Simon Howard

# Eye Colour FINGER length and SHOE SIZE

# Summary

Tabloid newspapers often run articles which make seemingly dubious claims about personality traits which can be derived from the lengths of a person's fingers. Since these claims appear to be rather suspicious I chose to investigate finger lengths in order to try and discover whether or not there is any truth in such claims. I therefore collected data about 100 of my college peers (50 males and 50 females) and conducted several statistical tests upon this data to see whether I could find evidence to support or refute the various newspapers' claims.

I investigated whether or not there was a correlation between the lengths of two fingers (the middle finger and the forefinger), and found that there was indeed a positive correlation present. I then went on to test for correlation between finger size and shoe size and, again, found that a positive correlation was present.

Using a difference in means test, I then compared the lengths of fingers in males and females, and discovered that there was evidence to suggest that a difference was present. My inferences that male fingers were probably longer than female fingers led me to conduct a one-way difference in means test, with which I found strong evidence to support my inference.

I expected a difference in the lengths of fingers on dominant and recessive hands, however a test using confidence intervals found no evidence to support this.

A magazine article claiming that degree of femininity can be judged through eye colour then led me to use contingency tables to find out if, as the article would suggest, females tended to have lighter coloured eyes than males. Again, I found no evidence to support this claim.

# Introduction

Tabloid newspapers often run articles which make seemingly dubious claims about different ways to find out about the personality of someone having only just met them. One such claim is that the lengths of, for example, the middle finger in relation to the forefinger can indicate a person's sexuality and other personality traits.

To me, these claims appear to be rather suspicious, particularly as they are rarely backed up with evidence. Therefore, I have chosen to investigate finger lengths in order to try and discover whether or not there is any truth in such claims.

I intend to first of all investigate whether or not there is a correlation between the lengths of the middle finger and the forefinger, since a link would seem to be in contradiction to the newspapers' claims, which would seem to apparently suggest that there is no link between the two. In order to do this, I will first of all need to fit a Normal distribution to the data, using a Chi-Squared test with the hypotheses:

$H_0$: The Normal distribution N($\hat{\mu},\hat{\sigma}^2$) is a suitable model for the data.

$H_1$: The Normal distribution N($\hat{\mu},\hat{\sigma}^2$) is an unsuitable model for the data.

Having then calculated the Product Moment Correlation Coefficient (r) I will test the significance of the value using the hypotheses:

$H_0$: $\rho = 0$ (There is zero correlation between the readings)

$H_1$: $\rho \neq 0$ (There is correlation between the readings)

I will then go on to see if there is a correlation between finger size and shoe size, which should provide an indication of whether finger size is simply in proportion to the size of the rest of the body, rather than being some psychological indicator. Since shoe size is discrete data, I cannot assume normality for the data. I will therefore calculate the Spearman's Rank Correlation Coefficient ($r_s$), and then test this with the hypotheses:

$H_0$: $\rho = 0$ (There is zero correlation between the readings)

$H_1$: $\rho \neq 0$ (There is correlation between the readings)

I will then go on to compare the lengths of fingers in males and females using a difference in means test with the hypotheses:

$H_0$: $\mu_m = \mu_f \Rightarrow \mu_m - \mu_f = 0$ (No difference in means)

$H_1$: $\mu_m \neq \mu_f \Rightarrow \mu_m - \mu_f \neq 0$ (Difference in means)

I will then go on to investigate whether or not there is any difference in finger sizes for dominant and recessive hands using confidence intervals.

I recently read an article in a magazine which suggested that lighter eye colours, such as blue, were an indicator of increased femininity over darker eye colours, such as brown. As this claim is of a similar type to the claims about finger lengths, I decided that it would be an interesting addition to the investigation to see if I could find any evidence to support this or not. Assuming that females on average have increased femininity than the average male, it could be assumed that, if the claims made in these articles are correct, lighter eye colours will be more prevalent among females. I will then use contingency tables to investigate the hypotheses:

$H_0$: The variables eyes colour and sex are independent
$H_1$: The variables eye colour and sex are *not* independent

In summary, this investigation will compare finger lengths on individuals, finger lengths on the different sexes, finger lengths with shoe sizes, and will also look into claims that lighter coloured eyes are an indicator of increased femininity.

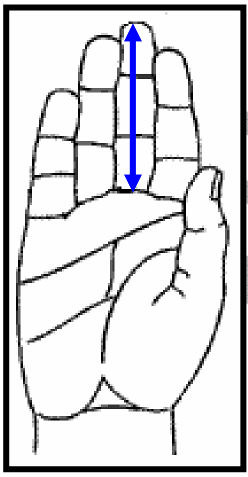
## Data Collection

Clearly, a census would be the most accurate sampling method, since this would produce definitive results for the college population. However, this was impractical due to the fact that a limited amount of time was available for the collection of data for this investigation. I therefore decided to take a sample of 100 college students. I chose to take fifty males and fifty females as my sample, so that there would be two distinct populations between which I could draw comparisons. I felt that, whilst more sampling units would be beneficial, fifty units was enough to draw fairly firm conclusions, whilst not being too many to be impractical to collect and process the data.

I chose opportunity sampling as my method of data collection for this investigation. I felt that random sampling would be very time consuming, as this would involve selecting individuals from all different faculties of the college, tracking them down and surveying them. This could clearly take a long time, whereas opportunity sampling would provide a comparatively quick data collection method, which was helpful given the limited amount of time provided to complete this investigation.

I chose subjects to participate in my survey by standing in the Link building at college, and asking people whether they would mind me measuring their hands and answering some questions. I also asked some friends to ask their friends if I could measure their hands, meaning that over a period of about two weeks' worth of break times, I had collected the data I required for this investigation. Before collecting data from any individual, I was careful to check with them that I had not done so already, in order to avoid any repeats.

I collected data in several categories: finger lengths, shoe size, eye colour, age and college faculty, and gender.



For finger lengths, I measured the middle and fore-fingers on each of the dominant and recessive hands. I defined the dominant hand as the one with which the respondent wrote most often, with the recessive hand being defined as the other one. The fore-finger was defined as that next to the thumb, and the middle finger as that next to the fore-finger. I measured down the centre of each finger, palm-upwards, from the lowest point of the crease in the skin where the finger joins the hand to the top of the finger, ignoring any nails extending beyond the length of the finger itself. Each person was asked to hold their hand as flat as possible, with the fingers together. As an example, the correct measurement length for the middle finger of the right hand is show in the diagram on the left.

Participants were asked to give the size of the shoes they were wearing at the time of questioning. I chose to ask the question in this way in order to avoid the problem of people who, for example, take different shoe sizes in trainers to the size they take in 'smart' shoes.

Whilst a more ideal solution to collecting data on eye colour would have been to judge it for myself, my colour vision is less than perfect and so I questioned each individual to establish what they thought their own eye colour was, and used this as the data. In situations where the subject was indecisive, offering responses such as ‘a kind of bluey-greeny colour’, or in the surprisingly common case where people did not know what colour their eyes were, I asked another person to judge. Using this method, each subject was categorised into either blue, green, grey or brown eye colours. There were no instances of people having two different eye colours, but in this case I would have taken the eye colour on the side corresponding to the dominant hand.

Finally, I determined both age and college faculty through questioning.

The following pages shows an empty data collection table. The form was initially filled in by hand, and then processed into a spreadsheet format.

## MALES

| | D Middle | D Fore | R Middle | R Fore | Shoe Size | Eye Colour | Age | Faculty |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
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| 50 | | | | | | | | |

## FEMALES

| | D Middle | D Fore | R Middle | R Fore | Shoe Size | Eye Colour | Age | Faculty |
|---|---|---|---|---|---|---|---|---|
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## Analysis

The following pages show the raw data collected processed in several initial ways.

The first page shows the raw data, as it was entered into a spreadsheet immediately following data collection.

I began by reordering the data for finger sizes within the spreadsheet package, in order to calculate the frequency densities necessary to produces histograms. These are shown on the following pages: On the first pair of facing pages, I have shown histograms for fore-fingers on both dominant and recessive hands, and on the following pair of facing pages, I have shown histograms for the middle fingers. The working for frequency density for these histograms is given in the appendix on page A13.

I have also included a back-to-back stem and leaf diagram as well as a comparative boxplot to show the relationship between male and female shoe sizes.

