Linköping University | Department of Physics, Chemistry and Biology
Type of thesis, 16 hp | Educational Program: Physics, Chemistry and Biology
Spring term 2016 | LITH-IFM-G-EX—16/3182--SE

# Eye preference in humans and its correlation with eye dominance, visual acuity and handedness.

**Joakim Cederlund**

Examinator, Per Jensen
Tutor, Matthias Laska

LINKÖPINGS UNIVERSITET

**Institutionen för fysik, kemi och biologi**
Department of Physics, Chemistry and Biology
Avdelningen för biologi
Instutitionen för fysik och mätteknik

**Datum**/Date

2016-06-03

**Språk**/Language

**Engelska**/English

Report category

Examensarbete
C-uppsats

**ISBN**
LITH-IFM-G-EX—16/3182--SE

**ISRN**

**Serietitel och serienummer** **ISSN**
Title of series, numbering

**Handledare**/Supervisor Matthias Laska

**Ort**/Location: Linköping

**URL för elektronisk version**

**Titel**/Title:
# Eye preference in humans and its correlation with eye dominance, visual acuity and handedness.

**Författare**/Author:
Joakim Cederlund

**Sammanfattning**/Abstract:

Handedness is the most obvious expression of lateralized behaviour in humans. However, there is only limited knowledge about other forms of lateralized behaviour, e.g. preferential use of an eye and whether these may correlate with handedness.
Thus to investigate this, 100 subjects (50 males and 50 females) between 11 and 80 years of age were assessed for their eye preference, eye dominance, visual acuity, and handedness. Eye preference was assessed by performing four different monocular tasks, eye dominance by performing the binocular Dolman test, visual acuity was assessed with a Snellen chart and handedness was surveyed using the Edinburgh Handedness Inventory. Regarding eye preference, the right eye was preferred by 69% of the subjects. 90 % of the subjects were consistent for their preferred eye across all four tasks. 66% of the subjects had a dominant right eye, 33% had left eye dominance and 1% could not be assessed using the Dolman test. 56% of the subjects differed in their visual acuity between both eyes, while 43% had the same visual acuity in both of their eyes. 86% of the subjects were right-handed while 4% were left handed and 10% were ambidextrous. Significant correlations were found between visual acuity and eye preference and between visual acuity and eye dominance. The study also found a positive correlation between handedness and eye preference. These results support the notion that there is a weak correlation between the different aspects of lateralized behaviour in humans.

**Nyckelord**/Keyword:
Eye preference, handedness, visual acuity, eye dominance, correlation.

Contents

## 1 Abstract

Handedness is the most obvious expression of lateralized behaviour in humans. However, there is only limited knowledge about other forms of lateralized behaviour, e.g. preferential use of an eye, and whether these may correlate with handedness.

Thus to investigate this, 100 subjects (50 males and 50 females) between 11 and 80 years of age were assessed for their eye preference, eye dominance, visual acuity, and handedness. Eye preference was assessed by performing four different monocular tasks, eye dominance by performing the binocular Dolman test, visual acuity was assessed with a Snellen chart and handedness was surveyed using the Edinburgh Handedness Inventory. Regarding eye preference, the right eye was preferred by 69% of the subjects. 90 % of the subjects were consistent for their preferred eye across all four tasks. 66% of the subjects had a dominant right eye, 33% had left eye dominance and 1% could not be assessed using the Dolman test. 56% of the subjects differed in their visual acuity between both eyes, while 43% had the same visual acuity in both of their eyes. 86% of the subjects were right-handed while 4% were left handed and 10% were ambidextrous. Significant correlations were found between visual acuity and eye preference and between visual acuity and eye dominance. The study also found a positive correlation between handedness and eye preference. These results support the notion that there is a correlation between the different aspects of lateralized behaviour in humans.

**Key words:** Eye preference, handedness, visual acuity, eye dominance, correlation.

## 2 Introduction

Handedness is a well-known phenomenon that occurs in humans. Handedness refers to a preferred usage of a specific hand in order to perform tasks. Approximately 90% of the world's population are right-handed and the majority of the remaining 10% are left-handed. However, handedness is not the only lateral preference that humans display. Lateral preference can also be observed in other parts of the human body, such as the use of a preferred eye (Mapp et al. 2003). Eye preference has not only been reported in humans but also in other animals such as rhesus monkeys (Kruper et al 1966). This phenomenon is even displayed by invertebrates such as octopuses (Byrne et al. 2002, 2004). Thus it seems that eye preference has ancient evolutionary roots. Visual input and experience have been shown to affect which limb is preferred (Ocklenburg et al. 2009), so it would seem that eye preference and handedness might be connected.

Different simple behavioural tests have been created to determine the eye preference in humans (Osburn and Klingsporn 1998). These tests often include

using objects that require the use of one eye.  However, there have been only a few studies that compared the different tests to one another and assessed if humans display a preference for the same eye across different tests.
There are also tests that have been made to assess eye dominance. Eye dominance refers to the phenomenon that input from one eye is dominant (that is: processed in a privileged manner) over simultaneous input from the other eye in binocular tasks.

Furthermore, the correlation between visual acuity and eye preference has not been properly explored. To add to the confusion surrounding the subject, previous studies have come up with conflicting results regarding the connection between handedness and eye preference (Bourassa et al. 1996; Brown and Taylor 1988).

### 2.1 Aim

The aims of the present study were:

- To assess if humans display an eye preference when performing monocular tasks.
- To determine if there is a consistency in the results from different tasks used to assess eye usage preferences.
- To assess the correlation between visual acuity and eye preference
- To assess the correlation between handedness and eye preference
- To assess the correlation between eye dominance and eye preference.
- To assess if visual acuity correlates with eye dominance.
- And to assess if there are gender differences between the mentioned variables.

## 3 Material and method

### 3.1 Subjects

A total of 100 humans (50 males and 50 females) ranging in age from 11 to 80 years of age participated in the study. The subjects were not informed about the true nature of the study beforehand and were only informed that there were some simple tasks to perform. The only exception to this was the parents of the children that participated in the study. They were informed beforehand about the tests and the exact nature of the study in order to be able to give their consent of letting their children participate. All subjects were informed about the goal of the study once all tests had been completed.

