Powder versus Liquid Detergents

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Hypothesis:
There is no difference between the stain removal properties of liquid and powder detergents.

Summary:
I decided to examine the differences between the stain removal properties of powdered and liquid detergents. Cloth squares of 100% cotton were stained with four different stains, and the stain removal properties of two powdered and two liquid detergents were compared, using water as a control. The stains were chosen after an internet survey of “stains which were difficult to remove” and the four stains selected for testing were selected after a preliminary test of twelve stains. An internet search found “Choice” articles (11, 12) which rated some detergents and the best and worst powdered and liquid detergents. I chose four that could be purchased in Hobart from this list. These few were selected for this test. The depth of stain and stain removal were recorded with the aid of two robots and some data-logging software on a laptop. The results were analysed using Microsoft Excel. There were some problems with the staining methodology, but the best result obtained was in general agreement that powder detergents have better stain removal properties than liquid detergents. However the differences measured were small, and further work would be needed to validate my result.

There are three main reasons for doing this experiment. First, I wanted to experiment with data-logging, a program with LEGO NXT robot (13) which records light sensor readings and produces graphical output images. Second, I thought it would be interesting to examine the differences between powder and liquid detergent, but using robots instead of the Hi-Tec equipment used in the “Choice” tests. Third, removing food stains is common in everyday laundry and it is useful for people to know whether powdered or liquid detergent is more effective in stain removing.

Aim:
To measure the difference between the food stain removal properties of powdered and liquid detergents.

List of Materials Used:
- LEGO NXT computer bricks (15), one of which is linked using a download cable to a laptop/computer
- HiTechnic Version 2 colour sensor (14) – set to measure reflected red values
- LEGO and HiTechnic Software (14, 16) used for Data Logging
- Microsoft Excel Spreadsheet – used for manipulating and graphing results
- 10cm by 10cm cloth squares of 100% cotton – prewashed (20 of these squares are used in the main experiment. Another 14 are used in the setting up of the experiment.)
- Coloured thread to label the cloth pieces
Powder versus Liquid Detergents

- 4 stains (blueberry spread, blackberry jam, pomegranate juice, Cadbury’s dairy milk chocolate)
- Double boiler to melt the chocolate
- 4 detergents: 2 powder (Omo 2x Small and Mighty, EcoStore Laundry Powder) and 2 liquids (Earth Liquid, Omo Liquid 3x Small and Mighty). Washing in pure water was used as a control
- Measuring spoons
- Weight-measuring scale
- Glass dropper for measuring liquids
- Cardboard piece for mounting the stained/washed cloth as they were winched under the robot
- Thread to connect the cardboard piece to the winch
- Front-loader washing machine to label the cloth pieces

Method:
For this test, I have decided to test the stain removal properties of 2 powder and 2 liquid detergents using water as a control. I have chosen 4 stains (see Appendix E) to use with each of these detergents and water.

1. Measure and cut out 10cm by 10cm squares from pre-washed 100% cotton cloth. Approximately 20 squares will be required. See Figure 1. Measurements can vary by two or three millimetres.

![Figure 1: Measuring the cutting out cloth pieces](image)

2. Mark each square using coloured thread, so that you can distinguish between the different stains. See Figure 2. The colours used to distinguish between the different stains follow Table B.2
3. Distribute one type of stain onto each cloth, so that there are 5 blackberry stains, 5 pomegranate stains... etc, until all 20 squares have been stained.

