EYE COLOUR and reaction time

An opportunity for critical statistical reasoning

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Eye colour is a variable that is often used in classroom data collection activities. It is relatively easy to document, subject to the occasional argument, and provides an example of a categorical variable other than gender to be used for graphing purposes. Figure 1 shows a pie graph produced by some students in a grade 5/6 classroom (Chick & Watson, 2001). Detailing the relative presence of the colours in the class is about as far as the use of the variable extends. As the students who worked with Chick and Watson found, attempts to show associations of eye colour with other variables such as weight, age, or number of fast foods eaten per week, are usually fruitless. In fact by grade 7 most students have dismissed eye colour as an "interesting" attribute to explore.

It was hence surprising to read a short article in *The Mercury* newspaper in Hobart about blue-eyed people being more intelligent and brown-eyed people having faster reaction times (see Figure 2). Such an article invites immediate scepticism from the statistically literate. The lack of data in the article should lead the interested reader to a search for further information, most likely through an internet search. Although the first claim might be considered too contentious for investigation in the classroom, the second one about brown eyes and reaction times seems quite harmless and could provide considerable motivation for data collection and analysis to confirm or refute the claim.

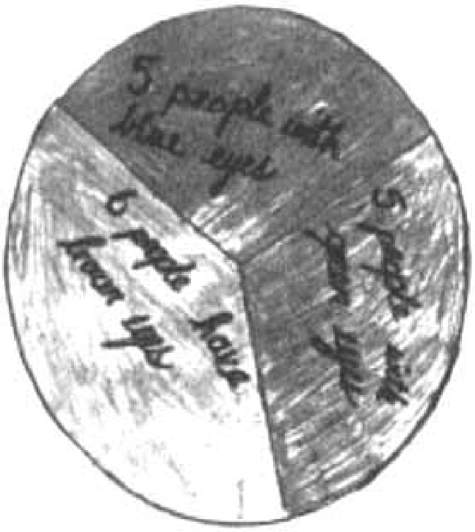

Figure 1. Typical pie graph of eye colour.

This article progresses through the steps that could be followed in a middle school classroom to explore the question and develop critical statistical reasoning skills (Watson, 2006). Students should first consider their initial reaction to the claims in the article and what questions they would like to have answered before accepting the claims. Second, students should undertake as much research on the topic as possible,

Eye colour achievements

The colour of your eyes could determine your achievements in life, say scientists. Those with blue eyes are more likely to sparkle academically than those with brown.

In reaction time trials in the US, brown eyes performed better, making them more likely to succeed at things like football, hockey and rugby.

But those with lighter eyes appeared to be better strategic thinkers.

Figure 2. Newspaper article. *The Mercury* (Hobart), 21 August 2007

probably through the Internet. Next students have the opportunity to collect data from their own class and see what their sample suggests about the claim. Finally students can collect larger random samples, such as from the Australian Bureau of Statistics' (ABS) *CensusAtSchool* website to check out the eye colour and reaction time claim. All of these steps should then contribute to a report that supplies evidence for and/or against the claim and reaches a tentative conclusion about its validity.

Questioning the article

Of interest from a critical literacy perspective is how the news media chose to report on the study. The article in *The Mercury* reproduced in Figure 2 is quite short but a search of the Internet produces reports of varying length. Students should collect a few of these and compare and contrast them. Some, such as the much longer one in Figure 3, include examples of well-known people with blue eyes. The one in Figure 3 also mentions the university in the US where the research was carried out, the name of the researcher, a supporting comment by another academic from another country, and extra information related to eye colour. Students should discuss this source: which elements add to their understanding of the claims made and which are extraneous? Another extract from *The Times of India* (see Figure 4) adds a few more details, for example noting that black eyes were not considered. Students could consider why this would be a significant addition in India. The use of language is also interesting in comparing the reports in Figure 3 and Figure 4. In the latter, the "brown-eyed people succeeded," whereas in the former they were "more likely to succeed" at activities such as football and hockey. One statement claims a fact whereas the other is a probabilistic statement. This raises other questions about the study itself. A few of these are finally answered in the extract in Figure 5, which provides the sample size and the explanations of the "forehand rally" activity that was carried out.

At this point is it important to get students to speculate about what the data might have looked like to produce the claims in the media reports. Without the information in Figure 5, many general comments can be made and graphs drawn. A task such as shown in Figure 6 would be highly relevant to building critical statistical literacy. Depending on how the classroom activity progressed, it could be used both before and after information such as in Figure 5 was available. Questions about the sample size may emerge when students begin to consider the subgroups with different coloured eyes. A careful reading of the results reported in Figure 5 should also raise some questions about which subgroups were compared with each other. As well, the use of the terms dark-eyed and light-eyed may address the ques-

Why Blue-eyed boys (and girls) are so brilliant

Scientists discover what may have made Stephen Hawking – and Lily Cole – so intelligent

By BEN CLERKIN – Last updated at 11:33am on 20th August 2007

The colour of your eyes could determine your achievements in life, say scientists. They claim those with blue eyes are more likely to sparkle academically than those with brown. They are more intelligent and gain more qualifications because they study more effectively and perform better in exams. The discovery might help explain the success of such disparate individuals as Stephen Hawking, Alexander Fleming, Marie Curie, Stephen Fry and Lily Cole.