### 3.2 Eye preference test

Eye preference was assessed by asking the subject to look through different objects that require the use of one eye. Basic instructions were given in order to make the choice of an eye as intuitive as possible. To this end, the subjects were instructed to focus on what they could see while using the object whereas their choice of eye to perform the task was silently recorded.
Four tasks were used in order to assess the eye preference of each participating subject. For each task the eye used was recorded.

- The tasks used during the test were:
- Telescope: subjects were asked to look through the telescope and describe what they see.
- Microscope:  subjects were asked to look into the microscope and describe what they see.
- Kaleidoscope: subjects were asked to look into the kaleidoscope and describe the shapes and colours they see.
- Camera: subjects were asked to look through the viewfinder of a photo camera as if they would take a picture.

### 3.3 Dolman test

In order to determine the dominant eye, subjects were asked to perform a Dolman test by standing at a distance of 5 metres from the Snellen chart previously used to determine visual acuity. They were then instructed to hold a wooden board measuring 40x30 centimetres with a small hole measuring 1 centimetre in diameter cut into the centre of it, with their arms outstretched in front of them. The subjects were asked to focus their gaze with both of their eyes being open on one of the more visible letters at the top of the Snellen chart. Then they were asked to alternatingly close one of their eyes and the eye that still could see the chosen letter through the hole was recorded as the dominant one.

### 3.4 Visual acuity

In order to assess the visual acuity in a subject, a classical Snellen chart with rows of increasingly smaller letters, was used.

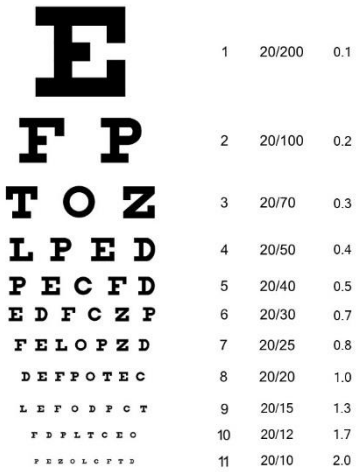


*Figure 1. An example of a Snellen chart (Khex14 2014).*

The subject was instructed to read as far down as possible on the chart, while keeping one eye closed. The further down the subject could read the higher the acuity of the eye used. When the subject misread a letter, the previously correctly read row was recorded as the visual acuity for that eye. The subject then read the chart once more using the previously closed eye.

### 3.5 Handedness test

Handedness was determined using the Edinburgh Handedness Inventory. This questionnaire is a validated and widely used test to assess handedness. The questionnaire is composed of ten questions about preferential hand usage regarding common situations such as writing and throwing a ball. Every subject was given the same instructions to fill it out. Using the answers, a score indicating the handedness can be calculated. Questions about the questionnaire posed by the subjects were answered by the experimenter in order to help the subject fill it in correctly.
The calculated score for each participant ranges from -100 to +100. Every score above +40 indicates right handedness and scores below -40 indicate left handedness. Scores ranging between -40 and +40 indicate that the subject is ambidextrous.

### 3.6 Data analysis

Analysis was performed on the whole group of subjects as well as on each gender separately. Age was also used as a factor to test its correlation with handedness.
The two-tailed binominal test was used in order to assess whether an observed ratio (e.g. the number of subjects preferring their right eye, and the number of subjects preferring their left eye in one of the four given tasks) differs

significantly from chance, (in this case 50:50 since there are two different choices - left or right).
The chi-square test was used to assess whether two observed ratios (e.g. the ratio of right eye- to left eye use in males, respectively in females) differs from each other.
The Spearman rank-correlation test was used to assess whether two measures (e.g. age and handedness) correlate with each other.

## 4 Results

### 4.1 Eye preference

Among all subjects 70% preferred the right eye during the microscope task and 30% preferred their left eye. In the telescope task 71% showed a right-eye preference and 29% showed left-eye preference. In the kaleidoscope task 69% of the subjects showed a right-eye preference and a 31% a left-eye preference. In the fourth and final task, the photo camera, 65% preferred to use their right eye and 35% preferred their left eye (figure 2). There was no significant difference in eye use between the different tasks (chi-square $p>0.05$)