**MALES**

| | D Middle | D Fore | R Middle | R Fore | Shoe Size | Eye Colour | Age | Faculty |
|---|---|---|---|---|---|---|---|---|
| 1 | 8.0 | 7.4 | 8.2 | 7.4 | 10 | Blue | 17 | MS |
| 2 | 7.8 | 7.6 | 7.7 | 7.3 | 9 | Blue | 18 | MS |
| 3 | 8.2 | 7.5 | 7.7 | 7.7 | 9 | Brown | 17 | MS |
| 4 | 8.7 | 7.5 | 8.5 | 7.5 | 11 | Brown | 17 | MS |
| 5 | 8.0 | 7.8 | 7.9 | 7.3 | 10 | Blue | 17 | MS |
| 6 | 8.4 | 7.4 | 8.3 | 7.5 | 11 | Blue | 18 | MS |
| 7 | 8.1 | 7.1 | 8.1 | 7.1 | 10 | Blue | 17 | MS |
| 8 | 8.7 | 7.7 | 8.7 | 7.5 | 12 | Green | 16 | MS |
| 9 | 7.9 | 7.1 | 7.7 | 6.9 | 9 | Brown | 16 | AH |
| 10 | 8.3 | 7.8 | 8.1 | 7.8 | 10 | Brown | 17 | AH |
| 11 | 7.7 | 7.3 | 7.7 | 7.4 | 9 | Blue | 16 | MS |
| 12 | 8.3 | 7.4 | 8.0 | 7.3 | 9 | Blue | 16 | MS |
| 13 | 8.8 | 8.1 | 9.1 | 8.5 | 11 | Brown | 17 | MS |
| 14 | 9.3 | 8.3 | 9.4 | 8.6 | 12 | Grey | 17 | MS |
| 15 | 10.0 | 9.1 | 10.2 | 9.5 | 13 | Blue | 18 | SO |
| 16 | 8.0 | 7.2 | 8.1 | 7.2 | 8 | Green | 17 | AH |
| 17 | 7.8 | 7.2 | 7.9 | 7.3 | 9 | Brown | 16 | MS |
| 18 | 7.8 | 6.8 | 7.7 | 7.0 | 10 | Blue | 17 | SO |
| 19 | 8.1 | 7.2 | 8.1 | 7.4 | 9 | Brown | 17 | AH |
| 20 | 8.2 | 7.7 | 7.8 | 7.5 | 10 | Blue | 17 | MS |
| 21 | 7.4 | 6.7 | 7.1 | 6.7 | 10 | Blue | 17 | MS |
| 22 | 8.6 | 7.5 | 8.5 | 7.5 | 11 | Blue | 17 | AH |
| 23 | 8.7 | 8.0 | 8.1 | 7.6 | 8 | Blue | 17 | MS |
| 24 | 7.9 | 7.6 | 7.8 | 6.9 | 9 | Brown | 18 | AH |
| 25 | 8.5 | 8.2 | 8.1 | 7.1 | 11 | Blue | 17 | AH |
| 26 | 7.8 | 7.2 | 8.1 | 7.2 | 12 | Blue | 17 | AH |
| 27 | 8.4 | 7.1 | 8.1 | 7.1 | 10 | Blue | 17 | SO |
| 28 | 8.5 | 7.9 | 8.3 | 7.6 | 11 | Brown | 16 | SO |
| 29 | 9.2 | 8.2 | 9.1 | 8.0 | 12 | Brown | 18 | MS |
| 30 | 8.1 | 7.5 | 7.9 | 7.3 | 9 | Blue | 17 | MS |
| 31 | 8.3 | 7.5 | 8.1 | 7.4 | 9 | Brown | 16 | MS |
| 32 | 7.9 | 7.2 | 7.9 | 7.1 | 10 | Brown | 16 | AH |
| 33 | 8.0 | 7.3 | 8.0 | 7.2 | 10 | Brown | 16 | AH |
| 34 | 8.5 | 7.8 | 8.4 | 7.7 | 10 | Brown | 16 | AH |
| 35 | 8.7 | 8.0 | 8.5 | 7.8 | 11 | Blue | 17 | MS |
| 36 | 8.4 | 7.8 | 8.6 | 7.8 | 12 | Blue | 16 | AH |
| 37 | 9.0 | 8.0 | 8.9 | 7.8 | 12 | Blue | 17 | MS |
| 38 | 7.4 | 6.9 | 7.3 | 6.9 | 9 | Blue | 17 | MS |
| 39 | 8.5 | 7.9 | 8.3 | 7.5 | 12 | Brown | 17 | MS |
| 40 | 7.9 | 7.2 | 7.8 | 7.2 | 10 | Brown | 16 | AH |
| 41 | 8.2 | 7.5 | 8.3 | 7.4 | 10 | Brown | 16 | AH |
| 42 | 8.5 | 7.7 | 8.3 | 7.5 | 9 | Green | 16 | MS |
| 43 | 8.3 | 7.6 | 8.2 | 7.6 | 11 | Brown | 16 | MS |
| 44 | 7.8 | 7.0 | 7.7 | 7.1 | 11 | Brown | 16 | AH |
| 45 | 7.8 | 6.8 | 7.5 | 6.8 | 12 | Blue | 17 | AH |
| 46 | 8.4 | 7.5 | 8.4 | 7.4 | 10 | Grey | 17 | AH |
| 47 | 8.5 | 7.6 | 8.6 | 7.6 | 9 | Brown | 17 | AH |
| 48 | 7.6 | 7.2 | 7.4 | 7.1 | 8 | Blue | 18 | MS |
| 49 | 7.9 | 7.4 | 7.8 | 7.3 | 10 | Blue | 16 | MS |
| 50 | 7.8 | 7.1 | 7.8 | 7.2 | 11 | Brown | 16 | MS |

**FEMALES**

| | D Middle | D Fore | R Middle | R Fore | Shoe Size | Eye Colour | Age | Faculty |
|---|---|---|---|---|---|---|---|---|
| 1 | 8.4 | 7.4 | 8.4 | 7.5 | 8 | Brown | 17 | AH |
| 2 | 8.2 | 7.4 | 8.1 | 7.4 | 9 | Brown | 17 | MS |
| 3 | 7.5 | 7.0 | 7.0 | 7.2 | 7 | Blue | 18 | MS |
| 4 | 6.7 | 6.4 | 6.8 | 6.5 | 3 | Brown | 17 | AH |
| 5 | 7.5 | 6.6 | 7.4 | 6.6 | 6 | Brown | 17 | MS |
| 6 | 7.4 | 6.7 | 7.3 | 6.8 | 6 | Blue | 17 | MS |
| 7 | 7.1 | 6.8 | 7.1 | 6.6 | 5 | Blue | 17 | MS |
| 8 | 7.3 | 6.9 | 7.3 | 6.9 | 7 | Brown | 16 | MS |
| 9 | 7.8 | 6.7 | 7.8 | 6.8 | 5 | Brown | 16 | MS |
| 10 | 7.2 | 6.9 | 7.4 | 7.1 | 7 | Brown | 17 | AH |
| 11 | 7.5 | 6.9 | 7.3 | 6.8 | 7 | Blue | 17 | AH |
| 12 | 8.0 | 7.5 | 7.9 | 7.5 | 7 | Blue | 16 | MS |
| 13 | 7.5 | 7.1 | 7.4 | 6.8 | 6 | Blue | 17 | MS |
| 14 | 7.7 | 7.0 | 7.5 | 6.8 | 6 | Brown | 16 | MS |
| 15 | 7.5 | 6.9 | 7.6 | 7.0 | 5 | Blue | 17 | MS |
| 16 | 7.6 | 7.0 | 7.6 | 6.6 | 3 | Green | 16 | MS |
| 17 | 7.5 | 6.5 | 7.5 | 6.5 | 7 | Grey | 17 | MS |
| 18 | 8.7 | 7.2 | 7.9 | 7.6 | 7 | Brown | 17 | AH |
| 19 | 7.1 | 6.7 | 7.2 | 6.4 | 5 | Blue | 17 | MS |
| 20 | 8.1 | 7.2 | 8.0 | 7.2 | 6 | Brown | 17 | AH |
| 21 | 7.7 | 6.7 | 8.1 | 7.1 | 7 | Blue | 18 | MS |
| 22 | 7.4 | 7.2 | 7.3 | 6.9 | 5 | Blue | 18 | MS |
| 23 | 7.2 | 7.0 | 7.3 | 6.8 | 5 | Blue | 17 | SO |
| 24 | 7.9 | 7.1 | 8.1 | 7.4 | 7 | Brown | 17 | MS |
| 25 | 7.3 | 6.7 | 7.7 | 6.9 | 6 | Green | 17 | AH |
| 26 | 7.7 | 7.4 | 8.0 | 7.1 | 5 | Brown | 17 | MS |
| 27 | 8.0 | 7.0 | 7.6 | 6.8 | 5 | Blue | 17 | MS |
| 28 | 7.6 | 7.3 | 7.8 | 7.1 | 7 | Blue | 17 | AH |
| 29 | 8.3 | 7.2 | 7.9 | 7.1 | 6 | Brown | 17 | SO |
| 30 | 8.4 | 7.4 | 7.7 | 7.2 | 8 | Blue | 18 | MS |
| 31 | 8.1 | 7.0 | 7.5 | 6.8 | 6 | Blue | 16 | MS |
| 32 | 8.2 | 7.6 | 8.2 | 7.3 | 8 | Brown | 16 | AH |
| 33 | 7.8 | 6.9 | 7.6 | 6.4 | 7 | Green | 16 | AH |
| 34 | 8.1 | 7.0 | 8.1 | 7.0 | 6 | Brown | 16 | AH |
| 35 | 8.0 | 7.2 | 7.8 | 7.2 | 8 | Brown | 17 | AH |
| 36 | 7.8 | 7.1 | 7.7 | 7.0 | 5 | Brown | 16 | AH |
| 37 | 7.5 | 7.0 | 7.6 | 7.2 | 5 | Brown | 16 | MS |
| 38 | 8.0 | 7.4 | 7.9 | 7.3 | 6 | Green | 16 | AH |
| 39 | 7.9 | 7.2 | 8.0 | 7.4 | 8 | Blue | 17 | MS |
| 40 | 8.1 | 7.7 | 8.0 | 7.6 | 7 | Blue | 17 | MS |
| 41 | 7.3 | 6.9 | 7.4 | 7.0 | 7 | Blue | 17 | MS |
| 42 | 7.5 | 6.9 | 7.3 | 6.9 | 6 | Brown | 17 | MS |
| 43 | 7.6 | 7.3 | 7.6 | 7.2 | 5 | Brown | 17 | MS |
| 44 | 8.4 | 7.4 | 8.3 | 7.3 | 5 | Blue | 16 | AH |
| 45 | 8.2 | 7.5 | 8.0 | 7.3 | 7 | Blue | 16 | AH |
| 46 | 7.9 | 7.0 | 7.6 | 6.8 | 8 | Blue | 16 | MS |
| 47 | 7.8 | 7.1 | 7.6 | 6.8 | 7 | Blue | 17 | MS |
| 48 | 7.4 | 7.1 | 7.2 | 6.9 | 7 | Brown | 17 | MS |
| 49 | 8.0 | 7.1 | 7.8 | 7.0 | 7 | Brown | 18 | AH |
| 50 | 7.5 | 6.9 | 7.5 | 6.8 | 5 | Brown | 17 | AH |

As the histograms for the lengths of fingers on dominant hands seem to show a typical bell-shaped normal distribution, I decided to complete a simple test for the suitability of a normal distribution, to see whether or not the data was indeed normally distributed.

By calculating the best estimates for the mean and standard deviation for the finger data, it is possible to find the percentage of the data which lies within one and two standard deviations of these best estimates. If about 66% of the data lies within 1 standard deviation, 95% within 2 standard deviations, and 99% within 3 standard deviations, then there is evidence to suggest that a normal distribution is appropriate.

Since the bar charts were split into fore-fingers and middle-fingers, I have chosen to test these categories individually for their normality:

***Fore-finger Lengths of Dominant Hands***

The best estimates for mean $\hat{\mu}$ and standard deviation $\hat{\sigma}$ can be calculated as follows:

$$\hat{\mu} = \frac{\sum fx}{\sum f} = \frac{729.2}{100} = 7.292$$

$$\begin{aligned}\hat{\sigma} &= \sqrt{\frac{n}{n-1} \times \left( \frac{\sum fx^2}{\sum f} - \hat{\mu}^2 \right)} \\ &= \sqrt{\frac{100}{99} \times \left( \frac{5336.28}{100} - 7.292^2 \right)} \\ &= \sqrt{0.191450505} \\ &= 0.437550574\end{aligned}$$

Therefore, figures for the ranges of different numbers of standard deviations can be calculated. Once the ranges have been established, the data in the spreadsheet can once again be reordered in order to find the percentage of the data collected which falls within these ranges.