In reaction time trials conducted by U.S. scientists, the brown-eyed performed better, making them more likely to succeed at activities such as football, hockey and rugby. But the researchers concluded that those with lighter eyes appeared to be better strategic thinkers.

Blue-eyed boys and girls proved to be more successful in activities that required them to plan and structure their time, such as golf, cross-country running and studying for exams.

Those highly intelligent Stephens (Hawking and Fry): New research has revealed that blue-eyed individuals may study more effectively and perform better in exams than those with dark eyes.

Stephen Hawking, author of A Brief History Of Time, is Britain's most eminent physicist.

Writer and actor Stephen Fry gained a scholarship to Cambridge.

Joanna Rowe, professor emeritus at the University of Louisville in Kentucky, who conducted the tests, said the results suggested a hitherto unexplored link between eye colour and academic achievement.

"It is just observed, rather than explained," she said. "There's no scientific answer yet." Dr Tony Fallone, senior psychology lecturer at the University of Bedfordshire, who has also studied eye colour, believes it should be taken more seriously as an indicator or personality and ability.

Most babies have blue eyes but they usually darken as the pigment melanin builds up in the iris.

Less melanin produces green, grey, or light brown eyes. Eyes with very little melanin appear blue or grey.

Figure 3. Longer report from the Internet (Clerkin, 2007).

Study – Eye Colour Matters

From The Times of India

New York: Success lies in the colour of your eyes, and those with blue ones are likely to achieve more in life than their peers as they tend to study more effectively and perform better in exams, says a study conducted by US scientists.

The study did not mention anything about people with black irises.

The test showed that brown eyed people had faster reaction time, but those with lighter eyes appeared to be better strategic thinkers.

Brown eyed people succeeded in activities such as football and hockey, but lighter eyed participants proved to be more successful in activities that required skills in time structuring and planning such as golf, cross country running and studying for exams, the scientists said.

Louisville university professor Joanna Rowe, who conducted the tests, said the results suggested an unexplored link between eye colour and academic achievement. "It is just observed, rather than explained," she said. "There's no scientific answer yet."

Figure 4. Report from *The Times of India* ("Study," 2007).

Ball colour, eye colour, and a reactive motor skill.

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Researchers investigating performance differences between light- and dark-eyed individuals have indicated that dark-eyed individuals perform better on reactive activities than light-eyed individuals. College students (61 men, 64 women) performed a forehand rally with different coloured raquetballs. Eye colour, sex, and total hits were recorded for each subject. Men scored significantly better with balls of each colour than did women. Dark-eyed men performed better than other subjects and performance was better with blue balls than yellow or green balls

PMID:7808908 [PubMed - indexed for MEDLINE]

Figure 5. *Medline* extract (Rowe & Evans, 2007).

Draw a graph that could possibly represent the relationship between the following variables that would support the conclusions made by the researchers at the University of Louisville:

a) Eye colour and reaction time.
b) Eye colour and academic achievement.

For each graph, explain in words why you chose the type of graph you used and the reasons for its shape, scale and units on each of the axes.

Figure 6. A task for students after the Internet search.

tion raised by *The Times of India* about black-eyed individuals. Finally, although reaction time is the phrase used in the first three reports, the Medline report suggests counting rather than time measurement. How this experiment was carried out to find that more rallies correspond to faster reaction time would lead to further interesting and relevant discussion.

Classroom data

Particularly in light of the relatively small sample size reported in Figure 5, students should ask questions about other possible samples, including their own class. They can come up with their own activity to measure reaction time and see if a similar relationship exists for their sample. A common activity used in upper primary and middle school classrooms involves two students, where one holds a ruler above the outstretched forefinger and thumb of another student. The ruler is dropped and the second student grabs it with the forefinger and thumb, then measuring the distance down the ruler as a gauge of reaction time. The shorter the distance measured, the quicker the reaction time. Another possibility is to use the Australian Bureau of Statistics' *CensusAtSchool* website, which has a reaction timer based on responding to a colour change on the computer screen by clicking on a mouse. There are tasks for both right and left hands, and data can be recorded in class for each student.[1]

Data collected from 30 students in a grade 10 class are used here to explore questions related to the results claimed in the reports in the figures. The students used the *CensusAtSchool* site to collect their reaction time data.

Claim 1: Brown-eyed people had faster reaction times than others (Figures 2, 3, and 4)

Claim 2: Males had faster reaction times than females (Figure 5).

Claim 3: Dark-eyed males performed better than other subjects (Figure 5).

The graphs shown in the following figures were produced using the *TinkerPlots* software (Konold & Miller, 2005). The plots include hat plots, which are variations on box-and-whisker plots, showing the middle 50% of the data in the crown of the hat and the top and bottom 25% in the brims of the hat. The mean value for right hand reaction time is indicated on the horizontal axis for each subgroup of the sample.

1. Data collected from the ABS website are of interest in comparing reaction times for left-handed, right-handed, and ambidextrous people, for males and females, and for students in different grades from 4 to 12. The presence of eye colour in the data set also allows the extension activity suggested in this article.

Figure 7 shows the plot for right hand reaction time in relation to Claim 1, that brown-eyed people were quicker than light-eyed people (here "other" includes green, blue, grey, and hazel). It does appear from this grade 10 sample that evidence supports the claim. The class would need to discuss the number of students with brown eyes and whether this affects the confidence they have in their result.