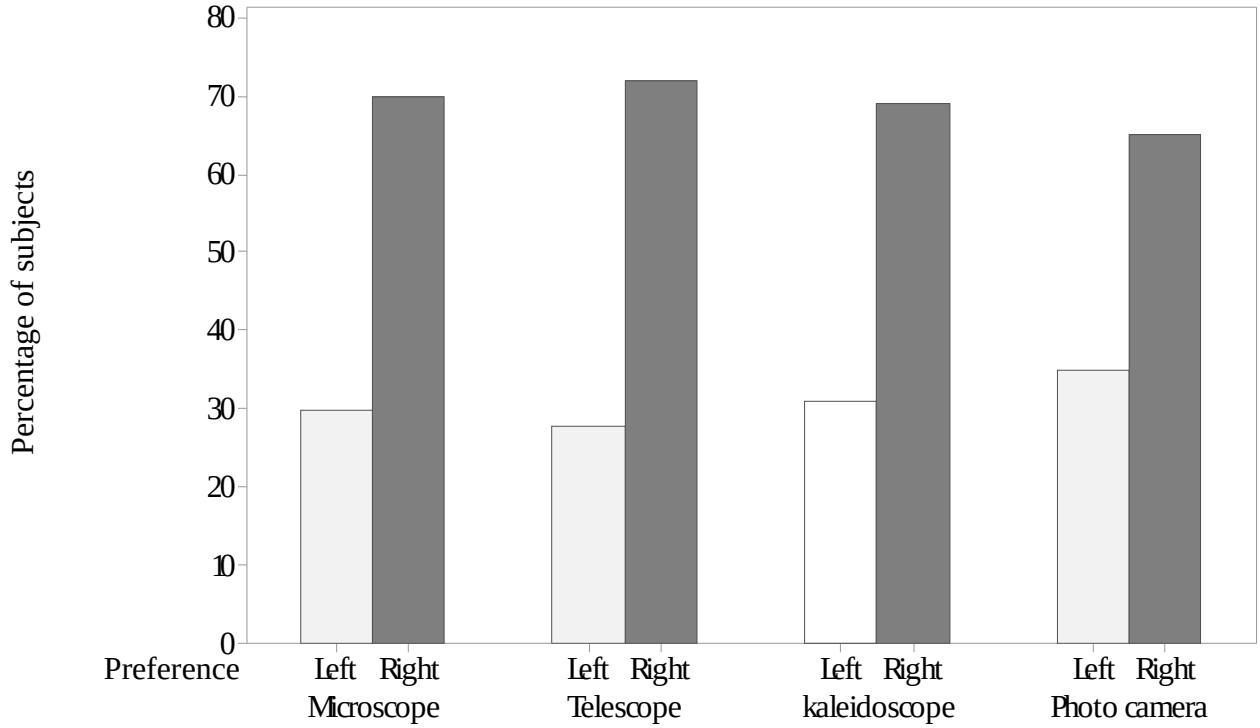


*Figure 2. Eye preference among all subjects in the different tasks. Light grey bars indicate left eye preference. Dark grey bars indicate right eye preference*.

As a group the subjects significantly preferred their right eye over their left eye in all four tasks (binominal test $p=0.000$ in all four tasks).

Among the female subjects, 68% preferred their right eye during the microscope task and 32% preferred the left eye. With the telescope task 72% of females preferred the right eye and 28% the left eye. During the photo camera task 60% of females preferred to use the right eye and 40% preferred the left eye. During the kaleidoscope task, 68% of females had right-eye preference and 32% had a left-eye preference (figure 3.).

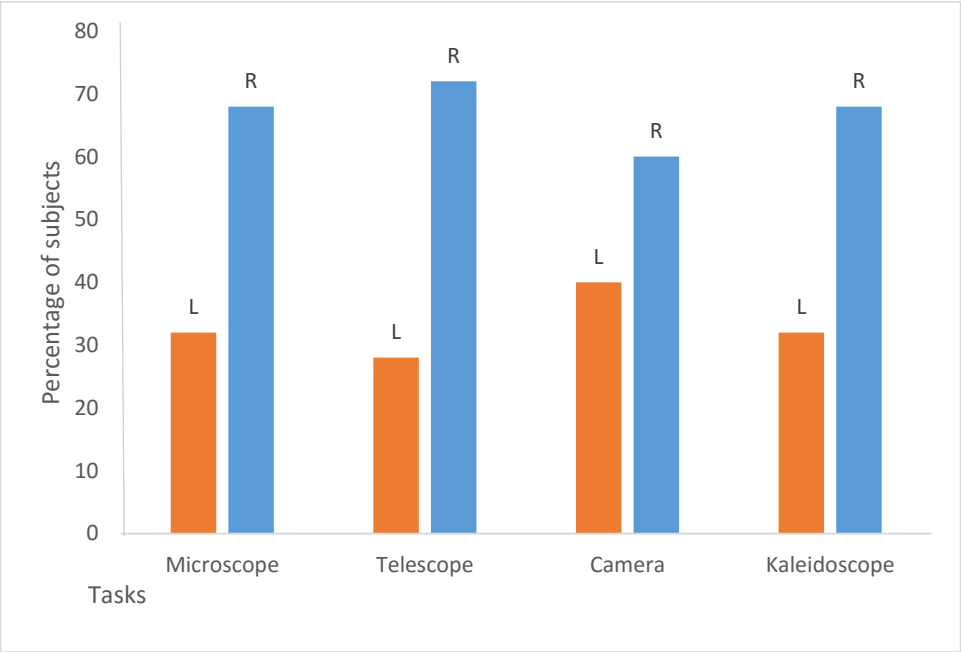


*Figure 3. Ratio of eye preference among female subjects in all four tasks. R: right eye preference. L: left eye preference.*

Among the male subjects, 72% used their right eye and 28% their left eye during both the microscope task and the telescope task. In the photo camera task, male subjects had a right-eye preference of 70% and a left-eye preference of 30%. In the kaleidoscope task, 70% of the male subjects preferred the right eye and 30% preferred the left eye (figure 4.).
No difference was found in the ratios of eye preference between males and females across all different tasks (Chi-square $p>0.05$). (Figure 3.; Figure 4.)

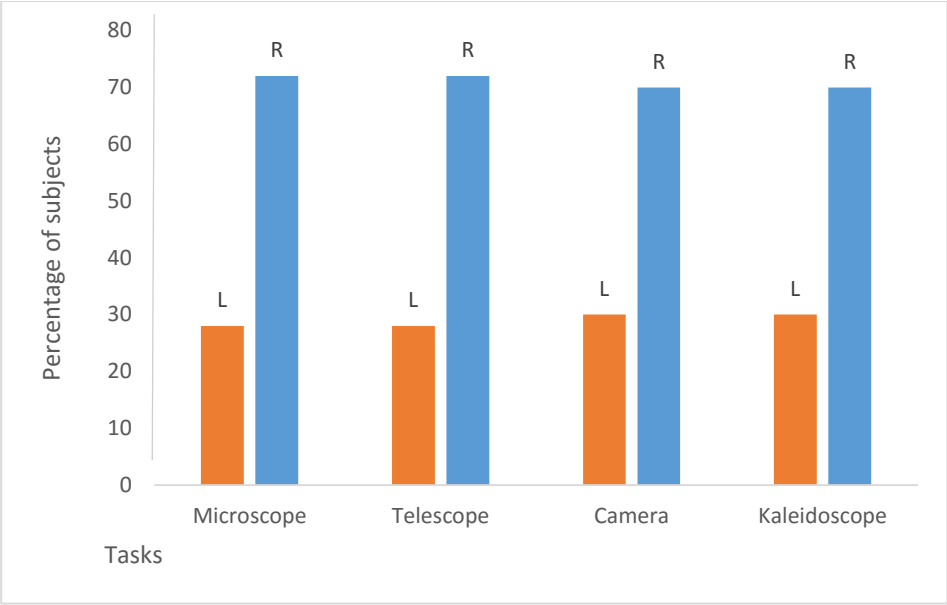


*Figure 4. Ratio of eye preference among male subjects in all four tasks.*

When looking at the consistency of eye preference for all subjects across all four tasks I found that the same eye was preferred in every task in 90% of the subjects while 9% used the same eye for three of the four tasks. Only 1% of subjects used one eye for two of the tasks and the other eye for the other two tasks.

