Is There a Correlation Between Eye Preference and Visual Acuity, Eye Dominance, and Handedness in Humans?

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Sammanfattning/Abstract:
Most humans do not only have a preferred hand to use in different situations, they also exhibit a clear preference when it comes to eye usage. Few studies have assessed whether different tests of eye preference give congruent or incongruent results, and furthermore, there are conflicting findings on whether eye preference correlates with eye dominance, visual acuity, and handedness. The present study assessed whether these variables correlate, alongside factors such as age and sex. A total of 79 subjects, 45 males and 34 females, were tested. A microscope, telescope, photo camera, and caleidoscope were used to assess eye preference, the Dolman test was used to assess eye dominance, the Edinburgh Handedness Inventory was filled in to assess handedness, and visual acuity was measured using a Snellen chart. Care was taken to include subjects of various ages and both sexes. Descriptive statistics show that most subjects were right-handed, had a right-eye preference and were consistent across the four eye preference tasks, and had a dominant right eye. Significant correlations were found between visual acuity and handedness, as well as eye preference and eye dominance.
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1 Abstract

Most humans do not only have a preferred hand to use in different situations, they also exhibit a clear preference when it comes to eye usage. Few studies have assessed whether different tests of eye preference give congruent or incongruent results, and furthermore, there are conflicting findings on whether eye preference correlates with eye dominance, visual acuity, and handedness. The present study assessed whether these variables correlate, alongside factors such as age and sex. A total of 79 subjects, 45 males and 34 females, were tested. A microscope, telescope, photo camera, and kaleidoscope were used to assess eye preference, the Dolman test was used to assess eye dominance, the Edinburgh Handedness Inventory was filled in to assess handedness, and visual acuity was measured using a Snellen chart. Care was taken to include subjects of various ages and both sexes. Descriptive statistics show that most subjects were right-handed, had a right-eye preference and were consistent across the four eye preference tasks, and had a dominant right eye. Significant correlations were found between visual acuity and handedness, as well as eye preference and eye dominance.

2 Introduction

Lateralisation characterises the vertebrate nervous system (Ghirlanda & Vallortigara 2004), with human handedness being the most prominent and therefore most studied manifestation of functional lateralisation. Not only do most humans have a preferred usage of one of their hands, they also exhibit a clear preference for the use of one of their eyes (Coren 1993, Ehrenstein et al. 2005). Several simple behavioural tests have been employed to determine eye preference in humans (Buxton & Crosland 1937, Ehrenstein et al. 2005), but few studies have systematically assessed whether results are congruent or incongruent between such tests. There are also conflicting findings regarding whether eye preference correlates with handedness (Bourassa 2010, Brown & Taylor 1988). Furthermore, most studies on eye preference did not test for differences in visual acuity between eyes (Pointer 2002), or assessed only a particular age, patient, or family groups (Coren et al. 1981, Fagard et al. 2008).

While “eye preference” refers to a choice in usage of one eye in monocular tasks, “dominant eye” refers to the brain’s tendency to prefer visual input from only one eye in binocular tasks (Ehrenstein et al. 2005). It is unknown whether eye preference correlates with eye dominance, with conflicting findings regarding whether the dominant eye correlates with handedness.

2.1 Aim

The aim of the present study was to assess eye preference, eye dominance, visual acuity, and handedness in a large sample of human subjects of both sexes across a wide age range, and to assess whether there was a correlation between these measures.
3 Material & methods

3.1 Subjects
A total of 79 subjects were tested, 45 men and 34 women. Care was taken to include subjects of different age classes, with ages ranging from 6 to 74 years old.

3.2 Tests

3.2.1 Visual acuity
A Snellen chart (Supplementary information 1) was used to measure visual acuity. Test subjects stood 4 metres away from the chart, which was put up against a unicoloured white wall. Each subject was asked to read the letters aloud while covering their left and right eye, respectively. The smallest row to be accurately read indicated the visual acuity of respective eye. Each row of letters was paired with a number which signified the visual acuity, where a higher number indicated higher visual acuity.

3.2.2 Eye preference
To assess eye preference, each test subject was asked to look into 4 different objects, A, B, C, and D.

A) Monocular microscope
The subject’s task was to look into a monocular microscope (Suppl. info. 2). The eye which was used to look into the microscope was recorded as the preferred eye.

B) Monocular telescope
The subject’s task was to look into a monocular telescope (Suppl. info. 3). The eye which was used to look into the telescope was recorded as the preferred eye.

C) Photo camera
The subject’s task was to pick up a photo camera (Suppl. info. 4) and look through the view finder placed in the middle of the apparatus. The eye which was used to look through the view finder was recorded as the preferred eye.