The graph in Figure 8 supports Claim 2, that males have faster reaction times than females, certainly for this class. Not only do the average reaction times for the two subgroups support this but it can be seen that the crowns

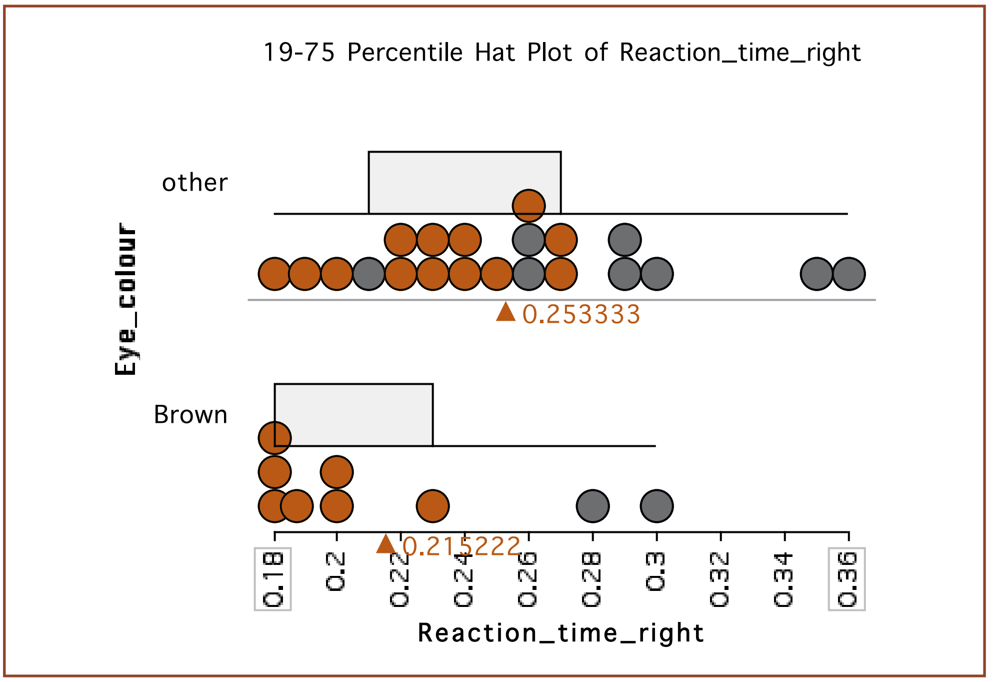

Figure 7. Grade 10 sample of reaction times for brown-eyed students and others.

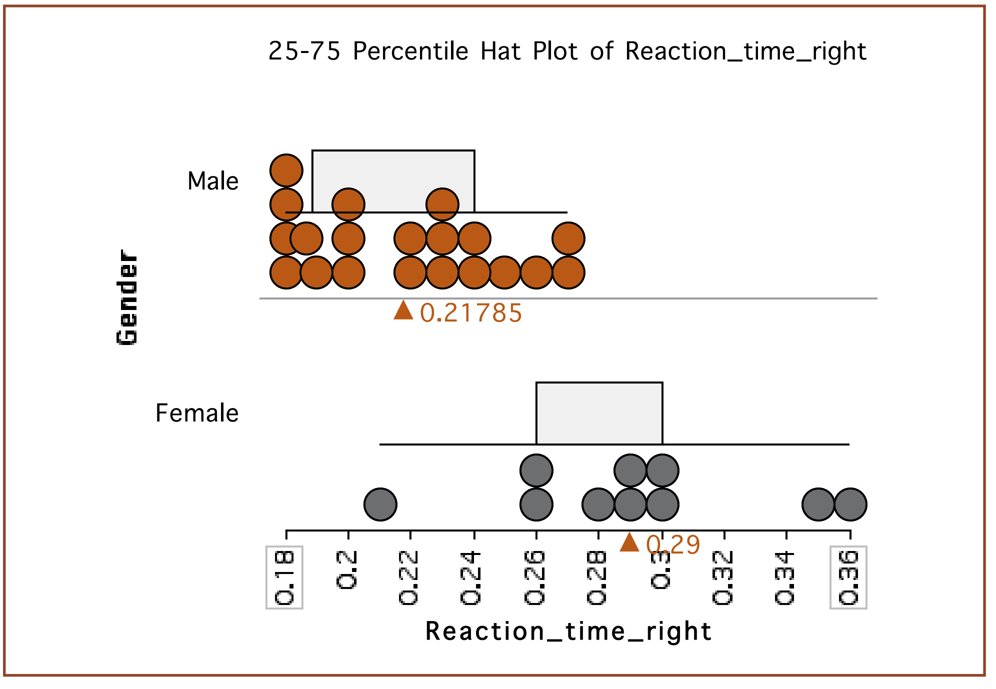

Figure 8. Grade 10 sample of reaction times for males and females.

of the hats do not overlap at all and only 3 of the 10 females are as fast as some of the males.