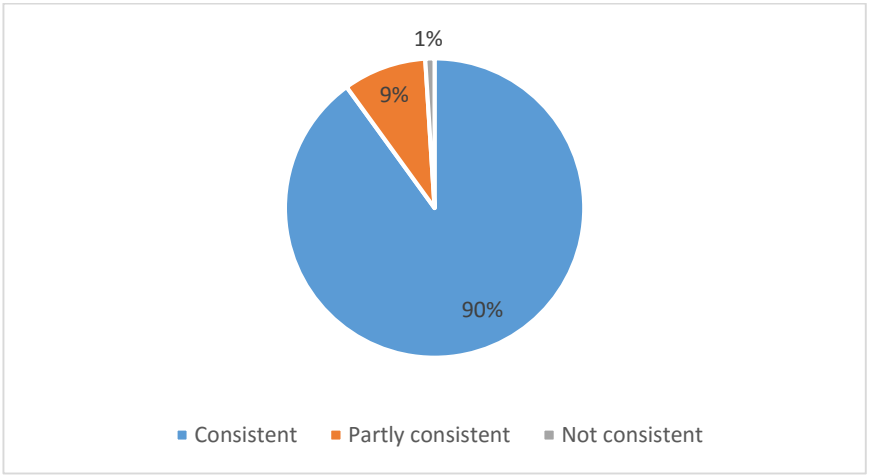


*Figure 5. Consistency of eye preference across the four tasks. Consistent: same eye used in all four tasks, partly consistent: same eye used in three of the four tasks. Not Consistent: Same eye used in two tasks each.*

When comparing consistent eye use in male subjects, 94% were consistent across all four tasks and 6% were consistent across three of the tasks. For the female subjects, 86% were consistent in eye usage across all four tasks, 12% were consistent in eye usage across three of the tasks and 2% were not consistent in eye usage. Accordingly, no significant difference between the genders was found regarding consistency of eye usage (Chi-square p>0. 05).

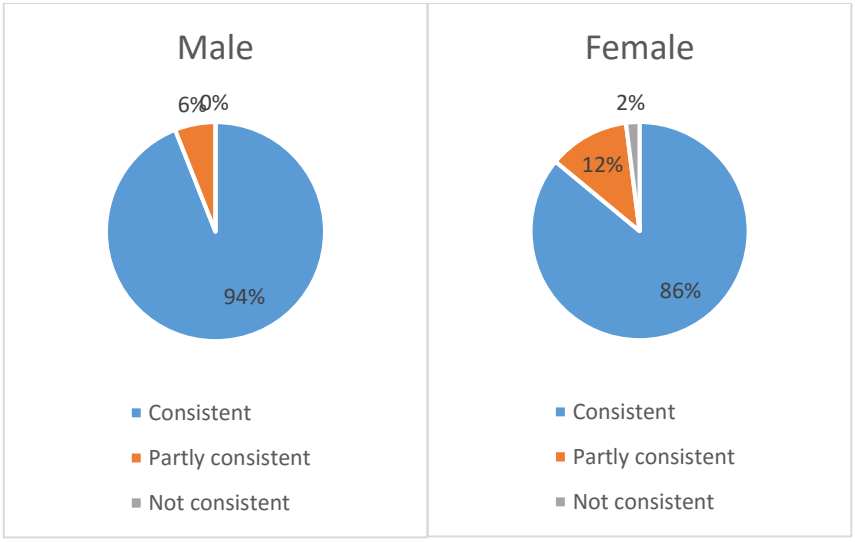


*Figure 6. Consistency of eye preference across the four tasks, in males (left panel), and females (right panel), respectively. Consistent: same eye used in all four tasks. Partly consistent: same eye used in three of the tasks. Not consistent: Same eye used in two tasks each.*

## 4.2 Eye Dominance

Considering the whole group of subjects, 66% had right eye dominance while 33% had left eye dominance. In one subject the eye dominance was impossible to decide using the Dolman test.

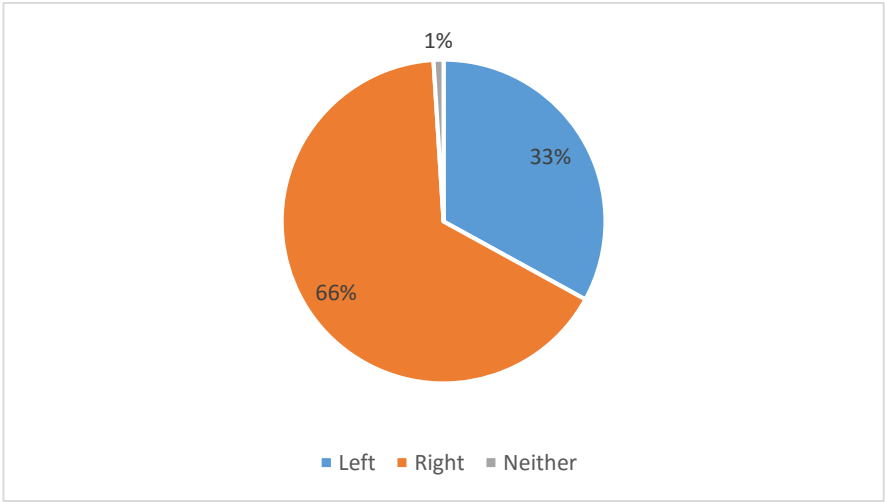


*Figure 7. Distribution of eye dominance among subjects as assessed by the Dolman test.*

When looking at the male subjects, 74% had right-eye dominance, 24% had left-eye dominance. In 2% of males (one single subject) the eye dominance could not be assessed. Among the female subjects the distribution of eye dominance was 48% right and 42% left. When comparing the eye dominance between genders a significant difference in the number of subjects with right eye dominance was found (chi-square p= 0.024).

