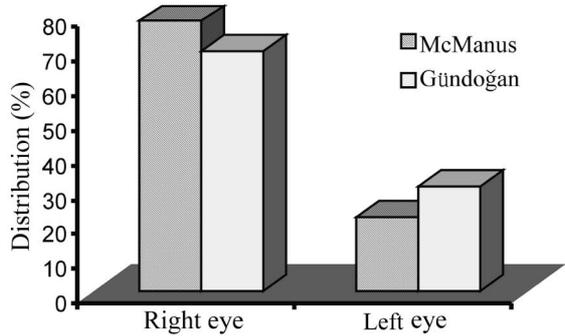
Figure 5　Dominant eye distributions among male students

DISCUSSION

Ocular dominance was determined by means of the near-far alignment test [16]. In this test, the subject is asked to hold a pencil in one hand directly in front of him- or herself. Then the subject is asked to align the tip with a point on distant wall with both eyes open. The subject is then asked alternatively to close one eye. Only when dominant eye is open and the other eye closed will the tip of pencil remain in good alignment with the point on the wall. The rest is repeated with the pencil in other hand[16,17]. When in doubt a variant of the test another test method was administered, in which the subject is asked to focus on a point on distant wall through a hole formed by the opposed thumb and index finger of one hand. Then the hand is moved toward the face while focusing on the same point, until one of the eyes is reached, which indicates the dominant eye [18,19]. Holding a pencil in hand or forming a hole by two fingers eye dominance can be contaminated by handedness.

On the other hand, during monocular activities for assessing dominant eye, holding some objects by hands, for instance observing the eye used to sight down a rifle may produce a spurious association with handedness due to the rifle typically being held with a finger of dominant hand on the trigger. Similarly as for looking through a small object such as kaleidoscope or bottle which is held in one hand, thus the holding of object in dominant hand may well distort measures of association between handedness and eye dominance [10,15]. These methodological insufficiencies for detecting dominant eye were caused errors by hand use contamination. For this reason these methods were modified by Gündoğan with restricting hand movements all through the tests (Figure 2). Moreover, we added centimeter schedules on the two sides of NP which gave us opportunity to have objective and measurable results for diagnosis of dominant eye (Figure 1B, Figure 2B).
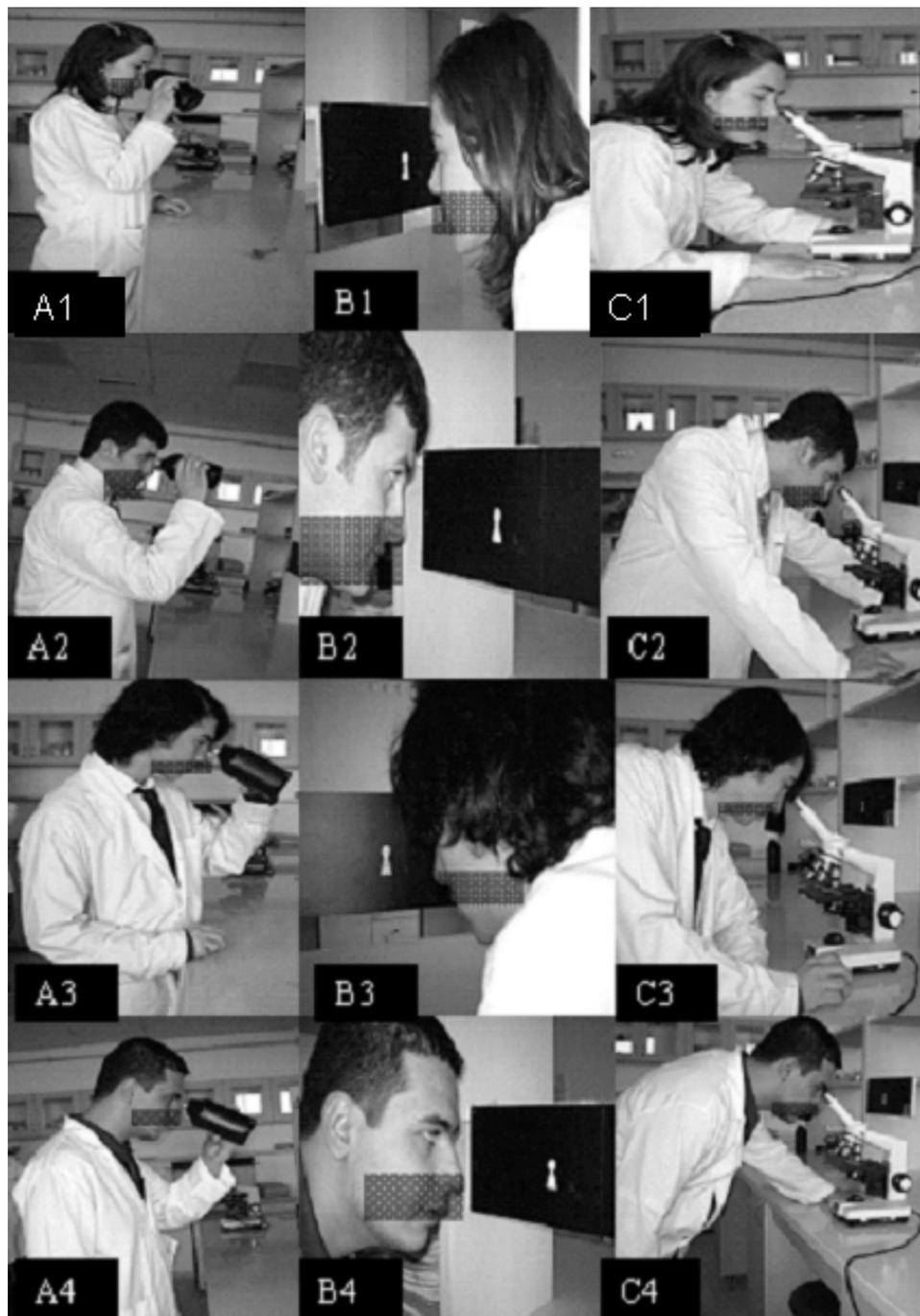
Figure 6 Monocular activities of McManus test. Looking through a bottle