3.1. For Blackberry Jam stains:

3.1.1. Use a half teaspoon measuring spoon, and flatten using a knife. See Figure 3 and 4.

3.1.2. Smear onto cloth, trying to keep a consistent shape.

3.1.3. Repeat 5 times on 5 different pieces of cloth.

3.2. For Pomegranate Juice Stains:

3.2.1. Use a glass dropper to remove pomegranate juice.

3.2.2. Drop the juice into a half teaspoon until full. See Figure 5.

3.2.3. Drop onto cloth.
3.2.4. Repeat 5 times on 5 different pieces of cloth.

Figure 5: Dropping juice onto a half teaspoon

3.3. For Blueberry Spread Stains:

3.3.1. Use a half teaspoon measuring spoon, and flatten using a knife. See Figure 6 and 7.

3.3.2. Smear onto cloth, trying to keep a consistent shape.

3.3.3. Repeat 5 times on 5 different pieces of cloth.

Figure 6: Using half teaspoon  Figure 7: Flattening using a knife

3.4. For Chocolate Stains

3.4.1. Melt chocolate in a bag using hot water

   a) Put chocolate in a bag and put it into hot water. Leave for around 30 minutes.

   b) Take the bag out and cut it open.
c) Use a half teaspoon measuring spoon, and flatten using a knife. See Figure 8.

d) Smear onto cloth, trying to keep a consistent shape.

OR

3.4.2. Melt chocolate in a double boiler

a) Put water into the bottom half of the double boiler.

b) Place some chocolate into the top half of the double boiler.

c) Keep stirring until melts. See Figure 9.

d) Use a half teaspoon measuring spoon, and flatten using knife.

e) Smear onto cloth, trying to keep a consistent shape.

4. Put cloth pieces aside on a non-absorbent surface (e.g. glass) for around a day so that the stains have time to soak into the cotton squares. See Figure 10.

Figure 8: Using half teaspoon and flattening

Figure 9: Stirring until melted

Figure 10: The stains on a glass surface
5. Measure the stains on the squares using the HiTechnic colour sensor mounted on an NXT robot (ClareBot). Set the data logging software to 5 readings per second, and 10 seconds per observation (50 readings in total).

5.1. Put the cloth “square” onto the cardboard piece. See Figure 11.

5.2. Put ClareBot over the cloth with the sensor just in front of it.

5.3. Start the data-logging program, see Figure 12.

5.4. Wait until ClareBot goes “beep” and then start the program for the “winch robot”.

5.5. Examine the data logging results on the laptop.

Figure 11: Put cloth onto cardboard piece
Figure 12: Start data logging program

6. Wash the stained squares with each of the different detergents in a front-loader washing machine on a 15 minute cycle.

6.1. *For Omo Powder*

6.1.1. Scoop out some powder using the provided “scoop”.

6.1.2. Level out the powder using a knife. See Figure 13.

6.1.3. Tip the powder onto a scale and measure ¼ the amount.

6.1.4. Re-scoop, gently tipping until powder reaches the desired ¼ amount. See Figure 14.
6.2. For Omo Liquid

6.2.1. Pour out some detergent into the provided “cap”.

6.2.2. Weigh the detergent (with the cap) in the scale.

6.2.3. Now empty the cap and reweigh to find out the weight of the cap.

6.2.4. Subtract the weight of the cap from the overall weight of the detergent and the cap together. You will find the weight of the detergent.

6.2.5. Find ¼ of the weight of the detergent.

6.2.6. Gently re-pour the detergent into the cap until weight reaches the desired ¼. Use method shown in Figure 15.

6.3. For EcoStore Laundry Powder

6.3.1. Scoop out some powder using the provided “scoop”.

6.3.2. Level out the powder using a knife. See Figure 16.
6.3.3. Tip the powder onto a scale and measure \( \frac{1}{4} \) the amount.

6.3.4. Re-scoop, gently tipping until powder reaches the desired \( \frac{1}{4} \) amount.

![Figure 16: Levelling the EcoStore Laundry Powder](image)

6.4. For Earth Liquid

6.4.1. Pour out some detergent (see Figure 17) into the provided “cap”.

6.4.2. Weigh the detergent (with the cap) in the scale.

6.4.3. Now empty the cap and reweigh to find out the weight of the cap.

6.4.4. Subtract the weight of the cap from the overall weight of the detergent and the cap together. You will find the weight of the detergent.