For this class of Grade 10 students, there are seven brown-eyed males. Figure 9 shows their reaction times compared with all other students in the class. Although the data sets overlap, again the mean values for the two groups and the non-overlapping crowns of the hat plots, provide support for Claim 3, that dark-eyed (brown-eyed) males have faster reaction times than the rest of the students in the class. Having seen the results in Figure 8, however, students should be suspicious of this outcome. If males have

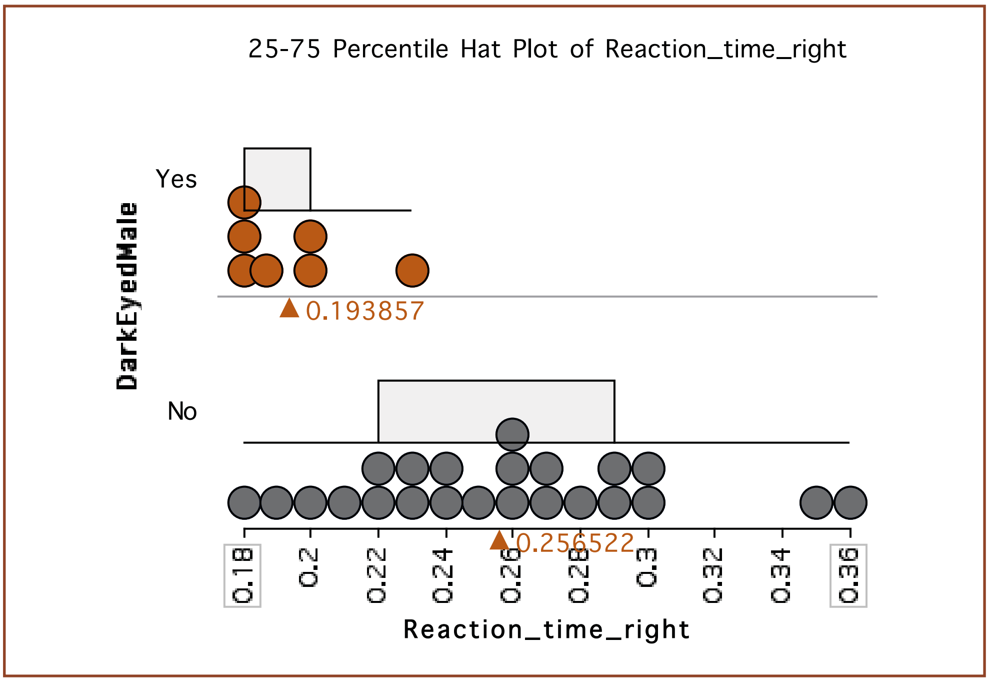

Figure 9. Grade 10 sample of reaction times for dark-eyed (brown-eyed) males and all other students (males and females).

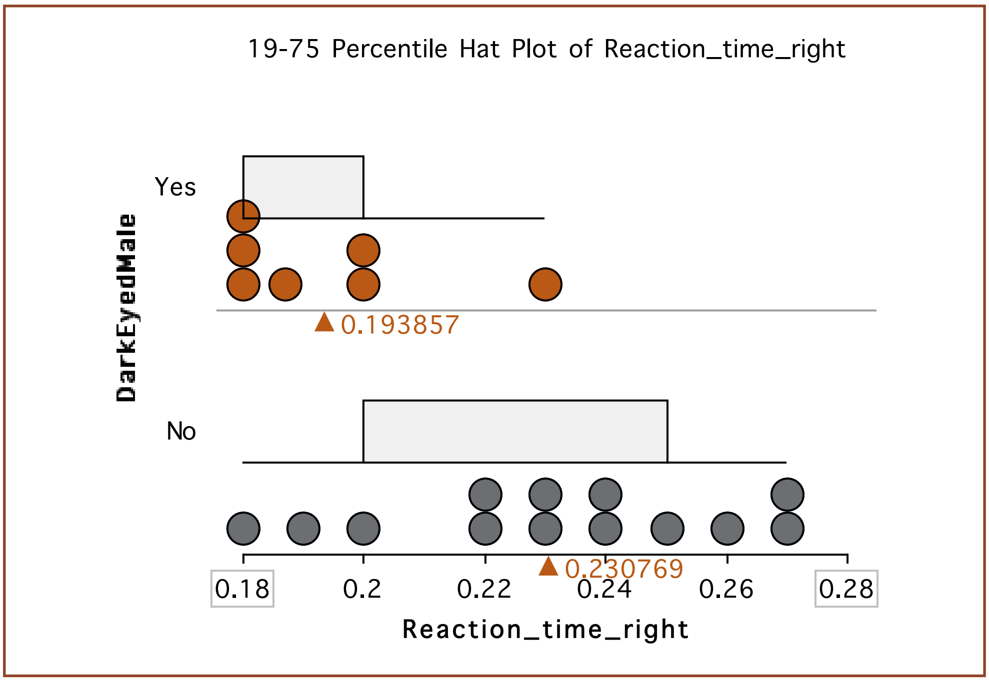

Figure 10. Grade 10 sample of reaction times for dark-eyed and light-eyed males.

faster reaction times than females, then putting all of the females in the "other" group will be likely to make the brown-eyed males look even better. What about the brown-eyed males and the "other" males?

Figure 10 shows the comparison of brown-eyed and light-eyed males in the Grade 10 class. The spread of reaction times for the light-eyed males is greater. Again the mean for the brown-eyed males is quicker and the crowns of the hats only touch. It would appear from the evidence of this Grade 10 class that there might be something to the claim that dark-eyed males have faster reaction times than "other" males. Students then need to consider the sample size and how confident they can be when there are only seven brown-eyed males in the class.