Previous studies to date have concluded that right-eye dominance was greater than the left-eye dominance [19-21]. In our study, the ratios of right eye dominance was also found higher than the left eye dominance as without gender difference the right eye dominance were 71.5 % and 61.5% (Table 2) and among females the ratios were as 67.3%, 56.4%, and in males the ratios were 78.3% and 69.6% according to McManus and Gündoğan tests respectively (Table 3, 4). So in our study, we also found right-eye dominance was greater than left-eye dominance both in male and female subjects as it was found for handedness in our previous study [22]. Interestingly, slight differences in

using different brain areas for language processing were recognized between males and females [23-25].

Authors mentioned that males used to prefer their left eyes rather than right eyes for monocular tasks such as sighting through a tube. About one third of the population was suggested to be left eye dominance[13]. In the first part of our study, we assessed dominant eye with monocular activities by McManus test [15]. The subjects were asked to look through a tip of dark bottle and the subjects were used to holding the bottle with their hand (Figure 6). As the subjects in the pictures A-1 and A-2 the bottle was held by right hand; in the picture A-3 and A-4 the other subjects prefer to

hold with their left hands. This hand preference can affect eye dominance determination as we mention before. This could be the cause of little differences between McManus[15] and Gündoǧan test-retest results.

In order to exclude hand contamination, during dominant eye assessment all through the performance tests period hand movements were restricted (Figure 2B). Because the frontal eye fields, which are important for the control of voluntary saccades, are located only about 20mm anterior to the sensorimotor cortex for the hands [26]. In our test period, this hand moving restriction was not contaminated by handedness. We thought that hand movement restrictions should be very important for correct assessment of eye dominance. Restricting head movements was also important for correct assessment of dominant eye which was stated to be altered according to visual field is being left or right side of the target point [27]. In our study, through restricting head movements we prevented shifting visual field during dominant eye assessment. Moreover, when we asked the subjects to close one of their eyes the shifting distances between NP to FPs means were (2.16±2.44)cm for right eyes and (3.35±2.47)cm for left eyes. The difference between two values without gender difference was significant (P <0.01). In females, the right eye mean value was (2.38±2.38)cm, left eye (3.05±2.41)cm. The difference between these two values was significant (P <0.01). In males, the right eye mean value was (1.81±2.51)cm, left eye (3.83±2.50)cm. The difference between these two values was not significant (ns) (Table 1). The comparisons of right and left eye shifting distance for all groups were analyzed by Wilcoxon sign test.

In all subjects minimum and maximum deviation distances values for both right and left eyes were showed constant distance as (0.00-6.50)cm (Table 1). This is a very important point for our study when we compared with previous study of Baykal *et al*[21] whose shifting distance values were much more higher than ours. Furthermore, focusing point distances of our study were more homogenous [21]. This homogenous measurement seems to confirm the reliability of the Gündoǧan test. During monocular activities such as McManus test, researcher does not have chance for objective criteria of measuring shifting distance and focusing points for a reliable diagnosis. On this point, we thought Gündoǧan method may be found a more reliable method for detecting dominant eye. On the other hand, we put attention to a subject related with questions which property was accepted by authors for detecting dominant eye? Sighting dominance, acuity dominance or sensory dominance? In the best review of the phenomenon on the basis of the assessment of eye dominance, authors mentioned that a careful distinguishing should be performed by investigators for sighting dominance from the others[28]. It was seen that a wide range of performance measures of dominance, sighting dominance has been proposed for dominant eye assessment[29,30].

If the concept of eye dominance is to be useful for detecting cerebral functional laterality, it should be reliable. It is therefore worth noting that a number of studies have found high consistency of repeated measures of sighting dominance [19,31,32]. This was the reason of testing and re-testing research procedure of our study and we compared Gündoǧan method results with the other most largely used monocular selection method of McManus for the same subjects.

Dominant eye has sometimes been assessed using questionnaires concerned with monocular activities [33,34]. During monocular activities subject is asked to look through a small object which is held in one hand. Then holding of object in dominant hand may well distort measurement of the association between hand preference and eye dominance. In monocular activities, two specific problems are shown: first, the items may refer to activities such as holding a rifle, a bottle, or a kaleidoscope which are contaminated by hand preference [35]; and second, there may be a process of setting, whereby once a subject has consistently answered "right" or "left" to many handedness items, then they will merely carry on answering in same direction to other questions concerning eye dominance [10]. Because of these specific problems in the study, we applied performance test for both McManus and Gündoǧan tests.

In conclusion, Gündoǧan performance test depends on measurement shifting distance between reference points which can give objective criteria for dominant eye assessment. It seems to be one of practically applicable and reliable method for detecting dominant eye. The eye dominance was considered to show functional laterality due to the dominance of one of hemispheres. It is an important topic for future research in laterality, and it may well become an important model system for future research.

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