6.4.5. Find \( \frac{1}{4} \) of the weight of the detergent.

6.4.6. Gently Re-pour the detergent into the cap until weight reaches the desired \( \frac{1}{4} \). See Figure 15 for the method used to pour Earth Liquid.

![Figure 17: Kind of Earth Liquid used](image)

6.5. For Water

6.5.1. The stains were washed with no added detergent, water only.
7. Once washed, put them aside on a non-absorbent surface (e.g. glass) to dry for a day. See step 4.

8. Remeasure the squares (when they are dry) using the same method as in step 5.

9. Use Microsoft Excel to combine the before and after readings for each of the 20 combinations of the stains and the detergents. Produce graphs of the comparative results.

10. Use Microsoft Excel to calculate the areas under the appropriate portions of the graphs in step 9.

Results:

Once I had calculated the areas, I obtained the following results:

Blackberry: This was a jam, and so it left whole fruit pieces on the stain. However, since the fruit pieces were not scraped off the cloth in the reading before washing, it caused some misleading results. This was because on each cloth piece, the fruit pieces were in different places. This caused several bumps on the graph (blue line), and as you can see from Figures 18 to 22, there are bumps in all sorts of places. This experiment would have been more accurate if I had scraped off the cloth pieces before measuring and washing.

![Figure 18: Graph of Blackberry before (46%) and after Omo Powder (90%)](image1.png)

![Figure 19: Graph of Blackberry before (47%) and after EcoStore Powder (90%)](image2.png)
Figure 20: Graph of Blackberry before (47%) and after Omo Liquid (87%)

Figure 21: Graph of Blackberry before (47%) and after Earth Liquid (91%)

Figure 22: Graph of Blackberry before (47%) and after Water (87%)
**Pomegranate:** This was the only stain which had no solid pieces in the middle. This made this result quite consistent in the measurement before washing. This also made the “washed” results show more detail and difference. See Figures 23 to 27. Pomegranate was probably the most reliable stain out of the whole experiment.

Figure 23: Graph of Pomegranate before (94%) and after Omo Powder (99%)

Figure 24: Graph of Pomegranate before (92%) and after EcoStore Powder (90%)
Figure 25: Graph of Pomegranate before (91%) and after Omo Liquid (94%)

Figure 26: Graph of Pomegranate before (93%) and after Earth Liquid (87%)

Figure 27: Graph of Pomegranate before (93%) and after Water (90%)
**Blueberry:** As can be seen from Figures 28 to 32, this spread was made of solid chunks (fruit pieces), and so pressing it onto the cloth was pretty difficult. Because of this, I ended up with lots of blueberry chunks on the stain. Same as with the blackberry jam, I did not think of removing the chunks before measuring and washing, so again I measured a misleading reading. These results would have been much more accurate if I had removed the lumps. I wish I had thought of this earlier!

![Graph of Blueberry before (49%) and after Omo Powder (95%)](image1.png)

*Figure 28: Graph of Blueberry before (49%) and after Omo Powder (95%)*

![Graph of Blueberry before (43%) and after EcoStore Powder (98%)](image2.png)

*Figure 29: Graph of Blueberry before (43%) and after EcoStore Powder (98%)*
Figure 30: Graph of Blueberry before (40%) and after Omo Liquid (86%)

Figure 31: Graph of Blueberry before (45%) and after Earth Liquid (92%)

Figure 32: Graph of Blueberry before (47%) and after Water (84%)
Chocolate: The chocolate was melted and was put on the cloths. However in the first method I used to melt the chocolate, it hardened too quickly. This was why I had to use a fair amount of pressure to press the chocolate onto the cloth with a knife. In the end it stuck on the cloth okay, but this was the one used with Omo Powder, and it was the only cloth piece which still had a bit of chocolate stuck on it after washing. This caused the Omo Powder reading not to be a fair reading, because the method used was not the same on the four other cloth pieces. See Figure 33. The “washed” readings of the other four cloth pieces were close to 100% on the “Final % of Ideal Result” in Table 1. This implies that the chocolate from those four cloth pieces merely fell off during washing, and didn’t penetrate into the cloth at all. See Figures 34 to 36.