D) Caleidoscope
The subject’s task was to pick up and look into a caleidoscope (Suppl. info. 5). The eye which was used to look into the caleidoscope was recorded as the preferred eye.

Tests C and D required that the subjects used their hands to bring the object close to their eyes. Thus, it was possible that hand preferences may have affected eye use. Tests A and B, in contrast, did not require hand use. Accordingly, there was no possibility that hand preferences may have affected eye use.

3.2.3 Eye dominance
The Dolman test, also known as the hole-in-the-card test, was used to assess eye dominance. Subjects were asked to hold a rectangular cardboard of 30 x 40 cm with a 1 cm hole in the middle (Suppl. info. 6) with their arms fully extended. With both eyes open, the subjects focused on a small target object 5 metres away. Once having
found the object with both eyes, the subjects were asked to close each of their eyes separately and report whether the object they focused on was still visible or not. The eye which focused on the object was recorded as the dominant eye.

### 3.2.4 Handedness

The Edinburgh Handedness Inventory, a widely used and well-validated questionnaire-based test, was used to assess preferred hand usage. The inventory contained 10 questions regarding preferred hand usage in 10 common activities (Suppl. info. 7), such as writing, throwing, and striking a match.

### 3.3 Statistical analyses

Data for sex, visual acuity, handedness, eye preference and consistency, and eye dominance were analysed using descriptive statistics. Binomial tests were used to compare measures between groups, e.g. males and females, right- and non-right-handers, and between tasks. Chi-Square-Tests were used to assess possible correlations between all measures. Regarding consistency of eye use across the four eye preference tasks, a subject could be regarded consistent (same eye for all four tasks), partially consistent (same eye for three of the four tasks), or inconsistent (same eye for two tasks each).

### 4 Results

#### 4.1 Visual acuity

Among the 79 subjects, 30% had a higher visual acuity with their right eye, whereas 29% saw better with their left eye, and 41% had the same visual acuity for both eyes (Figure 1). There was no significant difference between higher visual acuity in either the right or left eye (binomial test, \( p > 0.05 \)).

![Figure 1. Frequency (%) of higher visual acuity in left and right eye, as well as frequency (%) of same visual acuity for both eyes among all 79 subjects.](image)
Among the 45 male subjects, 29% had a higher visual acuity with the left eye, 20% with the right eye, and 51% had the same visual acuity for both eyes (Figure 2). Among the 34 female subjects, 26% had a higher visual acuity with the left eye, 47% with the right eye, and 26% had the same visual acuity for both eyes (Figure 3). There was no significant difference between higher visual acuity in either the right or left eye among neither male nor female subjects with differing visual acuity (binomial test, \( p > 0.05 \) for both males and females). There was no significant difference between higher visual acuity in either the right or left eye (chi-square test, \( p > 0.05 \)).

### 4.2 Eye preference

Among all 79 subjects, eye preference was almost always the same for all four eye preference tasks (Figure 4). 73% showed a right eye preference in both the microscope, telescope, and camera task, whereas 72% showed a preference for their right eye when looking into the kaleidoscope. Furthermore, 27% of all subjects preferred their left eye when looking into both the microscope, telescope, and camera, whereas 28% showed a preference for their left eye when looking into the kaleidoscope. Among all subjects, there was a significant difference between right and left eye preference for all four eye preference tasks respectively (binomial test, \( p < 0.05 \)).
Regarding consistency of eye preference between all four eye preference tasks, 90% of all 79 subjects were consistent (the same eye was used for all four tasks) with their eye preference, 9% were partially consistent (same eye for three of the four tasks), and 1% was inconsistent (same eye for two of the tasks each). There were significantly more consistent than non-consistent subjects regarding preferential eye use across the four tasks (binomial test, p < 0.05). Of the 90% which were consistent, 25% preferred using their left eye, whereas 75% preferred their right eye. There was a significant difference between right and left eye preference consistency (binomial test, p < 0.05).

Among the 45 male subjects (Figure 5), 80% preferred using their right eye when looking into the microscope, telescope, and caleidoscope. When looking into the camera, 78% preferred using their right eye. 20% of the male subjects preferred using their left eye in all tasks except when looking into the camera, where 22% showed a preference for their left eye. Among the 34 female subjects (Figure 6), 65% preferred using their right eye when looking into the microscope, telescope, and caleidoscope, whereas 68% preferred using their right eye when looking into the camera. Furthermore, 35% showed a preference for their left eye in the microscope, telescope, and caleidoscope task, whereas 32% preferred using their left eye when looking into the camera. Among male and female subjects, respectively, there were significantly more right- than left-eye-preferent subjects in all four eye preference tasks (binomial test, p < 0.05). Male and female subjects did not differ significantly in their right and left eye preference between either of the four eye preference tasks (chi-square-test, p > 0.05).