***One standard deviation***

Lower bound of range = $\hat{\mu} - \hat{\sigma} = 6.854449426 = 6.85$ (3sf)

Upper bound of range = $\hat{\mu} + \hat{\sigma} = 7.729550574 = 7.73$ (3sf)

Percentage of data within this range = 77%

***Two standard deviations***

Lower bound of range = $\hat{\mu} - 2\hat{\sigma} = 6.416898852 = 6.42$ (3sf)

Upper bound of range = $\hat{\mu} + 2\hat{\sigma} = 8.167101148 = 8.17$ (3sf)

Percentage of data within this range = 96%

***Three standard deviations***

Lower bound of range = $\hat{\mu} - 3\hat{\sigma} = 5.979348278 = 5.98$ (3sf)

Upper bound of range = $\hat{\mu} + 3\hat{\sigma} = 8.604651722 = 8.60$ (3sf)

Percentage of data within this range = 99%

The process will now be repeated for middle finger lengths

***Middle finger Lengths of Dominant Hands***

$$\hat{\mu} = \frac{\sum fx}{\sum f} = \frac{799.5}{100} = 7.995$$

$$\begin{aligned}\hat{\sigma} &= \sqrt{\frac{n}{n-1} \times \left( \frac{\sum fx^2}{\sum f} - \hat{\mu}^2 \right)} \\ &= \sqrt{\frac{100}{99} \times \left( \frac{6418.59}{100} - 7.995^2 \right)} \\ &= \sqrt{0.268661616} \\ &= 0.518325781\end{aligned}$$

Percentages of data within given ranges are to be calculated again, as above:

***One standard deviation***
Lower bound of range = $\hat{\mu}$ - $\hat{\sigma}$ = 7.476674218 = 7.48 (3sf)
Upper bound of range = $\hat{\mu}$ + $\hat{\sigma}$ = 8.513325782 = 8.51 (3sf)
Percentage of data within this range = 81%

***Two standard deviations***
Lower bound of range = $\hat{\mu}$ - 2$\hat{\sigma}$ = 6.958348437 = 6.96 (3sf)
Upper bound of range = $\hat{\mu}$ + 2$\hat{\sigma}$ = 9.031651563 = 9.03 (3sf)
Percentage of data within this range = 96%

***Three standard deviations***
Lower bound of range = $\hat{\mu}$ - 3$\hat{\sigma}$ = 6.440022655 = 6.44 (3sf)
Upper bound of range = $\hat{\mu}$ + 3$\hat{\sigma}$ = 9.549977345 = 9.55 (3sf)
Percentage of data within this range = 98%

The percentage of the data which falls within one standard deviation of the mean is a little higher than expected in both cases, but otherwise both sets of data show percentages of the right order to indicate normality. It therefore seems reasonable to go on to complete a $\chi^2$ test for each set of data in order to determine whether or not a normal distribution is, indeed, a suitable approximation to the data sets.

In the $\chi^2$ tests that follow, I have chosen to use a spreadsheet's NORMDIST function to calculate the $p$ values that would usually be found from Normal tables. In order to check that this function correctly calculates the values that I require, I shall test it by using it to calculate some values, and then comparing these values to those found in tables. In order to fully test the robustness of the function, I will include values from the tails of the distribution, as well as those from the middle:

| ***z*** | **Calculated *p*** | **Calculated *p* (correct to 4dp)** | ***p* from tables** |
|---|---|---|---|
| 0.000 | 0.5 | 0.5000 | 0.5000 |
| 0.500 | 0.691462467 | 0.6915 | 0.6915 |
| 1.000 | 0.84134474 | 0.8413 | 0.8413 |
| 1.500 | 0.933192771 | 0.9332 | 0.9332 |
| 2.000 | 0.977249938 | 0.9772 | 0.9772 |
| 2.500 | 0.99379032 | 0.9938 | 0.9938 |
| 2.999 | 0.998645594 | 0.9986 | 0.9986 |

It is clear from these calculations that the values calculated by the spreadsheet function are more accurate than those found from tables, which are corrected to four decimal places. Therefore it is logical and sensible to use the more accurate spreadsheet function in calculations such as the $\chi^2$ test in order to maintain a higher degree of accuracy, as well as to save time in looking up values of $p$ from tables.

***Chi-Squared Test for lengths of Middle Fingers on Dominant Hands***

The hypotheses for this test are:

$H_0$: The Normal distribution with mean 7.995 and standard deviation 0.518325781 is a suitable model for the data
$H_1$: The Normal distribution with mean 7.995 and standard deviation 0.518325781 is an unsuitable model for the data
$\alpha = 5\% = 0.05$

As calculated above,
$\hat{\mu} = 7.995$
$\hat{\sigma} = 0.518325781$

Let $a$ be the lower class boundary, and let $b$ be the upper class boundary
Let $n = 100$, since there are 100 data items in the set.
Let $O$ be the observed number in a given class, and let $E$ be the expected number in a given class.

| $a$ | $b$ | $\phi\frac{b-\hat{\mu}}{\hat{\sigma}}$ | $\phi\frac{a-\hat{\mu}}{\hat{\sigma}}$ | $E = \left(\phi\frac{b-\hat{\mu}}{\hat{\sigma}} - \phi\frac{a-\hat{\mu}}{\hat{\sigma}}\right) \times n$ |
|---|---|---|---|---|
| | 7.0 | 0.027451 | 0 | 2.745149172 |
| 7.0 | 7.5 | 0.169789 | 0.027451 | 14.23378915 |
| 7.5 | 8.0 | 0.503848 | 0.169789 | 33.40589529 |
| 8.0 | 8.5 | 0.835044 | 0.503848 | 33.11955635 |
| 8.5 | 9.0 | 0.973745 | 0.835044 | 13.87015432 |
| 9.0 | 9.5 | 0.998155 | 0.973745 | 2.440987245 |
| 9.5 | 10.0 | 0.999945 | 0.998155 | 0.178984842 |
| 10.0 | | 1 | 0.999945 | 0.005483631 |

The calculation requires that any row whose total is less than five should be grouped with other adjacent rows, until the total is greater than or equal to five. Therefore, for the second part of the calculation, grouping will be necessary as shown by }. Where grouping takes place, the $E$ value for the grouped class will be equal to the sum of the $E$ values for the classes which have been grouped together.

| Class | O | E | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|
| x<7.5 | 13 | 16.97894 | 0.932446 |
| 7.5<x<8.0 | 36 | 33.4059 | 0.201443 |
| 8.0<x<8.5 | 34 | 33.11956 | 0.023406 |
| x>8.5 | 17 | 16.49561 | 0.015423 |

$\sum\frac{(O-E)^2}{E}$ = 1.172718 = 1.173 (3dp)

Comparison of the $\sum\frac{(O-E)^2}{E}$ value with the relevant value from tables will indicate whether or not the Normal distribution is appropriate for this set of data. In order to obtain this critical value from tables, the number of degrees of freedom needs to be calculated. This is found by subtracting 1 and the number of estimates used (2: mean and variance were estimated) from the number of rows in the second table above.

Degrees of Freedom = 4 – 1 – 2 = 1

Therefore, the critical value from tables is 3.841, and $H_0$ will be rejected if

$$\sum \frac{(O-E)^2}{E} > 3.841$$

However,

$1.173 < 3.841$, so do not reject $H_0$.

Conclude from this test that $N(7.995, 0.518325781^2)$, or more approximately $N(7.995, 0.518^2)$ is an appropriate distribution to model this data.

To avoid needless repetition, the $\chi^2$ test for the data referring to the lengths of fore-fingers on dominant hands is given in the appendix on page A1, and shows that $N(7.292, 0.438^2)$ is an appropriate approximate distribution to model this data.

Therefore, we have shown through the use of the $\chi^2$ tests, that both middle and fore-finger lengths on the dominant hand can be modelled using a Normal distribution.

A scatter diagram of these two variables (see following page) suggests that there is some positive correlation between the two.

Since normality has been found for both of these variables, and since the points on the scatter diagram fall in an ellipse indicating a positive correlation, it seems reasonable to test for correlation between these variables by calculating the Product Moment Correlation Coefficient, and then comparing this to values from tables to find its significance.

For the test, let *f* be the lengths of fore-fingers and *m* be the lengths of middle fingers on the dominant hands on 100 KGV students.

The following totals can be found for the data (the working is in the appendix beginning on page A3, as it is rather lengthy!):

$\sum f = 729.2$ $\quad \sum m = 799.5$ $\quad \sum f^2 = 5336.28$

$\sum fm = 5849.08$ $\quad \sum m^2 = 6418.59$

Now, the calculations of $S_{fm}$, $S_{ff}$ and $S_{mm}$ need to be completed to be inserted into the final formula for r:

$$S_{fm} = \sum fm - \frac{\sum f \sum m}{n} = 5849.08 - \frac{729.2 \times 799.5}{100} = 19.1260$$

$$S_{ff} = \sum f^2 - \frac{\left(\sum f\right)^2}{n} = 5336.28 - \frac{(729.2)^2}{100} = 18.9536$$

$$S_{mm} = \sum m^2 - \frac{\left(\sum m\right)^2}{n} = \mathbf{6}418.59 - \frac{(799.5)^2}{100} = 26.5875$$

These values can now be used to calculate r:

$$r = \frac{S_{fm}}{\sqrt{S_{ff} S_{mm}}} = \frac{19.1260}{\sqrt{18.9536 \times 26.5875}} = 0.8520$$

I will now test this PMCC under the following hypotheses:

$H_0$: $\rho = 0$ (there is zero correlation between the readings)
$H_1$: $\rho > 0$ (there is positive correlation between the readings)
$\alpha = 1\% = 0.01$

I have chosen to use a one-way test, rather than the two-way test originally suggested in my introduction, since the scatter diagram on the previous page suggests positive correlation.

Critical value of r (from tables) = 0.2324, and so critical region is r > 0.2324.

r = 0.8520 falls into this critical region, and so the result is significant, and $H_0$ is rejected.

From this test, it can be concluded that there is strong evidence, at the 1% level, to suggest that there is positive correlation between the length of the middle finger, and the length of the recessive finger, of the dominant hand.

I have found that a relationship exists between two fingers. However, this would probably be expected, since most people's middle finger is longer than their forefinger. However, as a more robust test of whether finger lengths are proportional to the size of other parts of the body, I will test for a correlation between shoe size and the length of the middle finger on the dominant hand. To start with, I shall draw a scatter diagram to see if this suggests the presence of any relationship between these two variables.

The scatter diagram on the previous page shows evidence for a positive correlation, however a more statistical test could be used to confirm the presence and strength of the correlation present. In order to calculate a PMCC, normality is required. Despite the normal shape of each of sides of my back-to-back stem and leaf diagram, this data for shoe size cannot be normally distributed, as shoe size data is discrete. Because this data cannot possibly be normally distributed, the only other option is to calculate $r_s$, the Spearman's Rank Correlation Coefficient, in order to see whether this will provide evidence of a relationship between shoe size.

In order to obtain the rankings for the variables, I ordered the data in a spreadsheet and assigned numerical rankings. A table showing this ordered data can be found on pages A5 to A6 of the appendix.

Let $f$ represent rankings for middle finger lengths on dominant hands, and let $s$ represent rankings for shoe size.

The totals for these data are shown below. The calculations completed to find these totals are shown in the appendix, beginning on page A7.