![Figure 33: Graph of Chocolate before (50%) and after Omo Powder (chocolate chunk) (81%)](image)

![Figure 34: Graph of Chocolate before (55%) and after EcoStore Powder (100%)](image)
Figure 35: Graph of Chocolate before (44%) and after Omo Liquid (101%)

Figure 36: Graph of Chocolate before (52%) and after Water (99%)

You might be wondering... what’re all the percentages in the figure caption for?

This is how to work it out:

The maximum reading of the unstained (white) cotton cloth is on average, 220. The width of the stain was estimated from the appearance of the graph. The area under both coloured lines was calculated using Microsoft Excel. The percentage of the ideal result would be 100%. The area under the red line was then divided by the total area (assuming 220 for the unstained cloth). A reading of 100% e.g. chocolate stain (from upper table in Table 1) would indicate no stain. A reading less than this would be a measure of the density of the stain. In other words, a dark stain would give a lower reflection and a lower reading. And therefore have a lower percentage.
Here’s the table which shows the percentages of each graph:

Table 1: Showing the % of the graphs; % after washing and % before washing

<table>
<thead>
<tr>
<th>Stain</th>
<th>Blackberry</th>
<th>Pomegranate</th>
<th>Chocolate</th>
<th>Blueberry</th>
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</thead>
<tbody>
<tr>
<td>Identification</td>
<td>Two Black</td>
<td>One Red</td>
<td>Three mustard</td>
<td>Three Green</td>
</tr>
<tr>
<td>Omo Powder</td>
<td>90</td>
<td>99</td>
<td>81</td>
<td>95</td>
</tr>
<tr>
<td>Eco Powder</td>
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<td>98</td>
</tr>
<tr>
<td>Omo Liquid</td>
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<td>94</td>
<td>101</td>
<td>86</td>
</tr>
<tr>
<td>Earth Liquid</td>
<td>91</td>
<td>87</td>
<td>-</td>
<td>92</td>
</tr>
<tr>
<td>Water</td>
<td>87</td>
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<table>
<thead>
<tr>
<th>Stain</th>
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<th>Chocolate</th>
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<td>Two Black</td>
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<td>Three mustard</td>
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<tr>
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<td>Earth Liquid</td>
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<td>93</td>
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<tr>
<td>Water</td>
<td>47</td>
<td>93</td>
<td>52</td>
<td>47</td>
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</tbody>
</table>

**Discussion:**

The results from the Pomegranate part of the experiment agreed with results observed by Choice (11,12). The top rating powder detergent gave better cleaning than the top rated liquid detergent. However the margin was pretty small. Similarly, the lowest ranking powder detergent gave better stain removal than the lowest ranking liquid detergent; but again, the difference was minimal.

The results obtained by the blackberry and blueberry stains were made unreliable because of the pieces of fruit which were not scraped off the stain before washing. See Figure 38.

![Figure 38: Typical Lumpy Blueberry Stain](image)

The effect of these lumps on graph can be seen on the jagged blue lines of Figures 28 to 32.
I found that the method of reflection chosen did not examine the whole piece of cloth, but examined the strip lit by the HiTechnic colour sensor. Effectively, this was a strip through the cloth from one end to another, approximately 1 cm wide. This was lit by the LED in the HiTechnic colour sensor.

If these tests were run again, I still think that the use of the blackberry jam and the blueberry spread would produce useful results, but only if the lumps of fruit were removed or scraped from the cloth just before the pre-washed measuring.