Figure 4. Frequency (%) of left and right eye preference for all 79 subjects for all four eye preference tasks respectively.
Regarding consistency of eye preference, 87% of the 45 male subjects were consistent with their eye preference, 11% were partially consistent, and 2% were inconsistent. Among the 34 female subjects, 94% were consistent with their eye preference, whereas 6% were partially consistent. Among male and female subjects, respectively, there was a significant difference between consistent and non-consistent eye preference (binomial test, \( p < 0.05 \)). Between male and female subjects, there was no significant difference between consistency and non-consistency (chi-square-test, \( p > 0.05 \)). Of the 87% of male subjects which were consistent, 18% preferred using their left eye, whereas 82% preferred their right eye. Of the 94% of female subjects which were consistent, 34% preferred using their left eye, and 66% preferred their right eye. Among male and female subjects, respectively, there was a significant difference between right and left eye preference consistency (binomial test, \( p < 0.05 \)). There was no significant difference between left and right eye consistency between male and female subjects (chi-square-test, \( p > 0.05 \)).

### 4.3 Eye dominance

Among the 79 subjects (Figure 7), 63% showed right-eye-dominance, whereas 37% had a dominant left eye. Accordingly, a significantly higher proportion of subjects had a right dominant eye compared to a left dominant eye (binomial test, \( p < 0.05 \)).

Among the 45 male subjects (Figure 7), 69% had right-eye-dominance and 31% had left-eye-dominance. Among the 34 female subjects (Figure 7), 56% had a dominant right eye and 44% showed left-eye-dominance. Among the male subjects, there was a significant difference between right and left eye dominance (binomial test, \( p < 0.05 \)), whereas there was no significant difference among the female subjects regarding right and left eye dominance (binomial test, \( p > 0.05 \)). Between male and female subjects, there was no significant difference between right and left eye dominance (chi-square-test, \( p > 0.05 \)).
Figure 7. Frequency (%) of left and right eye dominance among all, male, and female subjects, respectively.

4.4 Handedness

Of all 79 subjects (Figure 8), 1% was left-handed, whereas 87% were right-handed and 12% were ambidextrous. Accordingly, there were significantly more right-handers than non-right-handers (left-handers and ambidextrous subjects grouped together) in the study population (binomial test, p < 0.05).

Among the 45 male subjects (Figure 8), 2% were left-handed, 87% were right-handed and 11% were ambidextrous. Among the 34 female subjects (Figure 8), no subject was left-handed, whereas 88% were right-handed and 12% were ambidextrous. There was a significant difference between right- and non-right-handers among male and female subjects, respectively (binomial test, p < 0.05). Between male and female subjects, there was no significant difference between right- and non-right-handers (chi-square-test, p > 0.05).
4.5 Visual acuity vs eye preference

Among the 47 subjects with differing visual acuity, 49% had a higher visual acuity with the same eye that was consistently preferred in the eye preference tasks. Accordingly, 51% had a higher visual acuity with the eye that they did not prefer in the four monocular tasks. There was no significant difference between higher visual acuity and correlating eye preference, and higher visual acuity and non-correlating eye preference (binomial test, \( p > 0.05 \)).

Of the 49% which saw better with their left eye, 30% also consistently preferred using their left eye, whereas 70% consistently preferred using their right eye instead. Among subjects with higher visual acuity with their left eye, there was a significant difference between left and right eye preference (binomial test, \( p < 0.05 \)).

Of the 51% which saw better with their right eye, 67% also consistently preferred using their right eye, whereas 33% consistently preferred using their left eye instead. Among subjects with higher visual acuity with their right eye, there was a significant difference between right and left eye preference (binomial test, \( p < 0.05 \)).

Between subjects with differing visual acuity, there was no significant difference between correlating eye preference (chi-square-test, \( p > 0.05 \)).

4.6 Visual acuity vs eye dominance

Among the 47 subjects with differing visual acuity, 62% had a higher visual acuity with their dominant eye. Accordingly, 38% had a higher visual acuity with their non-dominant eye. There was a significant difference between visual acuity and correlating eye dominance, and visual acuity and non-correlating eye dominance (binomial test, \( p < 0.05 \)).
Of the 49% which saw better with their left eye, 57% also had a dominant left eye, whereas 43% had a dominant right eye instead. Among subjects with higher visual acuity with their left eye, there was no significant difference between left and right eye dominance (binomial test, $p > 0.05$).