$\sum f = 5050.00$ $\quad\sum s = 5050.00$ $\quad\sum f^2 = 337936.50$

$\sum fs = 305551.75$ $\quad\sum s^2 = 336957.50$

The following calculations are now necessary, so that the results can be substituted into the final formula for $r_s$:

$$S_{fs} = \sum fs - \frac{\sum f \sum s}{n} = 305551.75 - \frac{5050.00 \times 5050.00}{100} = 50526.75$$

$$S_{ff} = \sum f^2 - \frac{\left(\sum f\right)^2}{n} = 337936.50 - \frac{(5050.00)^2}{100} = 82911.50$$

$$S_{ss} = \sum s^2 - \frac{\left(\sum s\right)^2}{n} = 336957.50 - \frac{(5050.00)^2}{100} = 81932.50$$

These results can now be substituted into the formula for $r_s$:

$$r_s = \frac{S_{fs}}{\sqrt{S_{ff} S_{ss}}} = \frac{50526.75}{\sqrt{82911.50 \times 81935.50}} = 0.6130$$

I will now test this Spearman's Rank Correlation Coefficient under the following hypotheses:

$H_0$: $\rho = 0$ (there is zero correlation between the readings)
$H_1$: $\rho > 0$ (there is positive correlation between the readings)
$\alpha = 1\% = 0.01$

I have chosen to use a one-way test since the scatter diagram suggests positive correlation.

Critical value of $r_s$ (from tables) = 0.2327, and so critical region is $r_s > 0.2327$.

$r_s = 0.6130$ falls into this critical region, and so the result is significant, and $H_0$ is rejected.

From this test, it can be concluded that there is strong evidence, at the 1% level, to suggest that there is positive correlation between the rankings of length of the middle finger of the dominant hand and shoe size.

The test above appears to suggest that finger size is, indeed, proportional to the size of other body parts. As I have collected data for both males and females, I will proceed to complete a difference in means test, to see whether, on general, one gender has larger fingers than the other. I have chosen once again to use the data for middle fingers in this test.

In order to complete a difference in means test, normality must be established separately for male and female finger lengths. Since the distribution required is that for the means, and the number of items of data in each category is large (>30), I can use the Central Limit Theorem to assume normality.

However, $\hat{\mu}$ and $\hat{\sigma}^2$ for the data will still be necessary.

The calculations for the data for males:

$$\hat{\mu}_m = \frac{\sum fx}{\sum f} = \frac{412.6}{50} = 8.252$$

$$\begin{aligned}\hat{\sigma}^2{}_m &= \frac{n}{n-1} \times \left( \frac{\sum fx^2}{\sum f} - \hat{\mu}^2 \right) \\ &= \frac{50}{49} \times \left( \frac{3416.64}{50} - (8.252)^2 \right) \\ &= 0.242138775\end{aligned}$$

The calculations for the data for females:

$$\hat{\mu}_m = \frac{\sum fx}{\sum f} = \frac{386.9}{50} = 7.738$$

$$\begin{aligned}\hat{\sigma}^2{}_m &= \frac{n}{n-1} \times \left( \frac{\sum fx^2}{\sum f} - \hat{\mu}^2 \right) \\ &= \frac{50}{49} \times \left( \frac{3001.95}{50} - (7.738)^2 \right) \\ &= 0.165669387\end{aligned}$$

The tables used to calculate $\sum fx$ , $\sum fx^2$ and $\sum f$ for both of these calculations are given in the appendix, beginning on page A9.

Using these best estimates, along with the Central Limit Theorem, and allowing M to represent the data for the males and F to represent the data for the females:

$$\overline{M} \sim N\left( \hat{\mu}_m, \frac{0.242138775}{50} \right) \text{ and } \overline{F} \sim N\left( \hat{\mu}_f, \frac{0.165669387}{50} \right).$$

Since $\overline{M}$ and $\overline{F}$ are independent,

$$\overline{M} - \overline{F} \sim N\left(\hat{\mu}_m - \hat{\mu}_f, \frac{0.242138775 + 0.165669387}{50}\right)$$

Assuming

H0: $\mu_{\mathrm{m}} = \mu_f \Rightarrow \mu_{\mathrm{m}} - \mu_f = 0$

H1: $\mu_{\mathrm{m}} \neq \mu_f \Rightarrow \mu_{\mathrm{m}} - \mu_f \neq 0$

α: 5% = 0.05

$$\frac{\overline{\mathrm{M}} - \overline{\mathrm{F}} - \mu_{\mathrm{m}} - \mu_f}{\sqrt{\frac{\hat{\sigma}_m{}^2}{n_m} + \frac{\hat{\sigma}_f{}^2}{n_f}}} = Z \sim N(0,1)$$

And under H0:

$$\frac{\overline{\mathrm{M}} - \overline{\mathrm{F}} - 0}{\sqrt{0.007833179}} = Z_{obs}$$

$$\frac{0.514}{\sqrt{0.007833179}} = Z_{obs}$$

$$Z_{obs} = 5.807565191$$

From tables,

$$p = 0.975 \Rightarrow Z = 1.96$$

Reject H0 if $|Z_{obs}| > 1.96$
and 5.807565191 > 1.96 so reject H0.

I can therefore conclude that there is evidence, at the 5% level, to suggest that there is a difference in the means, although this test cannot confirm whether it is that females' hands are bigger than males' or vice versa – it has only been able to establish that there is, indeed, a difference in the means of the two sets of data.

As I suspect that fingers of males are likely to be bigger than those of females, I will now conduct a one-way difference in means test which will be able to show whether, indeed, male fingers are bigger than those of females.

I have already calculated $\hat{\mu}$ and $\hat{\sigma}^2$ for both the males and females for the one-way test above, and so I will not recalculate these, and I have already shown that, assuming independence,

$$\overline{M} - \overline{F} \sim N\left(\hat{\mu}_m - \hat{\mu}_f, \frac{0.242138775 + 0.165669387}{50}\right)$$

Assuming the new hypotheses:
$H_0$: $\mu_{\mathrm{m}} = \mu_f \Rightarrow \mu_{\mathrm{m}} - \mu_f = 0$
$H_1$: $\mu_{\mathrm{m}} \neq \mu_f \Rightarrow \mu_{\mathrm{m}} - \mu_f > 0$

Since there was strong evidence to suggest a difference in means, I have chosen to adopt a lower value for α for this test:
α: 1% = 0.01

$$\frac{\overline{\mathrm{M}} - \overline{\mathrm{F}} - \mu_{\mathrm{m}} - \mu_f}{\sqrt{\frac{\hat{\sigma}_m{}^2}{n_m} + \frac{\hat{\sigma}_f{}^2}{n_f}}} = Z \sim N(0,1)$$

And under $H_0$:

$$\frac{\overline{\mathrm{M}} - \overline{\mathrm{F}} - 0}{\sqrt{0.007833179}} = Z_{obs}$$

$$\frac{0.514}{\sqrt{0.007833179}} = Z_{obs}$$

$$Z_{obs} = 5.807565191$$

From tables,

$$p = 0.99 \Rightarrow Z = 2.326$$

Reject $H_0$ if $|Z_{obs}| > 2.326$
and 5.807565191 > 2.326 so reject $H_0$.

I can therefore conclude that, at the 1% level, there is strong evidence to suggest that males have longer middle fingers than females.

Similarly to comparing the means of the finger sizes for the different sexes, it would be interesting to see whether there is any difference in the means for the middle fingers of the dominant and recessive hands. However, because independence in the data is not present since both readings have come from the same person (and a link between the two types of data has already been established earlier), a normal difference in means test cannot be completed. Instead, I will use 95% confidence intervals to compare the data.

Because there are 100 items of data in each category I am able to use the central limit theorem, and assuming notation of *D* referring to data for dominant hands, it can be stated that

$$\overline{D} \sim N\left(\mu_d, \frac{\hat{\sigma}_d{}^2}{50}\right)$$

Using a table of percentage points for the Normal distribution, I can show that

$$P\left(-1.96 < \frac{\overline{D} - \mu_d}{\hat{\sigma}_d / \sqrt{n}} < 1.96\right) = 0.95$$

This can now be rearranged:

$$P\left(\frac{-1.96\hat{\sigma}_d}{\sqrt{n}} < \overline{D} - \mu_d < \frac{1.96\hat{\sigma}_d}{\sqrt{n}}\right) = 0.95$$

$$P\left(\hat{\mu}_d - \frac{1.96\hat{\sigma}_d}{\sqrt{n}} < \overline{D} < \mu_d + \frac{1.96\hat{\sigma}_d}{\sqrt{n}}\right) = 0.95$$

Rearranging again:

$$P\left(-\overline{D} - \frac{1.96\hat{\sigma}_d}{\sqrt{n}} < -\mu_d < -\overline{D} + \frac{1.96\hat{\sigma}_d}{\sqrt{n}}\right) = 0.95$$

$$P\left(\overline{D} + \frac{1.96\hat{\sigma}_d}{\sqrt{n}} > \mu_d > \overline{D} - \frac{1.96\hat{\sigma}_d}{\sqrt{n}}\right) = 0.95$$

We can then use this to deduce a 95% confidence interval for $\mu_d$ as:

$$\left(\overline{D} - \frac{1.96\hat{\sigma}_d}{\sqrt{n}}, \overline{D} + \frac{1.96\hat{\sigma}_d}{\sqrt{n}}\right)$$

Replacing $\overline{D}$ with $\overline{d}$ since the confidence interval will be used for our observed $\overline{d}$ (which I will calculate shortly), and summarising, the confidence interval for $\mu_d$ can be stated as

$$\overline{d} \pm \frac{1.96\hat{\sigma}_d}{\sqrt{n}}$$

Similarly, I have deduced the formula for the confidence interval for $\mu_r$ as

$$\bar{r} \pm \frac{1.96\hat{\sigma}_r}{\sqrt{n}}$$

For the details of this deduction, please refer to page A10 of the appendix.

In order to use these formulae, $\bar{d}$, $\bar{r}$, $\hat{\sigma}_d$ and $\hat{\sigma}_r$ must be calculated. For calculations of the totals used in the following formulae, please refer to the appendix, beginning on page A11.

$$\bar{d} = \frac{\sum fx}{\sum f} = \frac{799.5}{100} = 7.995$$

$$\bar{r} = \frac{\sum fx}{\sum f} = \frac{790.5}{100} = 7.905$$

$$\begin{aligned}\hat{\sigma}_d &= \sqrt{\frac{n}{n-1} \times \left(\frac{\sum fx^2}{\sum f} - \bar{d}^2\right)} \\ &= \sqrt{\frac{100}{99} \times \left(\frac{6418.59}{100} - 7.995^2\right)} \\ &= \sqrt{0.268560606} \\ &= 0.518228333\end{aligned}$$

$$\begin{aligned}\hat{\sigma}_r &= \sqrt{\frac{n}{n-1} \times \left(\frac{\sum fx^2}{\sum f} - \bar{r}^2\right)} \\ &= \sqrt{\frac{100}{99} \times \left(\frac{6275.61}{100} - 7.905^2\right)} \\ &= \sqrt{0.269772727} \\ &= 0.519396502\end{aligned}$$

Therefore, the confidence interval for $\mu_d$ can be calculated as:

$$7.995 \pm \frac{1.96 \times 0.518228333}{\sqrt{100}}$$

The confidence interval for $\mu_d$ is 7.8934 to 8.0966.