The chocolate stain was quite different from the other stains. When I first tried to melt the chocolate to apply to the cloth, I placed the chocolate in a plastic bag that was immersed in hot water (see Method 3.4.1). When the bag was cut open to gain access to the melted chocolate, some water ended up mixed up with the chocolate, which may have affected the chocolate. This chocolate was difficult to spread on the cloth, so it required a lot of force. When washed, only some of the chocolate was removed from the cloth. This caused the dip in the red line which can be seen in Figure 33. Because of the problems I encountered with this part of the experiment, I changed to melting the chocolate in a double boiler (see Method 3.4.2). This worked much better, allowing the chocolate to be spread quite easily on the cloth squares. However, for these four pieces of cloth, all of the chocolate fell off during washing, and the cloth underneath showed almost no sign of staining. See Table 1 Chocolate “Final % of Ideal Result”. These very high figures (close to 100%) suggested that the chocolate did not actually stain the cloth at all, but just sat on the surface, and so was not a genuine stain.

The reading for chocolate with Earth Liquid Detergent (Table 1) was lost due to a problem with the equipment.

It is also of interest that water was almost as effective in stain removal as the worst of the liquid detergents. See Table 1 “Final % of Ideal Result”.

I had help from my family and my friends in obtaining some of the items needed to run this experiment. I also needed some help in getting the data readings, as it is not possible to operate the two robots by myself while at the same time operating the laptop.

Conclusions:
The results obtained with the pomegranate stain were consistent with my hypothesis. The results obtained with the pomegranate stain were generally in agreement with results obtained elsewhere, in that the best powder detergent (Omo Powder 2x Small and Mighty Concentrate) produced a better stain removal than the best liquid detergent (Omo Liquid 3x Small and Mighty Concentrate). Similarly, the worst rated powder detergent produced more stain removal than the worst rated liquid detergent. See Table 1; Pomegranate (red print). However, the differences observed were quite small and probably not enough to form a firm conclusion. Further tests would be necessary to confirm this conclusion.

Regarding the results obtained with the blackberry and blueberry stains, the non-removal of the lumps before measurement and washing made these results not reliable enough to produce a useful result. Repetition of the tests with blackberry and blueberry stains would, I think, produce an interesting and useful result, and this would seem a good direction for future research.
The chocolate result was unique in that it appeared to set hard on the surface of the cloth without appearing to penetrate actually into the cloth. It was thus not actually a stain.

While there was an observed difference which suggested that the stain removal properties of powder detergents were better than liquid detergents, the results obtained were not strong enough to allow me to conclude that my hypothesis (that there was no difference) is wrong.
Appendix A

Is the Experiment Even Possible?

Firstly, I needed to know whether I could even measure the difference between a washed and unwashed piece of cloth. After some thought, I decided to use NXT LEGO light sensors to measure the reflectivity of the stained and washed pieces of cloth. I proposed to use NXT light sensors since I knew how to operate them through my experience with LEGO robots in national and international robotics competitions.

I stained two 10cm by 10cm pieces of 100% cotton cloth with an unmeasured amount of blackcurrant syrup and left it for one hour. I washed one piece in a front loading washing machine on a 15-minute cycle, using the recommended amount of Omo Washing Powder. I left the other piece still with syrup on it. (See Figure A.1) As you can see, this test is a little rough, but it’s done to check whether there is any measurable difference in reflectivity at all.

![Figure A.1: Pieces of cloth stained with Blackcurrant Syrup, with left showing after washing and right showing before washing](image)

I stained two 10cm by 10cm pieces of 100% cotton cloth with an unmeasured amount of blackcurrant syrup and left it for one hour. I washed one piece in a front loading washing machine on a 15-minute cycle, using the recommended amount of Omo Washing Powder. I left the other piece still with syrup on it. (See Figure A.1) As you can see, this test is a little rough, but it’s done to check whether there is any measurable difference in reflectivity at all.

Once the washed cloth was dried, I mounted the light sensor onto ClareBot (see Figure A.2 and Reference 13 for building instructions for this robot) and programmed it to run over the washed and unwashed pieces of cloth. The results proved that it was actually possible to continue with the experiment because there was noticeable difference in the measurements.