Of the 51% which saw better with their right eye, 67% also had a dominant right eye, whereas 33% had a dominant left eye instead. Among subjects with higher visual acuity with their right eye, there was a significant difference between right and left eye dominance (binomial test, $p < 0.05$).

Between subjects with differing visual acuity, there was no significant difference between correlating eye dominance (chi-square-test, $p > 0.05$).

### 4.7 Visual acuity vs handedness

Among the 47 subjects with differing visual acuity, higher visual acuity correlated with handedness for 36%. Accordingly, 64% differed in the side that they preferred to use with their eye and hand, respectively. There was a significant difference between higher visual acuity and correlating handedness, and higher visual acuity and non-correlating handedness (binomial test, $p < 0.05$).

Of the 49% which saw better with their left eye, 9% were also non-right-handers, whereas 91% were right-handers instead. Among subjects with higher visual acuity with their left eye, there was a significant difference between non-right- and right-handers (binomial test, $p < 0.05$).

Of the 51% which saw better with their right eye, 63% were also right-handers, whereas 37% were non-right-handers instead. Among subjects with higher visual acuity with their right eye, there was no significant difference between right- and non-right-handers (binomial test, $p > 0.05$).

Between subjects with differing visual acuity, there was a significant difference between correlating handedness (chi-square-test, $p < 0.05$).

### 4.8 Eye preference vs eye dominance

Among the 71 subjects with consistent eye preference, 90% preferred their dominant eye. There was a significant difference between correlating eye preference and eye dominance, and non-correlating eye preference and eye dominance (binomial test, $p < 0.05$).

Of the 25% which preferred their left eye, 94% also had a dominant left eye, whereas 6% had a dominant right eye instead. Among subjects which preferred their left eye, there was a significant difference between left and right eye dominance (binomial test, $p < 0.05$).

Of the 75% which preferred their right eye, 89% also had a dominant right eye, whereas 11% had a dominant left eye instead. Among subjects which preferred their right eye, there was a significant difference between right and left eye dominance (binomial test, $p < 0.05$).

Between subjects with consistent eye preference, there was a significant difference between correlating eye dominance (chi-square-test, $p < 0.05$).
4.9 Eye preference vs handedness
Among the 71 subjects with consistent eye preference, 66% had correlating eye preference and handedness. There was a significant difference between correlating eye preference and handedness, and non-correlating eye preference and handedness (binomial test, p < 0.05).

Of the 25% which preferred their left eye, 28% were also non-right-handers, whereas 72% were right-handers instead. Among subjects which preferred their left eye, there was a significant difference between non-right- and right-handers (binomial test, p < 0.05).

Of the 75% which preferred their right eye, 79% were also right-handers, whereas 21% were non-right-handers instead. Among subjects which preferred their right eye, there was a significant difference between right- and non-right-handers (binomial test, p < 0.05).

Between subjects with consistent eye preference, there was no significant difference between correlating handedness (chi-square-test, p > 0.05).

4.10 Eye dominance vs handedness
Among all 79 subjects, 63% had correlating eye dominance and handedness. There was a significant difference between correlating eye dominance and handedness, and non-correlating eye dominance and handedness (binomial test, p < 0.05).

Of the 37% which had left eye dominance, 17% were also non-right-handers. Among subjects with left eye dominance, there was a significant difference between non-right- and right-handers (binomial test, p < 0.05).

Of the 63% which had right eye dominance, 90% were also right-handers. Among subjects with right eye dominance, there was a significant difference between right- and non-right-handers (binomial test, p < 0.05).

Between all 79 subjects, there was no significant difference between correlating eye dominance and handedness (chi-square-test, p > 0.05).

5 Discussion
5.1 Social and ethical aspects
Test subjects below the age of 18 had consent from their respective parents or guardians. The study was strictly voluntary, and test subjects could revoke or end their participation at any time. Studies like the present study on lateralised behaviour in healthy subjects may contribute to a better understanding of both brain function in general, and impaired brain function due to e.g. neurodegenerative diseases or brain injury.

5.2 Visual acuity
Most test subjects had differing visual acuity between their right and left eye, but the number of subjects with higher visual acuity with their right eye (30%) was similar to those which saw better with their left eye (29%). There was no major difference
between higher visual acuity in right or left eye among male subjects either, whereas most female subjects with differing visual acuity saw better with their right eye (47%) than with their left (26%). Though no studies could be found where visual acuity correlates with sex, Ehrenstein et al. (2005) had results where the majority of test subjects saw better with their right eye, similar to the results from the present study.