Collecting a larger sample

The existence of the large data set collected through the ABS *CensusAtSchool* project allows random samples of up to 200 students to be collected. The data set contains eye colour as well as reaction times (right and left), making it possible to explore Claims 1, 2, and 3, as done for the grade 10 sample. One way to explore these claims is to collect two random samples, of 200 males and of 200 females. These can be selected from grade 11 and 12 students across Australia, as these students would be closest to the ages of the US students in the reports. The random samples report on a large number of variables but only reaction times, gender, and eye colour are of interest in this investigation. As well these large random samples are

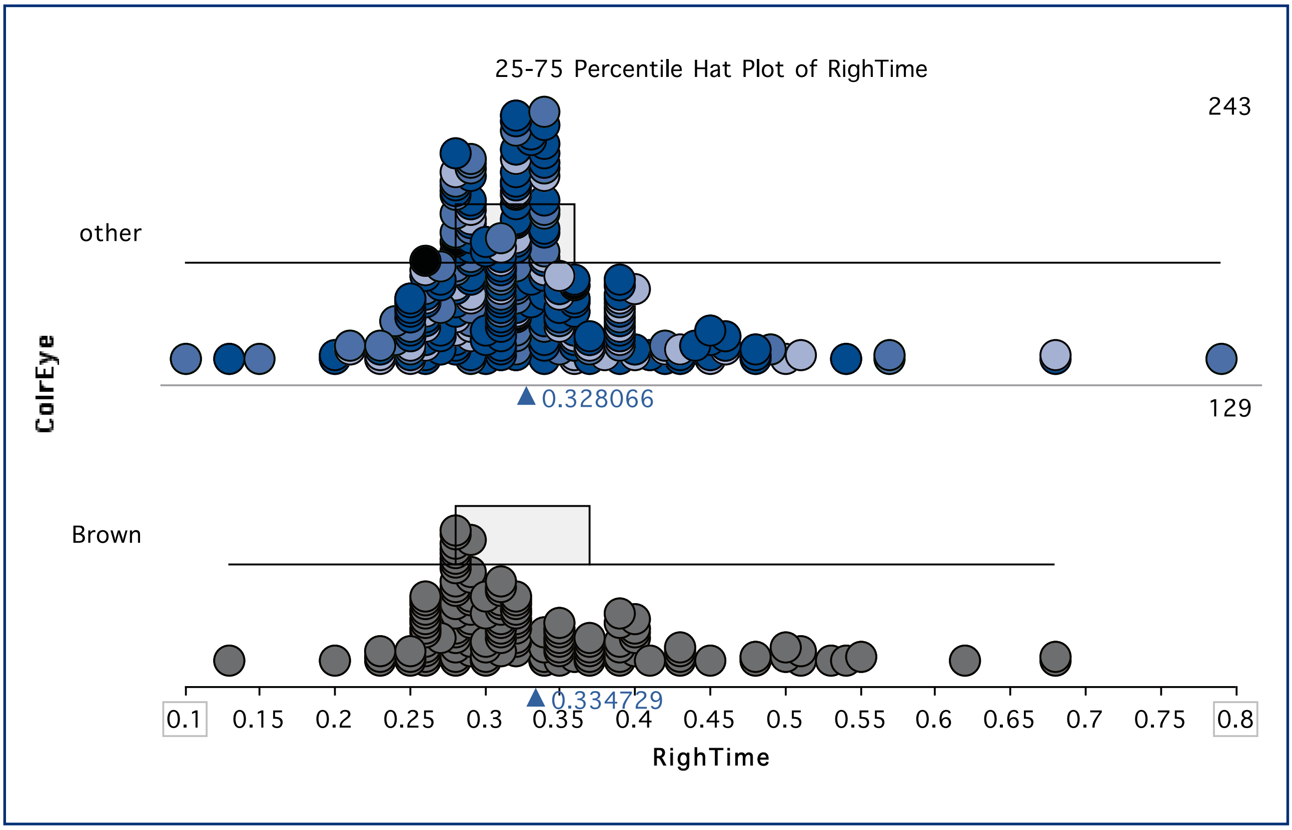

Figure 11. Reaction time for brown-eyed and other-coloured-eye students for large random sample.

likely to have outliers or missing data for reaction time, or “other” as an eye colour, different from brown, blue, green, grey, or hazel. The presence of these values needs to be discussed and students made aware of the decision process in eliminating them. The suggestions for deleting large values are likely to be related to a student missing the colour change and waiting several seconds for it to occur or to dropping the mouse. The two samples can be combined in *TinkerPlots* and with plots created, the outliers and “other” colours “hidden.” For the 400 students in the random sample used here, 28 cases were deleted, leaving 183 females and 189 males.

Figure 11 shows the comparison of brown-eyed students and “others” (blue, green, grey, and hazel). The distributions have similar spread and the crowns of the hats overlap with the “other” middle 50% range contained within the brown middle 50% range. In this case the mean for the light-eyed students’ reaction time (0.328 s) is slightly less than that for the brown-eyed students (0.335 s). Hence there is no support for Claim 1 from this random sample.