![Figure A.2: ClareBot](image)
The good thing is that my experiment will be possible to do! However, I noticed that ClareBot was mounted on wheels, and since the robot was running over the pieces of cloth, the movement of the robot was quite jerky and uneven. I will need to find some way of making the run more reliable and smooth for the next one.
Appendix B

Which Stains will I Test?

I searched on the internet for some stains which are difficult to remove, and conducted a survey.

These are the results I got:

Table B.1: Results of Internet Survey of Bad Stains.

<table>
<thead>
<tr>
<th>Coffee</th>
<th>Tomato Sauce</th>
<th>Soya Sauce</th>
<th>Ice Cream</th>
<th>Cheesy Sauces</th>
<th>Beetroot</th>
<th>Raspberries</th>
<th>Chocolate</th>
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<th>Pomegranate</th>
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I selected 10 stains to test from the ones mentioned in two or more references.

As a result of this, we chose to test the following stains; Coffee, Tomato Sauce, Blueberry, Grape, Pomegranate, chocolate, cranberry, soy sauce, mustard and beetroot. I also decided to add blackberry and prune juice to the list.
I then realised that I had no way to identify the pieces of cloth from one another. Chances are that some stains will have colours which are similar to others. I then decided to label and “sew on” colours and lines to each piece. Here is the colour chart:

Table B.2: Colour Chart used to Identify Different Stains

<table>
<thead>
<tr>
<th>Foods</th>
<th>Line1Colour</th>
<th>Line2Colour</th>
<th>Line3Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee</td>
<td>mustard</td>
<td>mustard</td>
<td>Nil</td>
</tr>
<tr>
<td>Tomato Sauce</td>
<td>red</td>
<td>Red</td>
<td>Nil</td>
</tr>
<tr>
<td>Blueberry</td>
<td>dark green</td>
<td>dark green</td>
<td>dark green</td>
</tr>
<tr>
<td>Grape</td>
<td>dark green</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>red</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Chocolate</td>
<td>mustard</td>
<td>mustard</td>
<td>mustard</td>
</tr>
<tr>
<td>Cranberry</td>
<td>red</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td>Prune</td>
<td>dark green</td>
<td>dark green</td>
<td>Nil</td>
</tr>
<tr>
<td>Mustard</td>
<td>mustard</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Blackberry</td>
<td>black</td>
<td>black</td>
<td>Nil</td>
</tr>
<tr>
<td>Beetroot</td>
<td>black</td>
<td>black</td>
<td>Black</td>
</tr>
<tr>
<td>Soy Sauce</td>
<td>black</td>
<td>Nil</td>
<td>Nil</td>
</tr>
</tbody>
</table>
Figure B.3: Picture of stains after the pieces of cloth are labelled and stained.

These pieces of cloth were set aside for the stains to soak in, and I left it for several days. Once they had soaked in, I measured them using the data logging program and the two robots (see Appendix C). I then washed them all using the recommended amount of OMO washing powder, and dried them overnight on a flat towel. When they were all dry, I re-measured them all with the data-logging program and the robots.
Appendix C

Which is the best sensor for the experiment?

While I received a good result with the initial experiment, the difference between the washed and the unwashed cloth with LEGO light sensors was satisfactory. However, I had access to other sensors, which had become available only a few days before, when HiTechnic introduced data-logging blocks. I decided to test if any of these newly-available sensors would be more sensitive than the LEGO light sensors. Since LEGO NXT allows me to use four sensors simultaneously, I attached one LEGO light sensor, two HiTechnic Version 1 colour sensors, and one HiTechnic Version 2 colour sensor to my ClareBot robot. (see Figure C.1). The HiTechnic sensors can be set to read reflected red, green, or blue colour changes, or measure the different colours. The normal LEGO light sensor is set specifically to measure red reflected light. The fifth light sensor on the right hand side of the robot was not used in this experiment.

Figure C.1: ClareBot with the four active sensors in front of the robot on its left-hand side.