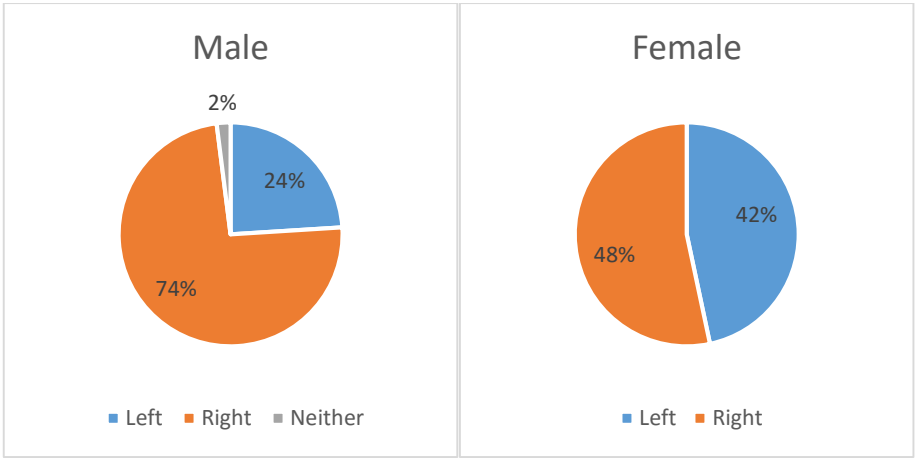


*Figure 8. Distribution of eye dominance among subjects as assessed by the Dolman test in males (right panel) and females (left panel).*

## 4.3 Visual acuity

Considering the whole group of subjects, 37% had a better visual acuity with their left eye, 29% with their right eye, and 43% had the same visual acuity in both of their eyes. Among female subjects there were 18% with higher left visual acuity, 34% with higher right visual acuity and 48% same visual acuity. Among male subjects, there were 38% with better left acuity, 24% better right acuity and 38% had the same visual acuity. When comparing the frequency of males and females with differing visual acuity, a significant difference in the number of males with better left visual acuity and the number of females with better left visual acuity was found (chi-square p= 0,005). (Figure 9.)

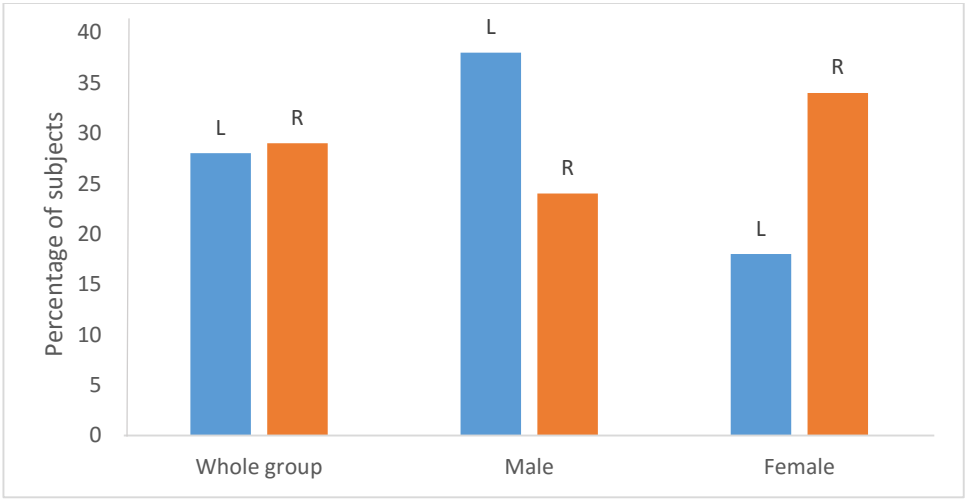


*Figure 9. Ratio of better visual acuity between right or left eye. For the whole group, males and females with differing visual acuity between their eyes.*

### 4.4 Visual acuity and eye preference

Among all subjects displaying differing visual acuity between both eyes, 64% showed consistency between eye preference and stronger visual acuity, while 36% did not display consistency between visual acuity and eye preference. A significant difference was found in the ratio between subjects displaying better right-eye acuity while displaying right-eyed preference and the number of subjects displaying better right-eye acuity while displaying left-eyed preference (chi-square p= 0.017). (Figure 10.)

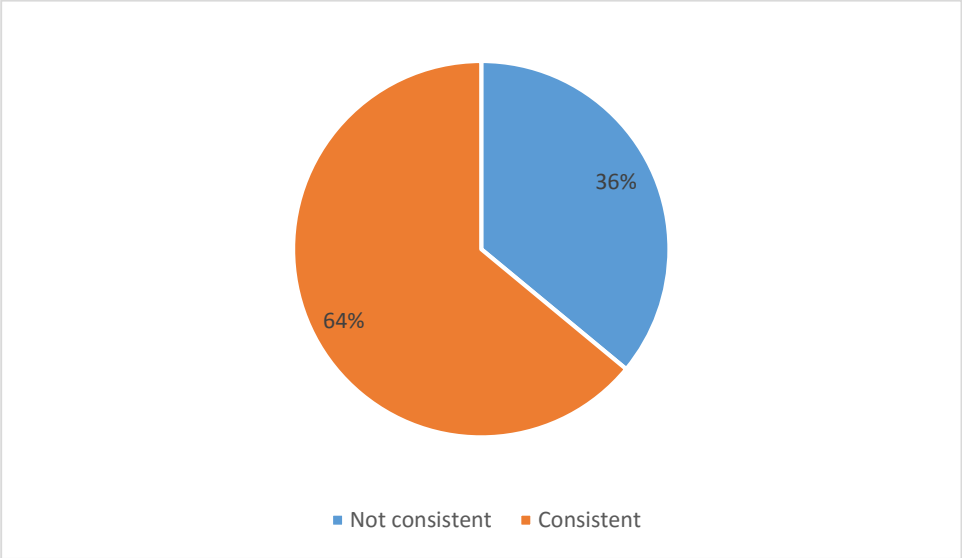


*Figure 10. Visual acuity vs eye preference, among subjects that have differing visual acuity between their eyes. Not consistent: Stronger visual acuity and eye preference do not occur on the same side. Consistent: stronger visual acuity and eye preference occur on the same side.*

### 4.5 Visual acuity and eye dominance

When looking at the consistency between better visual acuity and eye dominance among the subjects with differing visual acuity between eyes, 63% showed stronger visual acuity and eye dominance on the same side, while 37% did not show consistency between visual acuity and eye dominance. (Figure 11.)
When assessing the relation between visual acuity and eye dominance, a significant difference between the number of subjects with better right visual acuity among left and right dominance groups was found (chi-square p=0.028).