Claim 2, that males have faster reaction times than females, however, is supported by this data set, as is seen in Figure 12. The females’ distribution shows greater spread in the crown of the hat and a slower mean reaction time (0.352 s compared to 0.309 s) than the males’ distribution.[2]

Turning to Claim 3, that dark-eyed males have faster reaction times than other students, the plots shown in Figures 13 and 14 demonstrate the fallacy reported in the report in Figure 5. When comparing the dark-eyed males with all other cases (including females) in Figure 13 it can be seen that the distribution for dark-eyed males has less

2. A *t*-test carried out in Fathom indicated that there was a significant difference in the means of these two sets (t=5.183, p<0.0001).

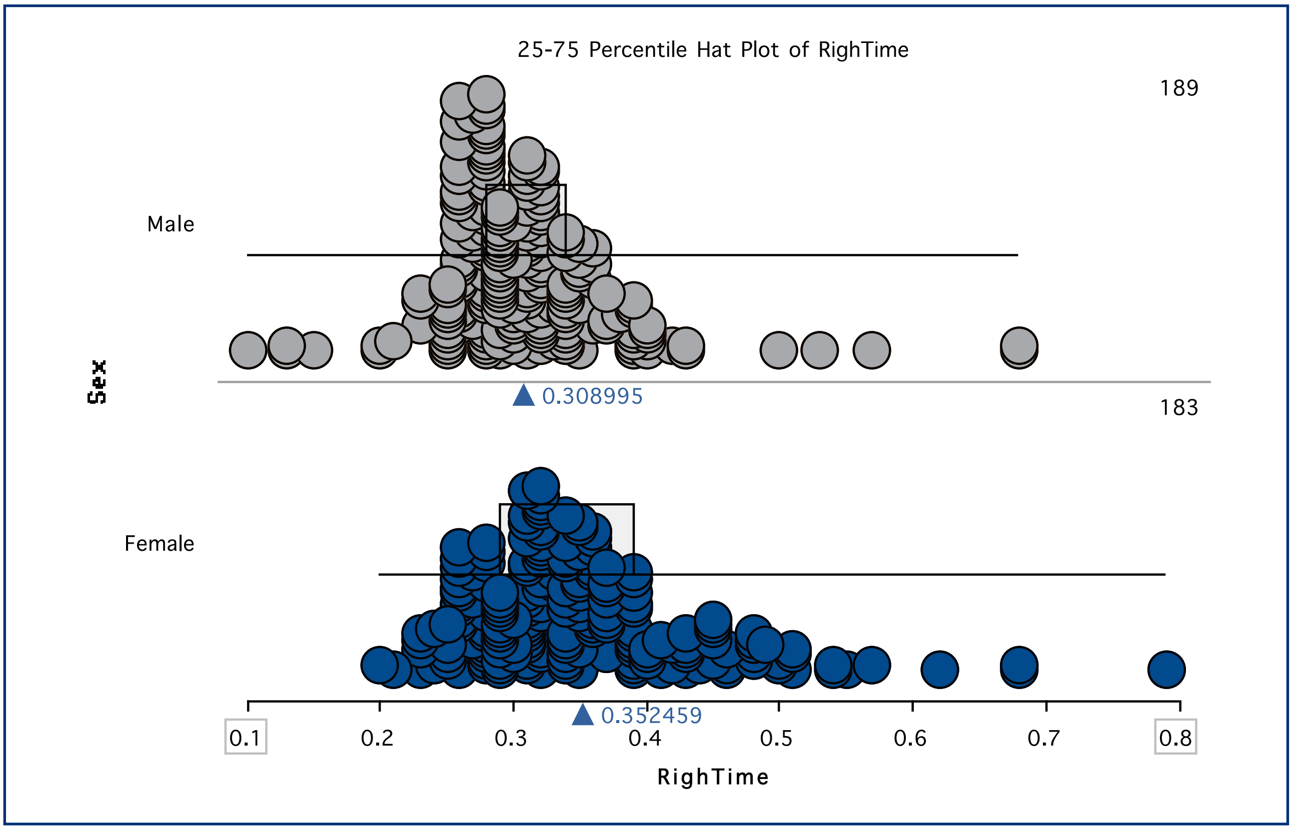

Figure 12. Reaction time for males and females for large random sample.