The confidence interval for $\mu_r$ can be calculated as:

$$7.905 \pm \frac{1.96 \times 0.519396502}{\sqrt{100}}$$

The confidence interval for $\mu_r$ is 7.8032 to 8.0068.

These intervals are shown graphically on the following page.

As the graphically displayed confidence intervals show clearly, there is overlap between the two confidence intervals when they are set up at the 5% level.

Therefore, I am forced to conclude that there is insufficient evidence to say that the means between middle fingers on dominant and recessive hands vary. This suggests that the sizes of people's middle fingers are usually very similar sizes, despite the fact that one hand is recessive and one hand dominant.

As discussed earlier in this document, there are often articles in newspapers which suggest that lighter coloured eyes, such as blue, suggest that a person has more effeminate characteristics than those who have darker coloured eyes, such as brown. Therefore, if the above is true, it is not unreasonable to assume that females will, on average, have lighter coloured eyes than males – that is, sex and eye colour are linked, and so not independent. Therefore, the hypotheses for the following test will be:

$H_0$: The variables eye colour and sex are independent
$H_1$: The variables eye colour and sex are *not* independent

In order to test this hypothesis, I shall set up contingency tables for eye colour against gender.

The contingency table for the observed data is as follows, with shaded data representing the totals:

| | Blue | Brown | Other | |
|---|---|---|---|---|
| Male | 24 | 21 | 5 | 50 |
| Female | 22 | 23 | 5 | 50 |
| | 46 | 44 | 10 | 100 |

I have chosen to group together the data for green eyes and grey eyes as I found so little data in these categories.

The expected data is as follows:

| | Blue | Brown | Other | |
|---|---|---|---|---|
| Male | $\frac{50 \times 46}{100}$ | $\frac{50 \times 44}{100}$ | $\frac{50 \times 10}{100}$ | 50 |
| Female | $\frac{50 \times 46}{100}$ | $\frac{50 \times 44}{100}$ | $\frac{50 \times 10}{100}$ | 50 |
| | 46 | 44 | 10 | 100 |

Calculating these values gives:

| | Blue | Brown | Other | |
|---|---|---|---|---|
| Male | 23 | 22 | 5 | 50 |
| Female | 23 | 22 | 5 | 50 |
| | 46 | 44 | 10 | 100 |

From simple probability, it can be stated that
P(A and B) = P(A)P(B)
**when A and B independent.**

Therefore, by calculating $\sum \frac{(O-E)^2}{E}$ from the observed (O) and expected (E) values in the tables above, and comparing these with a $\chi^2$ value from tables, it should be possible to determine whether indeed the factors of eye colour and sex are independent or not.

| Class | $O$ | $E$ | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|
| Male, blue | 24 | 23 | 0.4347826 |
| Male, brown | 21 | 22 | 0.0454545 |
| Male, other | 5 | 5 | 0 |
| Female, blue | 22 | 23 | 0.4347826 |
| Female, brown | 23 | 22 | 0.0454545 |
| Female, other | 5 | 5 | 0 |
| | | $\sum\frac{(O-E)^2}{E} =$ | 0.9604742 |

In order to look up a $\chi^2$ value from tables, I need to calculate the number of degrees of freedom. I shall calculate this using the formula

Degrees of freedom = (Number of rows – 1)(Number of columns – 1)

That is,

$$\text{Degrees of freedom} = (3-1)\times(2-1) = 2$$

At the 5% level, the $\chi^2$ value for two degrees of freedom is 5.991. Therefore, 5.991 becomes the critical value, and $H_0$ will be rejected if

$$\sum\frac{(O-E)^2}{E} > 5.991$$

However, 0.9605 < 5.991, so do not reject $H_0$.

From this test, we can conclude that there is insufficient evidence at the 5% level to suggest that eye colour and sex are not independent.

## Conclusions

From this investigation, I have found evidence to suggest that there is a link between the length of people's middle fingers and forefingers. This has not really surprised me, since people's fingers are, on the whole, in proportion to one another, with the middle finger being the largest, the forefinger and ring-finger being roughly similar in size, and the little finger being the smaller. During the investigation, none of my 100 test subjects seriously deviated from this pattern.

Furthermore, I have found evidence to suggest that not only are people's fingers in proportionate size to one another, finger size appears to be related to the size of other body parts, here looking specifically at shoe size. Before conducting this investigation, I was not entirely convinced either way on this particular hypothesis. I had considered that people were generally, overall, in proportion, but I was quite surprised to find that there was rank correlation at a level as low as 1%.

Since finger lengths are in proportion to the rest of the body, including the length of other fingers, it seems unlikely that newspaper articles claiming that finger lengths are an indicator of personality have much credibility, since the variations in length of one finger would seem influence the length of another. However, it would be wrong to claim that I have disproved these claims, as I have not looked directly into the claims that have been made, I have only found evidence that appears to make the claims less credible.

I also found evidence to suggest that finger length was related to sex, since the difference in means test for male fingers against female fingers showed that there was, indeed, a difference. This is a result that I expected to obtain, since I would expect that, on average, females would have smaller hands than males. I then went on to find strong evidence that, indeed, females have shorter middle fingers than females by conducting a one-way difference in means test.

I found no evidence at all to suggest that eye colour was in any way related to sex, and therefore it would seem rather unlikely that lighter colour eyes were an indicator of increased femininity. From my studies in biology, I already suspected that this would be the case, as I have been taught that inheritance of eye colour is not a sex-linked inheritance, and I have found no evidence to the contrary in this investigation.

During the collection of my data, I came across one individual (Female 33 on the data collection sheet) who had injured the forefinger on her recessive hand as a child, and as a consequence, had lost the very tip of her finger. The difference here was not noticeable to me, and I would not have guessed that this was the case had she not pointed this out to me, and so I chose to retain the data for use in the investigation. This, however, highlighted a flaw in my data collection method, as I had not considered this possibility, and has not thought of a way in which to overcome the problem. My judgement could not be relied on solely if there had been more people like this, since I would be more likely to notice the problem on those individuals who had scar tissue on their fingers, and so my assessment of whether the difference was 'noticeable' would not have been judged solely on length, which was the variable being investigated. A better method may have been to exclude such people from the investigation entirely. Also, as a further extension to the work, a regression line could be calculated in order to test mathematically whether her finger would have been likely to be much longer had the accident not occurred.

Furthermore, the accuracy of my measurement of people's fingers may have introduced flaws into the data, as I found it perhaps more difficult than I had expected to judge the exact length of each finger. The measuring method may have been improved by something as simple as using a tape measure, rather than a solid plastic ruler, to measure fingers as this would have adjusted more easily to the contours of the finger. However, this may have caused errors through the comparison of those with fat fingers with those with thinner fingers. Therefore, whilst there are advantages to using a tape measure, I do not think that the use of a plastic ruler was entirely inappropriate.

For further investigation, if more time had been available, I would have liked to have brought in the college faculties as a factor, since these may be an indicator of a person's general interests by giving an indication of the subjects they are taking, even if it is not an entirely accurate indication of personality. It may also have been interesting to extend the investigation to all ten fingers, rather than a sample four, to see if the trends identified among these four fingers can be extended to people's fingers as a whole.

Also, increasing the number of people in my sample would have allowed me to make more firm conclusions, and since the newspaper reports referred to the population as a whole, extending the investigation to include people outside of my own age group, or even outside of my own geographical region may have made for interesting comparisons.

As a final conclusion, I have found in this investigation evidence to suggest that finger lengths are in proportion to the lengths of other fingers as well as shoe size. I have found no evidence that the size of fingers on the dominant hand is any different to that on the recessive hand, nor have I found evidence to suggest that eye colour is in any way related to gender.

# Appendix

***Chi-Squared Test for lengths of Fore-Fingers on Dominant Hands***

The hypotheses for this test are:

$H_0$: The Normal distribution with mean 7.292 and standard deviation 0.438 (3sf) is a suitable model for the data
$H_1$: The Normal distribution mean 7.292 and standard deviation 0.438 (3sf) is an unsuitable model for the data
$\alpha = 5\% = 0.05$

As calculated above,
$\hat{\mu} = 7.292$
$\hat{\sigma} = 0.437550574 = 0.438\ (3\text{sf})$

Let $a$ be the lower class boundary, and let $b$ be the upper class boundary
Let $n$ = 100, since there are 100 data items in the set.
Let $O$ be the observed number in a given class, and let $E$ be the expected number in a given class.

| $a$ | $b$ | $\phi\dfrac{b-\hat{\mu}}{\hat{\sigma}}$ | $\phi\dfrac{a-\hat{\mu}}{\hat{\sigma}}$ | $E=\left(\phi\dfrac{b-\hat{\mu}}{\hat{\sigma}}-\phi\dfrac{a-\hat{\mu}}{\hat{\sigma}}\right)\times n$ |
|---|---|---|---|---|
| | 7.0 | 0.252274 | 0 | 25.22737718 |
| 7.0 | 7.5 | 0.68274 | 0.252274 | 43.04658738 |
| 7.5 | 8.0 | 0.947179 | 0.68274 | 26.44396941 |
| 8.0 | 8.5 | 0.997117 | 0.947179 | 4.993781437 |
| 8.5 | 9.0 | 0.999953 | 0.997117 | 0.283543072 |
| 9.0 | 9.5 | 1 | 0.999953 | 0.00471896 |
| 9.5 | 10.0 | 1 | 1 | $2.25323\times10^{-5}$ |
| 10.0 | | 1 | 1 | $3.03968\times10^{-8}$ |

The calculation requires that any row whose total is less than five should be grouped with other adjacent rows, until the total is greater than or equal to five. Therefore, for the second part of the calculation, grouping will be necessary as shown by }. Where grouping takes place, the $E$ value for the grouped class will be equal to the sum of the $E$ values for the classes which have been grouped together.

| Class | $O$ | $E$ | $\dfrac{(O-E)^2}{E}$ |
|---|---|---|---|
| $x<7.0$ | 21 | 25.22738 | 0.708386 |
| $7.0<x<7.5$ | 47 | 43.04659 | 0.363083 |
| $7.5<x<8.0$ | 24 | 26.44397 | 0.225873 |
| $x>8.0$ | 8 | 5.282066 | 1.398537 |

$\sum\dfrac{(O-E)^2}{E}$ **= 2.695879**

Comparison of the $\sum \frac{(O-E)^2}{E}$ value with the relevant value from tables will indicate whether or not the Normal distribution is appropriate for this set of data. In order to obtain this critical value from tables, the number of degrees of freedom needs to be calculated. This is found by subtracting 1 and the number of estimates used (2: mean and variance were estimated) from the number of rows in the second table above.