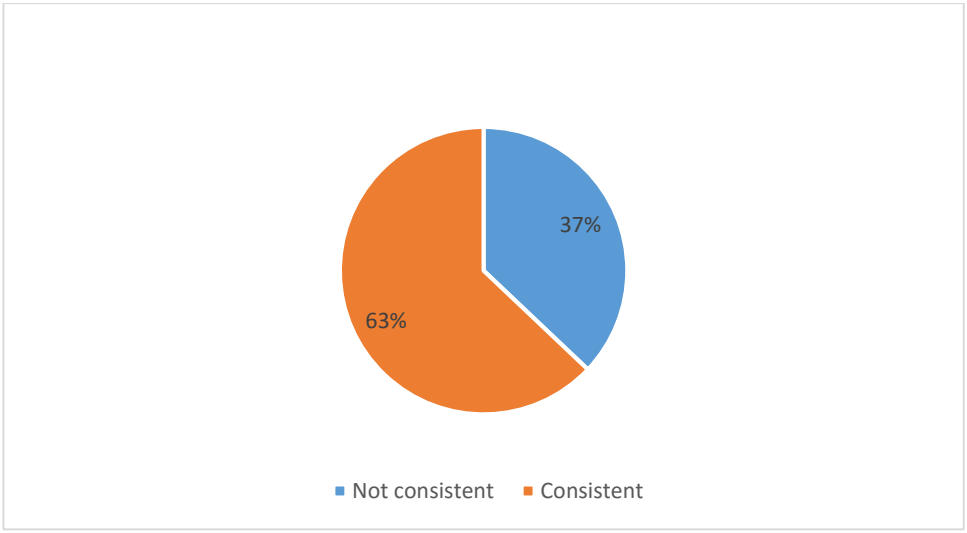


*Figure 11. Consistency of acuity and eye dominance to the same eye, among all subjects with differing visual acuity in their eyes. Not consistent: Stronger visual acuity and eye dominance occur on opposite sides. Consistent: stronger visual acuity and eye dominance occur on the same side.*

## 4.6 Handedness

Among the 100 subjects, 86 were right-handed, 4 left-handed and 10 were ambidextrous. Among female subjects there were 44 right-handed, 2 left-handed and 4 ambidextrous. Among the male subjects there were 42 right-handed, 2 left-handed and 6 ambidextrous. (Figure 11)
There was no significant difference between the distributions of handedness between males and females. (Chi square p= 0.8).

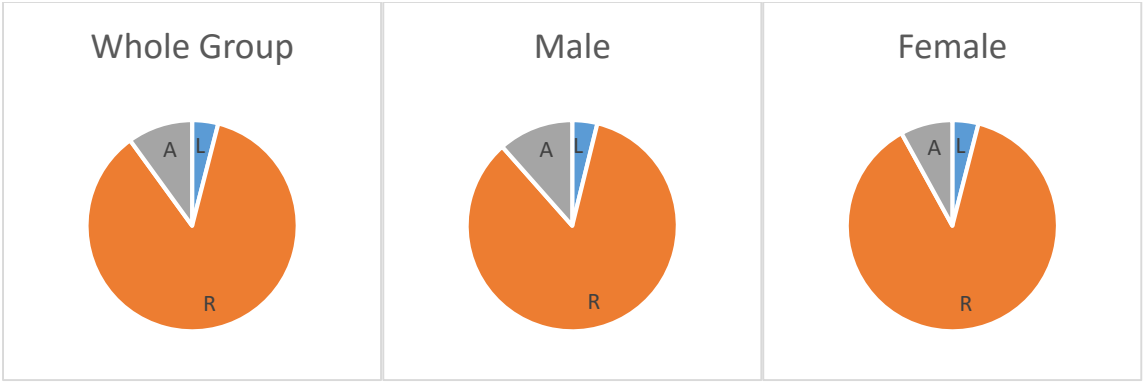


*Figure 12. Distribution of handedness as determined by the Edinburgh Handedness Inventory, left for the whole group, centre in males, right in females. (R: right-handed; L: left-handed; A: ambidextrous).*

When considering the whole group of subjects, no significant correlation between the strength of handedness and age was found (Spearman r=0.013 p=0.899). (Figure 13.)