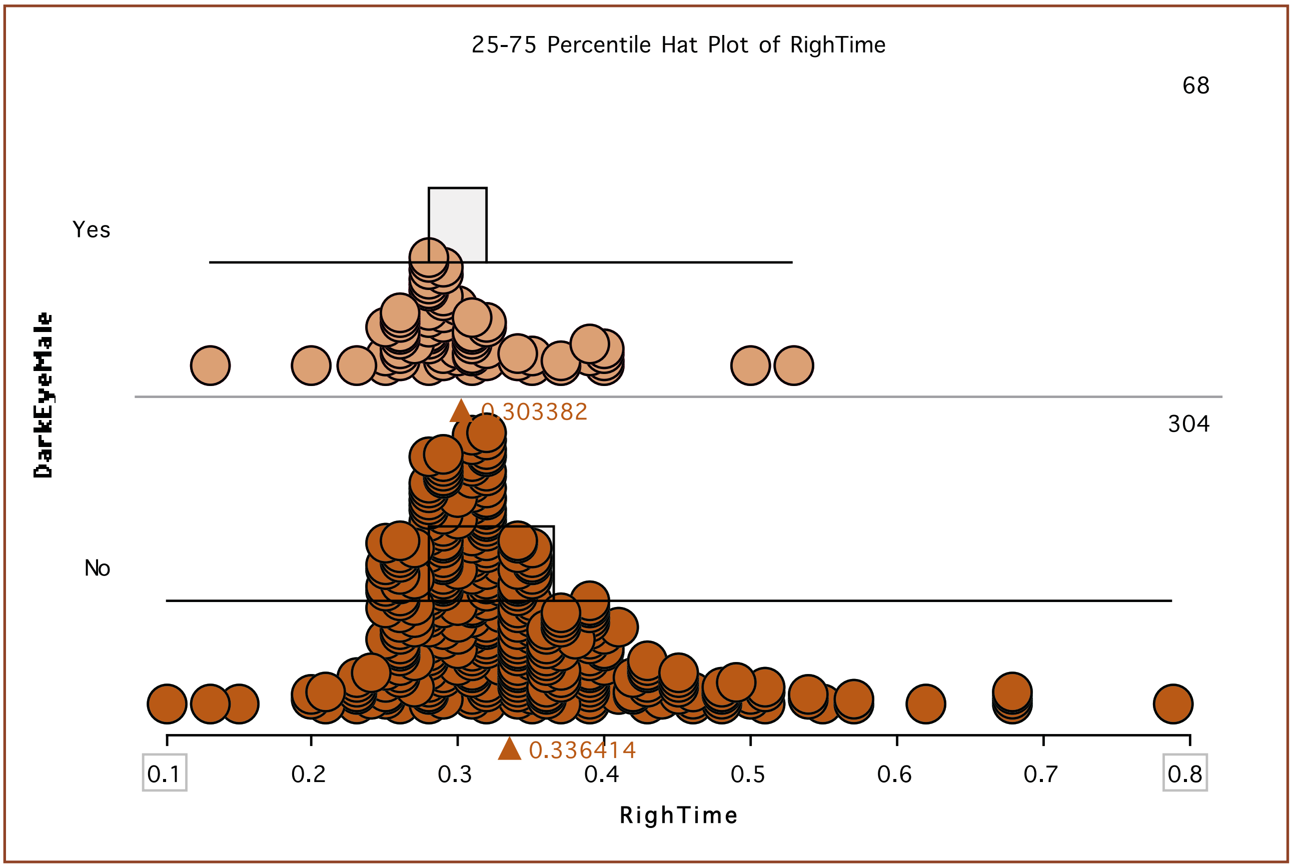

Figure 13. Reaction time for dark-eyed males and all other students for large random sample.