Degrees of Freedom = 4 – 1 – 2 = 1

Therefore, the critical value from tables is 3.841, and $H_0$ will be rejected if

$$\sum \frac{(O-E)^2}{E} > 3.841$$

However,

2.695879<3.841, so do not reject $H_0$.

Conclude from this test that N(7.292, 0.437550574 $^2$), or more approximately N(7.292, 0.438$^2$) is an appropriate distribution to model this data.

***Working used to find Totals for Correlation Test between Lengths of Middle and Fore-Fingers on Dominant Hands***

| $f$ | $m$ | $f^2$ | $fm$ | $m^2$ |
|---|---|---|---|---|
| 7.4 | 8.0 | 54.76 | 59.20 | 64.00 |
| 7.6 | 7.8 | 57.76 | 59.28 | 60.84 |
| 7.5 | 8.2 | 56.25 | 61.50 | 67.24 |
| 7.5 | 8.7 | 56.25 | 65.25 | 75.69 |
| 7.8 | 8.0 | 60.84 | 62.40 | 64.00 |
| 7.4 | 8.4 | 54.76 | 62.16 | 70.56 |
| 7.1 | 8.1 | 50.41 | 57.51 | 65.61 |
| 7.7 | 8.7 | 59.29 | 66.99 | 75.69 |
| 7.1 | 7.9 | 50.41 | 56.09 | 62.41 |
| 7.8 | 8.3 | 60.84 | 64.74 | 68.89 |
| 7.3 | 7.7 | 53.29 | 56.21 | 59.29 |
| 7.4 | 8.3 | 54.76 | 61.42 | 68.89 |
| 8.1 | 8.8 | 65.61 | 71.28 | 77.44 |
| 8.3 | 9.3 | 68.89 | 77.19 | 86.49 |
| 9.1 | 10.0 | 82.81 | 91.00 | 100.00 |
| 7.2 | 8.0 | 51.84 | 57.60 | 64.00 |
| 7.2 | 7.8 | 51.84 | 56.16 | 60.84 |
| 6.8 | 7.8 | 46.24 | 53.04 | 60.84 |
| 7.2 | 8.1 | 51.84 | 58.32 | 65.61 |
| 7.7 | 8.2 | 59.29 | 63.14 | 67.24 |
| 6.7 | 7.4 | 44.89 | 49.58 | 54.76 |
| 7.5 | 8.6 | 56.25 | 64.50 | 73.96 |
| 8.0 | 8.7 | 64.00 | 69.60 | 75.69 |
| 7.6 | 7.9 | 57.76 | 60.04 | 62.41 |
| 8.2 | 8.5 | 67.24 | 69.70 | 72.25 |
| 7.2 | 7.8 | 51.84 | 56.16 | 60.84 |
| 7.1 | 8.4 | 50.41 | 59.64 | 70.56 |
| 7.9 | 8.5 | 62.41 | 67.15 | 72.25 |
| 8.2 | 9.2 | 67.24 | 75.44 | 84.64 |
| 7.5 | 8.1 | 56.25 | 60.75 | 65.61 |
| 7.5 | 8.3 | 56.25 | 62.25 | 68.89 |
| 7.2 | 7.9 | 51.84 | 56.88 | 62.41 |
| 7.3 | 8.0 | 53.29 | 58.40 | 64.00 |
| 7.8 | 8.5 | 60.84 | 66.30 | 72.25 |
| 8.0 | 8.7 | 64.00 | 69.60 | 75.69 |
| 7.8 | 8.4 | 60.84 | 65.52 | 70.56 |
| 8.0 | 9.0 | 64.00 | 72.00 | 81.00 |
| 6.9 | 7.4 | 47.61 | 51.06 | 54.76 |
| 7.9 | 8.5 | 62.41 | 67.15 | 72.25 |
| 7.2 | 7.9 | 51.84 | 56.88 | 62.41 |
| 7.5 | 8.2 | 56.25 | 61.50 | 67.24 |
| 7.7 | 8.5 | 59.29 | 65.45 | 72.25 |
| 7.6 | 8.3 | 57.76 | 63.08 | 68.89 |
| 7.0 | 7.8 | 49.00 | 54.60 | 60.84 |
| 6.8 | 7.8 | 46.24 | 53.04 | 60.84 |
| 7.5 | 8.4 | 56.25 | 63.00 | 70.56 |
| 7.6 | 8.5 | 57.76 | 64.60 | 72.25 |
| 7.2 | 7.6 | 51.84 | 54.72 | 57.76 |
| 7.4 | 7.9 | 54.76 | 58.46 | 62.41 |
| 7.1 | 7.8 | 50.41 | 55.38 | 60.84 |
| 7.4 | 8.4 | 54.76 | 62.16 | 70.56 |
| 7.4 | 8.2 | 54.76 | 60.68 | 67.24 |

| | | | | | |
|---|---|---|---|---|---|
| | 7.0 | 7.5 | 49.00 | 52.50 | 56.25 |
| | 6.4 | 6.7 | 40.96 | 42.88 | 44.89 |
| | 6.6 | 7.5 | 43.56 | 49.50 | 56.25 |
| | 6.7 | 7.4 | 44.89 | 49.58 | 54.76 |
| | 6.8 | 7.1 | 46.24 | 48.28 | 50.41 |
| | 6.9 | 7.3 | 47.61 | 50.37 | 53.29 |
| | 6.7 | 7.8 | 44.89 | 52.26 | 60.84 |
| | 6.9 | 7.2 | 47.61 | 49.68 | 51.84 |
| | 6.9 | 7.5 | 47.61 | 51.75 | 56.25 |
| | 7.5 | 8.0 | 56.25 | 60.00 | 64.00 |
| | 7.1 | 7.5 | 50.41 | 53.25 | 56.25 |
| | 7.0 | 7.7 | 49.00 | 53.90 | 59.29 |
| | 6.9 | 7.5 | 47.61 | 51.75 | 56.25 |
| | 7.0 | 7.6 | 49.00 | 53.20 | 57.76 |
| | 6.5 | 7.5 | 42.25 | 48.75 | 56.25 |
| | 7.2 | 8.7 | 51.84 | 62.64 | 75.69 |
| | 6.7 | 7.1 | 44.89 | 47.57 | 50.41 |
| | 7.2 | 8.1 | 51.84 | 58.32 | 65.61 |
| | 6.7 | 7.7 | 44.89 | 51.59 | 59.29 |
| | 7.2 | 7.4 | 51.84 | 53.28 | 54.76 |
| | 7.0 | 7.2 | 49.00 | 50.40 | 51.84 |
| | 7.1 | 7.9 | 50.41 | 56.09 | 62.41 |
| | 6.7 | 7.3 | 44.89 | 48.91 | 53.29 |
| | 7.4 | 7.7 | 54.76 | 56.98 | 59.29 |
| | 7.0 | 8.0 | 49.00 | 56.00 | 64.00 |
| | 7.3 | 7.6 | 53.29 | 55.48 | 57.76 |
| | 7.2 | 8.3 | 51.84 | 59.76 | 68.89 |
| | 7.4 | 8.4 | 54.76 | 62.16 | 70.56 |
| | 7.0 | 8.1 | 49.00 | 56.70 | 65.61 |
| | 7.6 | 8.2 | 57.76 | 62.32 | 67.24 |
| | 6.9 | 7.8 | 47.61 | 53.82 | 60.84 |
| | 7.0 | 8.1 | 49.00 | 56.70 | 65.61 |
| | 7.2 | 8.0 | 51.84 | 57.60 | 64.00 |
| | 7.1 | 7.8 | 50.41 | 55.38 | 60.84 |
| | 7.0 | 7.5 | 49.00 | 52.50 | 56.25 |
| | 7.4 | 8.0 | 54.76 | 59.20 | 64.00 |
| | 7.2 | 7.9 | 51.84 | 56.88 | 62.41 |
| | 7.7 | 8.1 | 59.29 | 62.37 | 65.61 |
| | 6.9 | 7.3 | 47.61 | 50.37 | 53.29 |
| | 6.9 | 7.5 | 47.61 | 51.75 | 56.25 |
| | 7.3 | 7.6 | 53.29 | 55.48 | 57.76 |
| | 7.4 | 8.4 | 54.76 | 62.16 | 70.56 |
| | 7.5 | 8.2 | 56.25 | 61.50 | 67.24 |
| | 7.0 | 7.9 | 49.00 | 55.30 | 62.41 |
| | 7.1 | 7.8 | 50.41 | 55.38 | 60.84 |
| | 7.1 | 7.4 | 50.41 | 52.54 | 54.76 |
| | 7.1 | 8.0 | 50.41 | 56.80 | 64.00 |
| | 6.9 | 7.5 | 47.61 | 51.75 | 56.25 |
| Totals: | 729.2 | 799.5 | 5336.28 | 5849.08 | 6418.59 |

***Ordering data for Length of Middle Finger on Dominant Hand and Shoe Size in order to assign rankings***

| Length of Middle Finger on Dominant Hand | Rank for Length of Middle Finger on Dominant Hand | Shoe Size | Rank for Shoe Size |
|---|---|---|---|
| 6.7 | 1 | 3 | 1.5 |
| 7.1 | 2.5 | 5 | 9 |
| 7.1 | 2.5 | 5 | 9 |
| 7.2 | 4.5 | 7 | 35 |
| 7.2 | 4.5 | 5 | 9 |
| 7.3 | 7 | 7 | 35 |
| 7.3 | 7 | 6 | 21 |
| 7.3 | 7 | 7 | 35 |
| 7.4 | 11 | 10 | 74 |
| 7.4 | 11 | 9 | 59.5 |
| 7.4 | 11 | 6 | 21 |
| 7.4 | 11 | 5 | 9 |
| 7.4 | 11 | 7 | 35 |
| 7.5 | 18 | 7 | 35 |
| 7.5 | 18 | 6 | 21 |
| 7.5 | 18 | 7 | 35 |
| 7.5 | 18 | 6 | 21 |
| 7.5 | 18 | 5 | 9 |
| 7.5 | 18 | 7 | 35 |
| 7.5 | 18 | 5 | 9 |
| 7.5 | 18 | 6 | 21 |
| 7.5 | 18 | 5 | 9 |
| 7.6 | 24.5 | 8 | 48 |
| 7.6 | 24.5 | 3 | 1.5 |
| 7.6 | 24.5 | 7 | 35 |
| 7.6 | 24.5 | 5 | 9 |
| 7.7 | 28.5 | 9 | 59.5 |
| 7.7 | 28.5 | 6 | 21 |
| 7.7 | 28.5 | 7 | 35 |
| 7.7 | 28.5 | 5 | 9 |
| 7.8 | 36 | 9 | 59.5 |
| 7.8 | 36 | 9 | 59.5 |
| 7.8 | 36 | 10 | 74 |
| 7.8 | 36 | 12 | 95.5 |
| 7.8 | 36 | 11 | 86.5 |
| 7.8 | 36 | 12 | 95.5 |
| 7.8 | 36 | 11 | 86.5 |
| 7.8 | 36 | 5 | 9 |
| 7.8 | 36 | 7 | 35 |
| 7.8 | 36 | 5 | 9 |
| 7.8 | 36 | 7 | 35 |
| 7.9 | 45.5 | 9 | 59.5 |
| 7.9 | 45.5 | 9 | 59.5 |
| 7.9 | 45.5 | 10 | 74 |
| 7.9 | 45.5 | 10 | 74 |
| 7.9 | 45.5 | 10 | 74 |
| 7.9 | 45.5 | 7 | 35 |
| 7.9 | 45.5 | 8 | 48 |
| 7.9 | 45.5 | 8 | 48 |
| 8.0 | 54 | 10 | 74 |