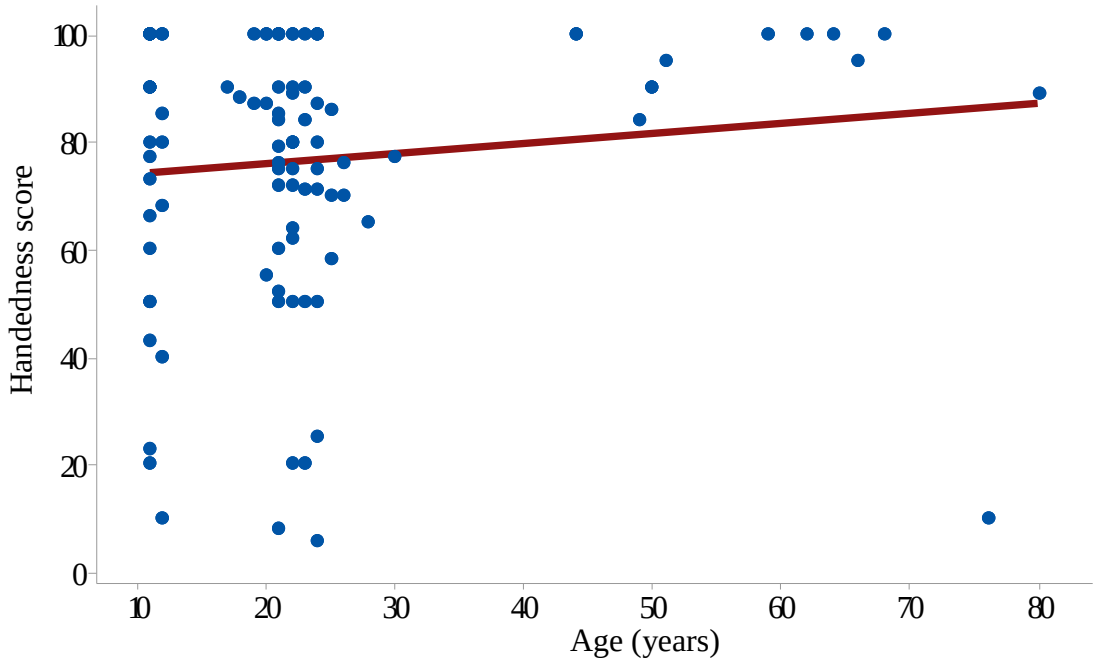


*Figure 13. Correlation between age and strength of handedness.*

## 4.7 Eye preference vs handedness

Among all left-handed subjects, 75% preferred their left eye and 25% preferred their right eye. Among the right-handed subjects only 30% preferred their left eye, while 70% preferred their left eye. This gave rise to a significant difference between the two preferences in regard to handedness (Chi-square p= 0.000)

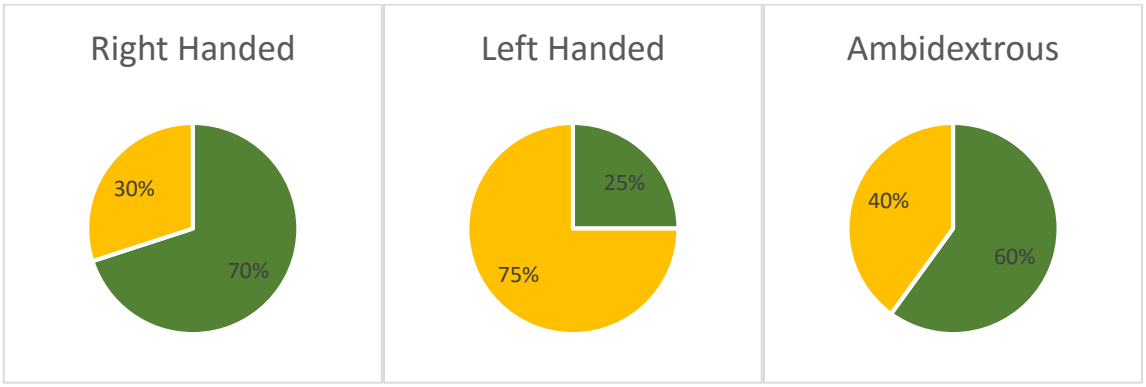


*Figure 14. Handedness and eye preference in all subjects. Green: indicates preference for the right eye. Yellow: indicates preference for the left eye.*

### 4.8 Eye Dominance vs handedness

When looking at the consistency between handedness and eye dominance in the whole group of subjects, 61% showed eye dominance and handedness on the same side while these differed for the other 39%.

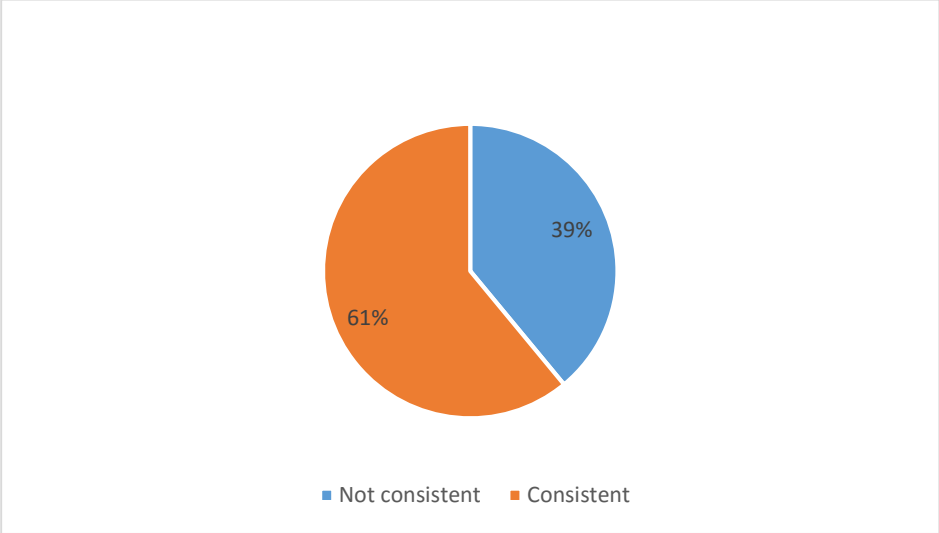


*Figure 15. Consistency between eye dominance and handedness in all subjects. Consistent: shows same side for both handedness and eye dominance. Not consistent: shows that handedness and eye dominance occur on opposite sides.*

## 5 Discussion

### 5.1 Eye preference

90% of the 100 subjects in the present study were consistent in their preferred eye across the four tasks. This high degree of consistency still remained when looking at males and females separately. A high consistency of eye preference across different tasks has also been reported in an earlier study on school-age children (Van der Elst et al 2011). Thus it can be concluded that humans do prefer to use one eye across different tasks and that this preference is found significantly more often for the right eye than for the left eye.

### 5.2 Eye dominance

When looking at the eye dominance among the subjects, 66% had right eye dominance and 33% left eye dominance. These results were extremely similar to results found in a previously conducted study (Pointer 2001). The results from Pointer's study also corresponded well with the ratio of right and left eye dominance in males that were found in the present study, but they did differ from the ratio displayed in females. It is possible, however, that the reason that there is a difference between males and females is pure chance caused by the small sample size (n= 100 in this study compared to n= 400 in the study by Pointer (2001).

During testing I stumbled upon a single male subject in which the Dolman test was unable to properly assess which eye was the dominant one. The subject in question was afflicted with slight strabismus, or more commonly referred to as cross eyedness. This is a condition that hampers binocular vision and prevents focused vision upon an object from both eyes. Although this was one isolated incident during testing it still poses an interesting question: If the eye dominance in people afflicted with conditions that affects the focusing capabilities of the eyes (e.g. strabismus) is affected.