5.3 Eye preference

As mentioned in the introduction, most humans prefer the use of one of their eyes (Coren 1993, Ehrenstein et al. 2005), but few studies have assessed whether different tests of eye preference yield congruent or incongruent results. The present study aimed to assess this, with a finding that most test subjects consistently preferred their right eye (72-73%) when performing all four eye preference tasks. The difference between right and left eye preference was big among male and female subjects respectively as well, though a greater proportion of female subjects preferred their left eye (32-35%) than male subjects (20-22%). The results of the present study are in agreement with previous studies which have pointed out a right-eye preference on several occasions; Coren et al. (1981) stated that both young adults and preschool children in their study displayed right-eye preferences, and Reiss and Reiss (2010) conducted a study where 66% showed a preference for their right eye.

Regarding consistency across the eye preference tasks, most subjects (90%) were entirely consistent, with only 10% in total being either partially or inconsistent. Among male and female subjects, respectively, consistency was also frequent (87% and 94%, respectively). Coren (1993) had a majority of test subjects where the right eye was consistently used, and Nachshon et al. (2009) saw that their subjects were consistent across tasks for 40%, with 37% showing right-eye preferences.

5.4 Eye dominance

Most of all test subjects in the present study showed right-eye-dominance (63%) when performing the Dolman test. Among male and female subjects, respectively, the majority had a dominant right eye (69% and 56%, respectively) as well, with a bigger difference in right and left eye dominance among male subjects. No previous studies could be found where any distribution of right and left eye dominance was presented, thus making it impossible to find support for the present distribution of right and left eye dominance.

5.5 Handedness

As expected, the majority of all test subjects of the present study were found to be right-handed. Only 13% were non-right-handers, of which most were ambidextrous. A single test subject was left-handed. The low number of subjects which were left-handed was somewhat unexpected, as previous studies reported about 10% (Bourassa 2010) of the test subjects which were left-handed. This would indicate that at least 7 subjects should have been left-handed in the present study, instead of the lone subject which was. This might be due to chance only, where a bigger sample size might have included more left-handers.
5.6 Correlational analyses

As mentioned in the introduction, few studies have assessed associations between eye preference and visual acuity, whereas there are conflicting findings on whether eye preference correlates with handedness and eye dominance.

In the present study, no correlation was found between handedness and eye dominance, in contrast to the claim that handedness and eye dominance would associate statistically (McManus 2010). Pointer (2002), on the other hand, stated that the degree of association between handedness, eye dominance, and eye preference is statistically no greater than chance, which agrees more with the present results since there also was no significant correlation between handedness and eye preference found.

Interesting, but not entirely unexpected, was the correlation found between eye preference and eye dominance. According to Ehrenstein et al. (2005), eye preference seems to be reflected by eye dominance, while Fagard et al. (2008) instead claimed that eye dominance is unrelated to eye preference, once again showing the conflicting findings regarding eye preference correlations.

In the present study, no significant correlation was found between neither visual acuity and eye preference, nor visual acuity and eye dominance. However, between subjects with differing visual acuity, a significant correlation was found between visual acuity and handedness, though this probably has to do with most of the human population being right-handed, and the fact that only a single test subject was left-handed, thus making the statistics slightly unreliable.

5.7 Conclusion

In accordance with previous studies, most of the present test subjects were right-handed. A clear preference for the right eye was also found, alongside major right-eye-dominance. No clear correlations were found between several of the parameters, except for eye preference and eye dominance, and visual acuity and handedness. It is hard to explain how and why some variables correlate, while others do not, but the results suggest that further studies are needed if possible correlations are to be found and understood. The present study may contribute to increased knowledge about lateralised brain function, in turn leading to a better understanding of brain function in general, and impairments of brain function due to injury, disease, or aging.

6 Acknowledgments

I would like to thank my tutor, Matthias Laska, as well as family and friends for continuous support and help with this bachelor thesis.

7 References


Supplementary information

Suppl. info. 1. Snellen chart used to measure visual acuity.

Suppl. info. 2. Microscope used to measure eye preference.

Suppl. info. 3. Telescope used to measure eye preference.

Suppl. info. 4. Camera used to measure eye preference, with viewfinder in the middle of the apparatus.
Suppl. info. 7. Questions used in the Edinburgh Handedness Inventory to assess handedness. Should the subject always use the right hand in a given situation, two marks were made in the right column, and vice versa for left hand usage. Should the subject be indifferent to right- or left-hand usage, a mark was made in each column.

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