| | | | |
|---|---|---|---|
| 8.0 | 54 | 10 | 74 |
| 8.0 | 54 | 8 | 48 |
| 8.0 | 54 | 10 | 74 |
| 8.0 | 54 | 7 | 35 |
| 8.0 | 54 | 5 | 9 |
| 8.0 | 54 | 8 | 48 |
| 8.0 | 54 | 6 | 21 |
| 8.0 | 54 | 7 | 35 |
| 8.1 | 62 | 10 | 74 |
| 8.1 | 62 | 9 | 59.5 |
| 8.1 | 62 | 9 | 59.5 |
| 8.1 | 62 | 6 | 21 |
| 8.1 | 62 | 6 | 21 |
| 8.1 | 62 | 6 | 21 |
| 8.1 | 62 | 7 | 35 |
| 8.2 | 68.5 | 9 | 59.5 |
| 8.2 | 68.5 | 10 | 74 |
| 8.2 | 68.5 | 10 | 74 |
| 8.2 | 68.5 | 9 | 59.5 |
| 8.2 | 68.5 | 8 | 48 |
| 8.2 | 68.5 | 7 | 35 |
| 8.3 | 74 | 10 | 74 |
| 8.3 | 74 | 9 | 59.5 |
| 8.3 | 74 | 9 | 59.5 |
| 8.3 | 74 | 11 | 86.5 |
| 8.3 | 74 | 6 | 21 |
| 8.4 | 80 | 11 | 86.5 |
| 8.4 | 80 | 10 | 74 |
| 8.4 | 80 | 12 | 95.5 |
| 8.4 | 80 | 10 | 74 |
| 8.4 | 80 | 8 | 48 |
| 8.4 | 80 | 8 | 48 |
| 8.4 | 80 | 5 | 9 |
| 8.5 | 86.5 | 11 | 86.5 |
| 8.5 | 86.5 | 11 | 86.5 |
| 8.5 | 86.5 | 10 | 74 |
| 8.5 | 86.5 | 12 | 95.5 |
| 8.5 | 86.5 | 9 | 59.5 |
| 8.5 | 86.5 | 9 | 59.5 |
| 8.6 | 92.5 | 11 | 86.5 |
| 8.7 | 92.5 | 11 | 86.5 |
| 8.7 | 92.5 | 12 | 95.5 |
| 8.7 | 92.5 | 8 | 48 |
| 8.7 | 92.5 | 11 | 86.5 |
| 8.7 | 92.5 | 7 | 35 |
| 8.8 | 96 | 11 | 86.5 |
| 9.0 | 97 | 12 | 95.5 |
| 9.2 | 98 | 12 | 95.5 |
| 9.3 | 99 | 12 | 95.5 |
| 10.0 | 100 | 13 | 100 |

***Working used to find Totals for Spearman's Rank Correlation Test between Lengths of Middle Fingers on Dominant Hands and Shoe Size***

| $f$ | $s$ | $f^2$ | $fs$ | $s^2$ |
|---|---|---|---|---|
| 1 | 1.5 | 1.00 | 1.50 | 2.25 |
| 2.5 | 9 | 6.25 | 22.50 | 81.00 |
| 2.5 | 9 | 6.25 | 22.50 | 81.00 |
| 4.5 | 35 | 20.25 | 157.50 | 1225.00 |
| 4.5 | 9 | 20.25 | 40.50 | 81.00 |
| 7 | 35 | 49.00 | 245.00 | 1225.00 |
| 7 | 21 | 49.00 | 147.00 | 441.00 |
| 7 | 35 | 49.00 | 245.00 | 1225.00 |
| 11 | 74 | 121.00 | 814.00 | 5476.00 |
| 11 | 59.5 | 121.00 | 654.50 | 3540.25 |
| 11 | 21 | 121.00 | 231.00 | 441.00 |
| 11 | 9 | 121.00 | 99.00 | 81.00 |
| 11 | 35 | 121.00 | 385.00 | 1225.00 |
| 18 | 35 | 324.00 | 630.00 | 1225.00 |
| 18 | 21 | 324.00 | 378.00 | 441.00 |
| 18 | 35 | 324.00 | 630.00 | 1225.00 |
| 18 | 21 | 324.00 | 378.00 | 441.00 |
| 18 | 9 | 324.00 | 162.00 | 81.00 |
| 18 | 35 | 324.00 | 630.00 | 1225.00 |
| 18 | 9 | 324.00 | 162.00 | 81.00 |
| 18 | 21 | 324.00 | 378.00 | 441.00 |
| 18 | 9 | 324.00 | 162.00 | 81.00 |
| 24.5 | 48 | 600.25 | 1176.00 | 2304.00 |
| 24.5 | 1.5 | 600.25 | 36.75 | 2.25 |
| 24.5 | 35 | 600.25 | 857.50 | 1225.00 |
| 24.5 | 9 | 600.25 | 220.50 | 81.00 |
| 28.5 | 59.5 | 812.25 | 1695.75 | 3540.25 |
| 28.5 | 21 | 812.25 | 598.50 | 441.00 |
| 28.5 | 35 | 812.25 | 997.50 | 1225.00 |
| 28.5 | 9 | 812.25 | 256.50 | 81.00 |
| 36 | 59.5 | 1296.00 | 2142.00 | 3540.25 |
| 36 | 59.5 | 1296.00 | 2142.00 | 3540.25 |
| 36 | 74 | 1296.00 | 2664.00 | 5476.00 |
| 36 | 95.5 | 1296.00 | 3438.00 | 9120.25 |
| 36 | 86.5 | 1296.00 | 3114.00 | 7482.25 |
| 36 | 95.5 | 1296.00 | 3438.00 | 9120.25 |
| 36 | 86.5 | 1296.00 | 3114.00 | 7482.25 |
| 36 | 9 | 1296.00 | 324.00 | 81.00 |
| 36 | 35 | 1296.00 | 1260.00 | 1225.00 |
| 36 | 9 | 1296.00 | 324.00 | 81.00 |
| 36 | 35 | 1296.00 | 1260.00 | 1225.00 |
| 45.5 | 59.5 | 2070.25 | 2707.25 | 3540.25 |
| 45.5 | 59.5 | 2070.25 | 2707.25 | 3540.25 |
| 45.5 | 74 | 2070.25 | 3367.00 | 5476.00 |
| 45.5 | 74 | 2070.25 | 3367.00 | 5476.00 |
| 45.5 | 74 | 2070.25 | 3367.00 | 5476.00 |
| 45.5 | 35 | 2070.25 | 1592.50 | 1225.00 |
| 45.5 | 48 | 2070.25 | 2184.00 | 2304.00 |
| 45.5 | 48 | 2070.25 | 2184.00 | 2304.00 |
| 54 | 74 | 2916.00 | 3996.00 | 5476.00 |
| 54 | 74 | 2916.00 | 3996.00 | 5476.00 |

| | | | | | |
|---|---|---|---|---|---|
| | 54 | 48 | 2916.00 | 2592.00 | 2304.00 |
| | 54 | 74 | 2916.00 | 3996.00 | 5476.00 |
| | 54 | 35 | 2916.00 | 1890.00 | 1225.00 |
| | 54 | 9 | 2916.00 | 486.00 | 81.00 |
| | 54 | 48 | 2916.00 | 2592.00 | 2304.00 |
| | 54 | 21 | 2916.00 | 1134.00 | 441.00 |
| | 54 | 35 | 2916.00 | 1890.00 | 1225.00 |
| | 62 | 74 | 3844.00 | 4588.00 | 5476.00 |
| | 62 | 59.5 | 3844.00 | 3689.00 | 3540.25 |
| | 62 | 59.5 | 3844.00 | 3689.00 | 3540.25 |
| | 62 | 21 | 3844.00 | 1302.00 | 441.00 |
| | 62 | 21 | 3844.00 | 1302.00 | 441.00 |
| | 62 | 21 | 3844.00 | 1302.00 | 441.00 |
| | 62 | 35 | 3844.00 | 2170.00 | 1225.00 |
| | 68.5 | 59.5 | 4692.25 | 4075.75 | 3540.25 |
| | 68.5 | 74 | 4692.25 | 5069.00 | 5476.00 |
| | 68.5 | 74 | 4692.25 | 5069.00 | 5476.00 |
| | 68.5 | 59.5 | 4692.25 | 4075.75 | 3540.25 |
| | 68.5 | 48 | 4692.25 | 3288.00 | 2304.00 |
| | 68.5 | 35 | 4692.25 | 2397.50 | 1225.00 |
| | 74 | 74 | 5476.00 | 5476.00 | 5476.00 |
| | 74 | 59.5 | 5476.00 | 4403.00 | 3540.25 |
| | 74 | 59.5 | 5476.00 | 4403.00 | 3540.25 |
| | 74 | 86.5 | 5476.00 | 6401.00 | 7482.25 |
| | 74 | 21 | 5476.00 | 1554.00 | 441.00 |
| | 80 | 86.5 | 6400.00 | 6920.00 | 7482.25 |
| | 80 | 74 | 6400.00 | 5920.00 | 5476.00 |
| | 80 | 95.5 | 6400.00 | 7640.00 | 9120.25 |
| | 80 | 74 | 6400.00 | 5920.00 | 5476.00 |
| | 80 | 48 | 6400.00 | 3840.00 | 2304.00 |
| | 80 | 48 | 6400.00 | 3840.00 | 2304.00 |
| | 80 | 9 | 6400.00 | 720.00 | 81.00 |
| | 86.5 | 86.5 | 7482.25 | 7482.25 | 7482.25 |
| | 86.5 | 86.5 | 7482.25 | 7482.25 | 7482.25 |
| | 86.5 | 74 | 7482.25 | 6401.00 | 5476.00 |
| | 86.5 | 95.5 | 7482.25 | 8260.75 | 9120.25 |
| | 86.5 | 59.5 | 7482.25 | 5146.75 | 3540.25 |
| | 86.5 | 59.5 | 7482.25 | 5146.75 | 3540.25 |
| | 92.5 | 86.5 | 8556.25 | 8001.25 | 7482.25 |
| | 92.5 | 86.5 | 8556.25 | 8001.25 | 7482.25 |
| | 92.5 | 95.5 | 8556.25 | 8833.75 | 9120.25 |
| | 92.5 | 48 | 8556.25 | 4440.00 | 2304.00 |
| | 92.5 | 86.5 | 8556.25 | 8001.25 | 7482.25 |
| | 92.5 | 35 | 8556.25 | 3237.50 | 1225.00 |
| | 96 | 86.5 | 9216.00 | 8304.00 | 7482.25 |
| | 97 | 95.5 | 9409.00 | 9263.50 | 9120.25 |
| | 98 | 95.5 | 9604.00 | 9359.00 | 9120.25 |
| | 99 | 95.5 | 9801.00 | 9454.50 | 9120.25 |
| | 100 | 100 | 10000.00 | 10000.00 | 10000.00 |
| Totals: | 5050.00 | 5050.00 | 337936.50 | 305551.75 | 336957.50 |