Figure C.2: Cloth moving on pulley with ClareBot fixed in position.
I mounted the cloth on a cardboard strip and added another robot to pull the cardboard along. This second robot had a motor attached to it with an axle piece which acted as a winch. A piece of string was put on the ends of the cardboard piece and the winch, making the cardboard able to be pulled along. On this cardboard piece, I put the piece of cloth which I’m going to measure. Using this method, it allows us to have a more steady reading, without the constant jerking of the robot moving along by wheel. A program was loaded into the winch robot, which pulled the cardboard when the robot was turned on. This robot didn’t need to be connected to the computer, which saved me a lot of effort. The ClareBot robot was connected to a laptop which was simultaneously running a LEGO NXT data logging program. After experimenting, I decided to make it read 50 observations in the period of 10 seconds.

I tested with several different coloured stains with the new sensor-testing arrangement. In FigureD.1, I used tomato sauce as the stain. I also set the HiTechnic version 2 sensor to measure red light, while setting the HiTechnic version 1 sensors to measure blue and green light. This was to test the difference of the four sensors. However, once I had tested these out, I realised that the HiTechnic Version 2 colour sensor was much better than version 1 sensors. The problem was that I couldn’t tell whether it was because of the different sensors or the different light colours used.

I tried another test, this time replacing one HiTechnic Version 1 colour sensor with one Version 2 colour sensor. I set all four of the sensors to measure red light in order to compare their readings. I eventually discovered that both the HiTechnic version 2 colour sensors were relatively similar, however their readings were far more sensitive than the other two sensor readings. Using this information, I can conclude that using the HiTechnic version 2 colour sensors to observe the stains would be the best method to use.
Appendix D

*Which is the best sensor colour for the experiment?*

I tested another run, this time setting the HiTechnic Version 2 colour sensors to green and red. The HiTechnic Version 1 colour sensor was set to blue. I used mustard as a test stain for this run, since mustard has a medium-dark yellow stain and is not very responsive to most colour/light sensors. Problem was, I found that the blue values appeared to be quite useless and insensitive in this run.

Yet another run was started, this time using a slightly fainter stain (tomato sauce). The results are in Figure D.1. But first of all, here is how I record the light value results.

When I checked the difference between the four sensors, I used a data logging program from NXT. It produced a graphical output of the reflected light readings on the laptop when I started running the program (See Figure D.1).

![Graphical Output from LEGO NXT data-logging program](image)

The numerical values (from the 50 readings) can be seen in the table at the bottom of Figure D.1. When I put these numerical values into Microsoft Excel and graphed it, the result is as shown in Figure D.2.
Where Red = HiTechnic colour sensor version 2 set to red; Blue = HiTechnic colour sensor version 1 set to blue; Green = HiTechnic colour sensor version 2 set to green; and Light = Lego Light sensor.

Figure D.2: Figure D.1 when put into Microsoft Excel

When the start times of the graphs were aligned in Excel, I obtained Figure D.3.

Where Red = HiTechnic colour sensor version 2 set to red; Blue = HiTechnic colour sensor version 1 set to blue; Green = HiTechnic colour sensor version 2 set to green; and Light = Lego Light sensor.

Figure D.3: Figure D.2 when start and finish times were lined up.

Judging by the results, it seemed like the normal NXT light sensor (purple) was hardly what I wanted. There showed a minimal amount of reflection in a somewhat dark red stain (tomato sauce). The Version 1 HiTechnic colour sensor (blue) showed a little reflection but it was a surprisingly dark value. Having it so low meant that we could not see the full value since the graph only goes down to 0. The Version 2 HiTechnic colour sensors (green, red) looked the most promising, but the green line was reaching the limit of the graph, which meant that we also couldn’t see the full value to compare it to. The red values were also most similar to the colour variations on the stained piece of cloth. So it seems like the HiTechnic colour sensor set to red values is the best option to use.
Appendix E

*Which are the best stains for the experiment?*

The stains shown in Table B.2 were then used in runs with a HiTechnic version 2 colour sensor set to red. The aim was to choose the best stains for the full experimental run. I used the pulley and removed the four sensors, leaving only the HiTechnic version 2 sensor in red which was chosen by the experiments listed in Appendix D. After some rebuilding, ClareBot took the shape shown in Figure E.1.