### 5.3 Visual acuity

I found that more than 50% of the subjects had differing visual acuity between the left and right eye. This frequency of differing visual acuity corresponds well to earlier findings by Pointer (2001). However, in contrast to Pointer's results, visual acuity did differ between male and female subjects, with higher left eye acuity being more common among the male subjects. It is possible that this significant difference is caused by chance due to the small number of subjects in the present study (n=100) in comparison with the study performed by Pointer (2001) (n=400). Further studies with larger numbers of subjects need to be done to see if this difference in left eye acuity between males and females remains.

### 5.4 Handedness

The handedness scores collected in the present study agree with earlier studies on frequencies of right- and left-handedness in humans, with 86% of the subjects being right handed, 4% being left handed and 10% being ambidextrous. This correlates well with previous findings of 90% right-handedness and 10% left-handedness (Gilbert and Wysocki 1992; Bourassa et al 1996).
The only difference from previous studies, was the slightly higher frequency of ambidextrous subjects.

### 5.5 Correlations between measures

There was no significant correlation between age and strength of handedness. Nothing pointed towards an increase in the strength of handedness with older age. Among all of the older subjects (age > 50) only one was ambidextrous while all the other elderly subjects were found to be right handed. This result is similar to findings by Kalisch et al (2006). In the earlier study, many older subjects reported themselves to be unambiguously right handed, but when assessed with practical handedness tests there was a tendency for subjects of losing their right handedness and slipping towards being ambidextrous when advancing in age. The older subjects in Kalisch's subjects were unaware of this change and would thus still in written questionnaires refer to themselves as right handed. This could very well be the case in the present study as well and I

propose that for further studies a reliable handedness questionnaire should be paired together with practical tasks to assess handedness more accurately.

Assessing the correlation between handedness and eye preference the two variables were closely linked in right-handed subjects showing a majority of these subjects also preferred their right eye and left handed subjects showing a greater preference for their left eye. However since these two groups differed markedly in size (left-handed: n =4, n right-handed: n = 86) the data gathered from comparing them might be unreliable because of the small sample size of left-handed subjects. An earlier study reported that while right-handedness and right eye preference are the most common lateralized behaviours, there is no significant correlation between them (Porac and Coren 1975). This finding correlates well with the results of the present study.

When comparing the differing visual acuity between subjects with right eye preference and left eye preference, it was found that there was a significant difference in the distribution of individuals with better visual acuity in their right eye. The subjects with right eye preference included a higher frequency of individuals with better visual acuity in their right eye, than in the left eye. This correlation between the eye with better visual acuity and the preferred eye being the same was also found in the previously mentioned study by Pointer (2001). Thus the results of the present study support the notion that eye preference is linked to visual acuity.

There was a significant difference in the number of subjects displaying either better right or left visual acuity across both eye dominance groups (left and right). This gave very similar results as the previously mentioned correlation between eye preference and visual acuity, as subjects with right eye dominance also mostly had better visual acuity in their right eye. However these findings do not correspond well with previous findings (Pointer 2007). Pointer found no straight correlation between eye dominance and higher visual acuity of the same eye. It would thus be interesting to look further into this in future studies in order to discern whether visual acuity really is linked with eye dominance or not.

## 6 Social and ethical considerations

Minors that participated as subjects in the study did all have written consent from their parents or guardian.

## 7 Acknowledgment

I want to thank Matthias Laska for all the support and help I have received throughout the study.

## 8 References

Bourassa DC, McManus IC, Bryden MP (1996) Handedness and eye dominance: a meta-analysis of their relationship. Laterality 1, 5-34.

Brown ER, Taylor P (1988) Handedness, footedness, and eyedness. Percept. Mot. Skills. 66, 183-186.

Byrne RA, Kuba M, Griebel U (2002) Lateral asymmetry of eye use in Octopus vulgaris. Anim. Behav. 64, 461-468.

Byrne RA, Kuba M, Meisel DV (2004) Lateralized eye use in Octopus vulgaris shows antisymmetrical distribution. Anim. Behav. 68, 1107-1114.

Gilbert AN, Wysocki CJ (1992) Hand preference and age in the United States. Neuropsychologia. Vol 30, No 7, 601-608.

Kalisch T, Wilimzig C, Kleibel N, Tegenthoff M, Dinse HR (2006) Age-Related Attenuation of Dominant Hand Superiority. PLOS one http://dx.doi.org/10.1371/journal.pone.0000090

Khex14, (10 February 2014) Sample Snellen chart with decimal scale. http://creativecommons.org/licenses/by-sa/3.0/legalcode

Kruper DC, Boyle BE, Patton RA (1966) Eye and hand preference in rhesus monkeys (Macaca mulatta). Psychonom. Sci. 5: 277-278.

Mapp AP, Ono H, Barbeito R (2003) What does the dominant eye dominate? A brief and somewhat contentious review. Percept. Psychophys. 65, 310-317.

Ocklenburg S, Bürger C, Westermann C, Shneider D, Biedermann H, Güntürkün O (2009) Visual experience affects handedness. Behav. Brain. Res. 207, 447-551.

Osburn DM, Klingsporn MJ (1998) Consistency of performance on eyedness tasks. Br. J. Psychol. 89, 27-37.

Pointer JS (2007) The absence of lateral congruency between sighting dominance and the eye with better visual acuity. Ophthal. Physiol. Opt. 27: 106-110.

Pointer JS (2001) Sighting dominance, handedness and visual acuity preference: three mutually exclusive modalities? Ophthal. Physiol. Optics 21: 117-126.

Porac C, Coren S (1975) Is sighting dominance a part of generalized laterality? Percept. Mot. Skills 40: 763-769.

Van der Elst W, Meijs CJC, Hurks PPM, Wassenberg R, Van Boxtel MPJ, Jolles J (2011) Lateral preferences and their assessment in school-aged children. Laterality: Asymmetries of Body, Brain and Cognition volume 16,issue 2, 2011: 207-226.