***Working used to get totals for best estimates for the middle finger of the dominant hands of the males in the sample***

| x | f | fx | $fx^2$ |
|---|---|---|---|
| 7.4 | 2 | 14.8 | 109.5 |
| 7.6 | 1 | 7.6 | 57.8 |
| 7.7 | 1 | 7.7 | 59.3 |
| 7.8 | 7 | 54.6 | 425.9 |
| 7.9 | 5 | 39.5 | 312.1 |
| 8.0 | 4 | 32.0 | 256.0 |
| 8.1 | 3 | 24.3 | 196.8 |
| 8.2 | 3 | 24.6 | 201.7 |
| 8.3 | 4 | 33.2 | 275.6 |
| 8.4 | 4 | 33.6 | 282.2 |
| 8.5 | 6 | 51.0 | 433.5 |
| 8.6 | 1 | 8.6 | 74.0 |
| 8.7 | 4 | 34.8 | 302.8 |
| 8.8 | 1 | 8.8 | 77.4 |
| 9.0 | 1 | 9.0 | 81.0 |
| 9.2 | 1 | 9.2 | 84.6 |
| 9.3 | 1 | 9.3 | 86.5 |
| 10.0 | 1 | 10.0 | 100.0 |
| Totals: | 50.0 | 412.6 | 3416.6 |



***Working used to get totals for best estimates for the middle finger of the dominant hands of the females in the sample***

| x | f | fx | $fx^2$ |
|---|---|---|---|
| 6.7 | 1 | 6.7 | 44.9 |
| 7.1 | 2 | 14.2 | 100.8 |
| 7.2 | 2 | 14.4 | 103.7 |
| 7.3 | 3 | 21.9 | 159.9 |
| 7.4 | 3 | 22.2 | 164.3 |
| 7.5 | 9 | 67.5 | 506.3 |
| 7.6 | 3 | 22.8 | 173.3 |
| 7.7 | 3 | 23.1 | 177.9 |
| 7.8 | 4 | 31.2 | 243.4 |
| 7.9 | 3 | 23.7 | 187.2 |
| 8.0 | 5 | 40.0 | 320.0 |
| 8.1 | 4 | 32.4 | 262.4 |
| 8.2 | 3 | 24.6 | 201.7 |
| 8.3 | 1 | 8.3 | 68.9 |
| 8.4 | 3 | 25.2 | 211.7 |
| 8.7 | 1 | 8.7 | 75.7 |
| Totals: | 50.0 | 386.9 | 3001.95 |

***Deducing the formula for the confidence interval for*** $\mu_r$

100 items of data, so CLT can be used to state that:

$$\overline{R} \sim N\left(\hat{\mu}_r, \hat{\sigma}_r{}^2\right)$$

A table of percentage points for the Normal distribution is used to show that

$$P\left(-1.96 < \frac{\overline{R} - \hat{\mu}_r}{\hat{\sigma}_r / \sqrt{n}} < 1.96\right) = 0.95$$

Rearranging:

$$P\left(\hat{\mu}_r - \frac{1.96\hat{\sigma}_r}{\sqrt{n}} < \overline{R} < \hat{\mu}_r + \frac{1.96\hat{\sigma}_r}{\sqrt{n}}\right) = 0.95$$

Rearranging again:

$$P\left(\overline{R} + \frac{1.96\hat{\sigma}_r}{\sqrt{n}} > \hat{\mu}_r > \overline{R} - \frac{1.96\hat{\sigma}_r}{\sqrt{n}}\right) = 0.95$$

Use this to deduce a 95% confidence interval for $\mu_r$ as:

$$\left(\overline{R} - \frac{1.96\hat{\sigma}_r}{\sqrt{n}}, \overline{R} + \frac{1.96\hat{\sigma}_r}{\sqrt{n}}\right)$$

Summarising, the confidence interval for $\mu_r$ can be stated as

$$\overline{r} \pm \frac{1.96\hat{\sigma}_r}{\sqrt{n}}$$

### *Calculation of totals for Middle Finger, Dominant Hand*

| | x | f | fx | $fx^2$ |
|---|---|---|---|---|
| | 6.7 | 1 | 6.70 | 44.89 |
| | 7.1 | 2 | 14.2 | 100.82 |
| | 7.2 | 2 | 14.4 | 103.68 |
| | 7.3 | 3 | 21.9 | 159.87 |
| | 7.4 | 5 | 37.0 | 273.80 |
| | 7.5 | 9 | 67.5 | 506.25 |
| | 7.6 | 4 | 30.4 | 231.04 |
| | 7.7 | 4 | 30.8 | 237.16 |
| | 7.8 | 11 | 85.8 | 669.24 |
| | 7.9 | 8 | 63.2 | 499.28 |
| | 8.0 | 9 | 72.0 | 576.00 |
| | 8.1 | 7 | 56.7 | 459.27 |
| | 8.2 | 6 | 49.2 | 403.44 |
| | 8.3 | 5 | 41.5 | 344.45 |
| | 8.4 | 7 | 58.8 | 493.92 |
| | 8.5 | 6 | 51.0 | 433.50 |
| | 8.6 | 1 | 8.60 | 73.96 |
| | 8.7 | 5 | 43.5 | 378.45 |
| | 8.8 | 1 | 8.80 | 77.44 |
| | 9.0 | 1 | 9.00 | 81.00 |
| | 9.2 | 1 | 9.20 | 84.64 |
| | 9.3 | 1 | 9.30 | 86.49 |
| | 10.0 | 1 | 10.0 | 100.00 |
| Totals: | | 100 | 799.5 | 6418.59 |

### *Calculation of totals for Middle Finger, Recessive Hand*

| | x | f | fx | $fx^2$ |
|---|---|---|---|---|
| | 6.8 | 1 | 6.8 | 46.24 |
| | 7.0 | 1 | 7 | 49 |
| | 7.1 | 2 | 14.2 | 100.82 |
| | 7.2 | 2 | 14.4 | 103.68 |
| | 7.3 | 7 | 51.1 | 373.03 |
| | 7.4 | 5 | 37 | 273.8 |
| | 7.5 | 5 | 37.5 | 281.25 |
| | 7.6 | 8 | 60.8 | 462.08 |
| | 7.7 | 9 | 69.3 | 533.61 |
| | 7.8 | 9 | 70.2 | 547.56 |
| | 7.9 | 8 | 63.2 | 499.28 |
| | 8.0 | 7 | 56 | 448 |
| | 8.1 | 13 | 105.3 | 852.93 |
| | 8.2 | 3 | 24.6 | 201.72 |
| | 8.3 | 6 | 49.8 | 413.34 |
| | 8.4 | 3 | 25.2 | 211.68 |
| | 8.5 | 3 | 25.5 | 216.75 |
| | 8.6 | 2 | 17.2 | 147.92 |
| | 8.7 | 1 | 8.7 | 75.69 |
| | 8.9 | 1 | 8.9 | 79.21 |
| | 9.1 | 2 | 18.2 | 165.62 |
| | 9.4 | 1 | 9.4 | 88.36 |
| | 10.2 | 1 | 10.2 | 104.04 |
| Totals: | | 100 | 790.5 | 6275.61 |

***Working for Histogram of Forefingers on Dominant Hands***

| Lower Bound | Upper Bound | Width (w) | Frequency (f) | **Frequency Density (f/w)** |
|---|---|---|---|---|
| 6.0 | 6.5 | 0.5 | 1 | **2** |
| 6.5 | 7.0 | 0.5 | 20 | **40** |
| 7.0 | 7.5 | 0.5 | 47 | **94** |
| 7.5 | 8.0 | 0.5 | 24 | **48** |
| 8.0 | 8.5 | 0.5 | 7 | **14** |
| 8.5 | 9.5 | 1 | 1 | **1** |

***Working for Histogram of Forefingers on Recessive Hands***

| Lower Bound | Upper Bound | Width (w) | Frequency (f) | **Frequency Density (f/w)** |
|---|---|---|---|---|
| 6.0 | 6.5 | 0.5 | 2 | **4** |
| 6.5 | 7.0 | 0.5 | 26 | **52** |
| 7.0 | 7.5 | 0.5 | 47 | **94** |
| 7.5 | 8.0 | 0.5 | 21 | **42** |
| 8.0 | 10.0 | 2 | 4 | **2** |

***Working for Histogram of Middle on Dominant Hands***

| Lower Bound | Upper Bound | Width (w) | Frequency (f) | **Frequency Density (f/w)** |
|---|---|---|---|---|
| 6.5 | 7.0 | 0.5 | 1 | **2** |
| 7.0 | 7.5 | 0.5 | 12 | **24** |
| 7.5 | 8.0 | 0.5 | 36 | **72** |
| 8.0 | 8.5 | 0.5 | 34 | **68** |
| 8.5 | 9.0 | 0.5 | 13 | **26** |
| 9.0 | 9.5 | 0.5 | 3 | **6** |
| 9.5 | 10.5 | 1 | 1 | **1** |

***Working for Histogram of Middle on Recessive Hands***

| Lower Bound | Upper Bound | Width (w) | Frequency (f) | **Frequency Density (f/w)** |
|---|---|---|---|---|
| 6.5 | 7.0 | 0.5 | 1 | **2** |
| 7.0 | 7.5 | 0.5 | 17 | **34** |
| 7.5 | 8.0 | 0.5 | 39 | **78** |
| 8.0 | 8.5 | 0.5 | 32 | **64** |
| 8.5 | 9.0 | 0.5 | 7 | **14** |
| 9.0 | 9.5 | 0.5 | 3 | **6** |
| 9.5 | 10.5 | 1 | 1 | **1** |

# Introduction

# Analysis

# Data Collection

# Conclusions

# Appendix