![Remodelled version of ClareBot](image)

Figure E.1: Remodelled version of ClareBot

Once I had measured the values of the stains, the cloths were washed in a front loader washing machine on a 15 minute cycle using only half the recommended amount of Omo Laundry Powder Detergent. The cloth pieces were then taken out of the washing machine and placed on a surface which would not absorb any moisture. They were then allowed to dry for a day, before each stain was remeasured.

For this experiment, I only used half the recommended amount of Omo because on the previous experiment, the results showed almost complete elimination of the stain.

The twelve graphs produced in this way seemed to fall into three main groups.

The first group consisted of blueberry, blackberry, soy sauce, and mustard. All of these were very dark stains, yet showed a considerable reduction in colour after washing. A typical example of a graph from this group is shown in Figure E.2
I chose blueberry and blackberry to represent this group because they were very dark. It also contained some lumpy fruit pieces which I felt might soak in and make the stain more difficult to remove. I also chose these two stains because blackberry was a jam, and blueberry was a semi-solid spread.

The second group consisted of stains which were initially less dark, caused by mainly water-based stains. These were beetroot, prune juice, grape juice, coffee, pomegranate juice, tomato sauce and cranberry juice. A typical example of a graph from this group is shown in Figure E.3.
some others, the comments I read in the survey (reported in Appendix B) reported that pomegranate stains were particularly difficult to remove.

The third group consisted of only one substance, which was chocolate. The reason chocolate is by itself is because it is solid at ordinary room temperatures, but melts at body heat. A melted finger smear of chocolate that has solidified onto cloth can be a particularly difficult stain to remove. As you can see from Figure E.4, there were still some chocolate pieces stuck on the cloth after I washed it. I decided to make chocolate the fourth of the stains in the final test for this reason.

![Figure E.4: Chocolate stain, before and after.](image)

The final list of stains chosen consisted of two from the dark lumpy group (blackberry jam and blueberry spread), one from the water-based stain group (pomegranate juice), and chocolate. These will be the stains I will use in my final experiment.
Appendix F

Which powder detergent and liquid detergent will I use?

I decided to find and use 2 liquid detergents, 2 powder detergents and water as a control.
I decided to find and use a good and a bad liquid detergent, as well as a good and a bad powder detergent.

I was aware that the Australian Consumers’ Association had done some tests on powder and liquid detergents. These were reported by “Choice” (www.choice.com.au). An article in February 2010 (11) reported results from testing 23 powder detergents. It suggested that Omo Front Loader Small and Mighty 2x Concentrate was the best powder detergent, and that Front Loader EcoStore Laundry Powder was the third worst powder detergent. I couldn’t use the worst powder detergent because it was for a top loader washing machine, while the one I use is a front loader. I couldn’t use the second worst because I could not find it for sale in Hobart.

The article also commented that, if the powder detergent was used at quarter strength, the stain-washing results were still reasonable and the spent “grey water” could be used to water plants in a garden. I decided to test all of our laundry powders and liquid detergents at quarter strength for this reason.

I may not get the same results as “Choice”, however, because “Choice” used pieces of cloth stained with nut oil, milk, and a pigment in their tests; I am using fruit and plant-based stains.

To choose a liquid detergent, I read an April 2008 article in “Choice” (12) which tested 21 laundry liquids; 7 of which were suitable for front-loaders. The best I could buy was Omo 3x Small and Mighty Liquid Detergent. The worst I could find and buy was an Earth Choice Liquid Detergent, however since this was half-way down the list, it is still said to be a reasonably good detergent. I couldn’t find the worst detergents for sale in Hobart.

“Choice” also commented in its test that it found that usually powder detergents are better than liquid detergents. However, whether the same result will apply for the fruit-based stains I will be testing, is unknown at this stage.
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