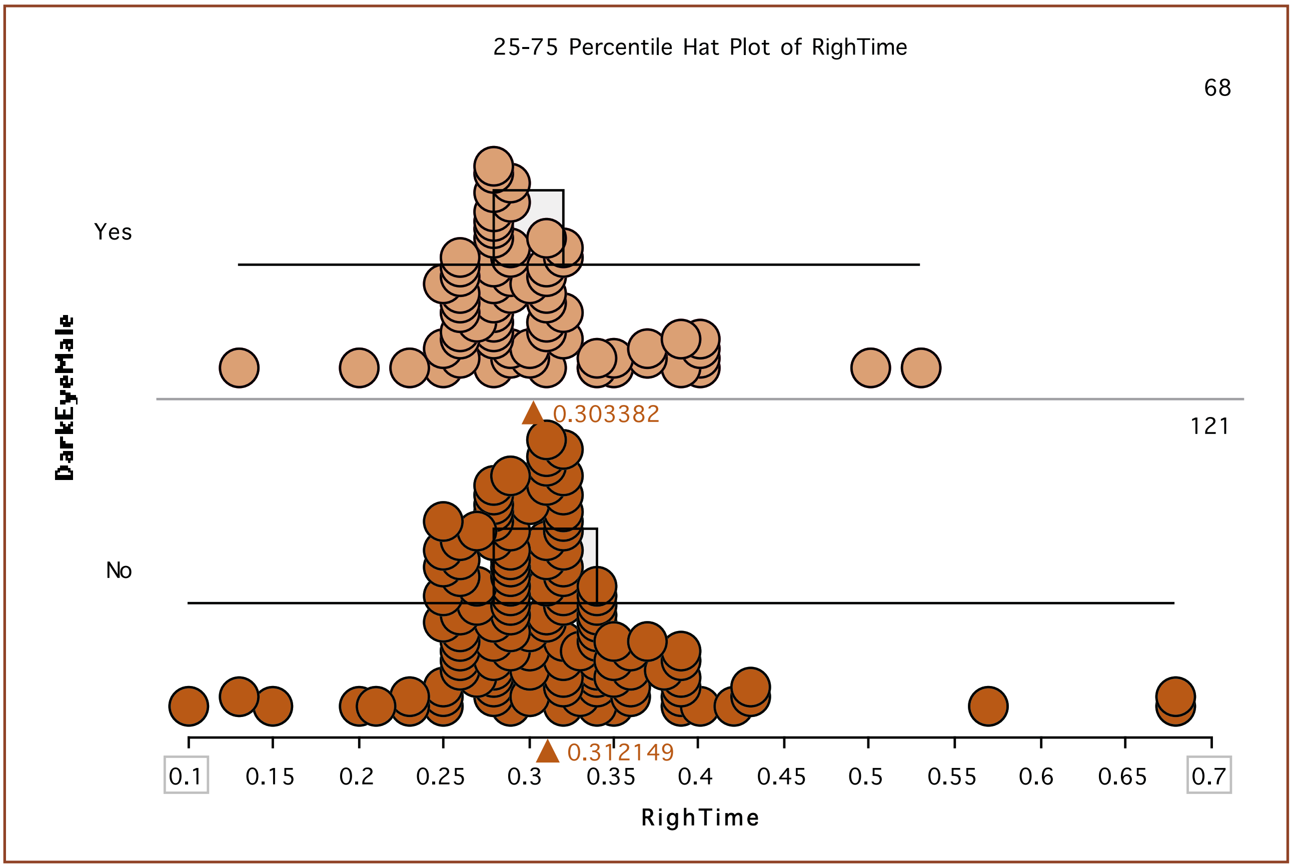

Figure 14. Reaction time for dark-eyed males and other males for large random sample.

spread and a centre 50% over the left part of the "other" cases' centre 50%. The mean reaction time is seen to be quicker (0.303 s compared to 0.336 s).[3] In Figure 14, however, the means are much closer together (0.303 s compared to 0.312 s) and the crown of the hat for dark-eyed males is inside of the crown for the other-colour-eyed males.[4] If for some reason it were decided to eliminate the five values greater than or equal to 0.5 and the four values less than 0.2, as other potential outliers, the difference would virtually disappear.

3. A t-test carried out in Fathom indicated that there was a significant difference in the means of these two sets (t=3.744, p=0.00027).
4. A t-test carried out in Fathom indicated that there was not a significant difference in the means of these two sets (t=0.8772, p=0.38).

The results of repeating the questions that were asked of the grade 10 class of 30 students, with a random sample of 400 (372 with outliers removed) grade 11/12 students, were quite different. With the larger sample there was no support for Claim 2 that brown-eyed people have a faster average reaction time as measured by the ABS website timer or for a similar claim for brown-eyed males. The data did support brown-eyed males having a faster average reaction time than all other students (Claim 3) but this result was confounded by the result showing that the average reaction time for males was faster than for females (Claim 2).

Reporting the investigation

A final report written based on the data used in this article would be quite complex, given the differing evidence provided by the grade 10 class and the large random sample. The data, however, provide a stunning example of what is likely to happen in authentic settings when relatively small sample sizes are involved. Students may initially believe that the claims in the news reports are "rubbish." After collecting data from their own class, however, they may be converted to believing the claims. The need to collect a larger sample should become evident and in this case, the evidence supports scepticism about the original claim. Students may wish to collect further evidence from other classes or other large random samples. In their reports, they should also discuss the necessity to define carefully what is meant by reaction time, as it would appear from the report in Figure 5 that counts rather than time were used to define the variable of interest. The reports should finally point out the statistical illiteracy of the *Medline* report, with students demonstrating their detective skills in finding this error.

Conclusion

As a cross-curriculum activity with Physical Education or Health Science subjects, it may be possible to attempt to replicate the experiment carried out in the US. The difficulty of course would be collecting a large random sample using the same variable.

Depending on the level of the class and the objectives of the curriculum, investigations based on this reported study can be quite short or extended even further than suggested here. All aspects of a statistical investigation — data collection, data representation, data reduction, and informal inference — are illustrated here, as well as the importance of considering the influence of variation and chance. Students could even try to contact the researchers for further information on their study. The important conclusion to this type of investigation is the development of critical statistical reasoning that questions unusual or suspicious claims discovered in the media or elsewhere in society. This article provides a model that can be used in other contexts discovered by students or their teachers. Once students have had success in this type of investigation they should become motivated to find more myths to investigate.

Acknowledgements

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From Helen Prochazka's Scrapbook

Maths and the Atom Bomb

Stanislaw Ulam (1909 –1984) was a Polish mathematician who participated in the Manhattan Project and proposed the Teller–Ulam design of thermonuclear weapons.

David Bergamini wrote in "Life Science Library of Mathematics" (1963)

> From the inception of the atomic age, mathematicians have been as deeply involved in nuclear physics as physicists themselves. This remains true today, even though machines now do much work formerly done by human experts. The several hundred mathematicians recruited for the wartime Los Alamos project to develop the atomic bomb had at their disposal just one IBM machine, a rudimentary prototype of later computers. With a modern high-speed computer, their work could have been done in less than a hundredth of the time it actually took.
>
> Yet in the postwar project to develop the H-bombs, Dr Stanislaw Ulam proved a match for the 'thinking' machines'. A host of calculations had to be made to decide whether the bomb was feasible. The data was given to a team working with the computer ENIAC – and also to Dr Ulam. Doing calculations the long, old fashioned way, Ulam and one assistant turned in their answers before the instructions to ENIAC had been completed. These figures disproved the first theories about the bomb, but Ulam came up with an approach that worked.

His triumph over ENIAC led Dr Edward Teller, head of the project, to remark later: 'In an emergency, the mathematician still wins – if he is really good.'