Is there a possibility your lip print is inherited?

Introduction

Genetic and forensic sciences are topics I have always had an interest in. Choosing biology as one of my HL subjects only amplified this curiosity; learning about genetics in biology made me curious as to how our different body parts are the way they are because of who our parents are. This fuelled an interest in my fingerprints and lip prints. The central question leading me to my research question was: “If everything in my body is coded from the genetics of my parents, does this mean that my finger and lip prints are genetically identical to my parents?”. This led me to delve deeper into the extent of how hereditary these supposedly “unique” prints actually are. The more I learned about this topic, the more I realised how little lip prints were investigated compared to fingerprints despite their use in personal identification and investigations. In the end, I decided to research lip prints in particular because the lack of research surrounding them piqued my curiosity. Therefore, in this investigation I am going to research the hereditariness of lip prints, allowing me to look more closely at topics of personal interest, namely, genetic and forensic sciences.

A lip print is identified as the wrinkles and groves on our lips that are composed into a specific pattern. Lip print patterns are unique to the individual and are analogous to fingerprints (Negi, A, & Negi, A. 2016). Meaning that just like our fingerprints, lip prints are also something that can identify exactly who we are. However, when it comes to forensics or criminology, lip prints are not widely used or researched. The reasoning could be the different times these separate identification methods were discovered. The use of fingerprints for identification can be traced to as early as 300 B.C. in China according to *the fingerprint sourcebook* published by the U.S. Department of Justice (Holder, E. H. 2011), whereas the use of lip prints for identification only started being used in 1932 by Edmond Locard (Prabhu, R. V. 2012). This explains how the amount of time fingerprints as a method of identification has had to develop and be integrated as a tool in science and society leaves it as a much more popular and trusted method to identify an individual, as opposed to lip prints.

In present times, more people are becoming cautious with regard to “fingerprinting” a crime scene, some even going as far as to burn the pads of their fingers to avoid identification. This is where lip prints come in. Because people do not realize how identifiable their lip prints are, they are less likely to get rid of it and

more likely to leave it behind at ´the scene of the crime'. They are most commonly used when you get a picture of the suspect and can analyse the groves of the lips from the picture, or when the suspect leaves evidence like; used cups, napkins, or lip prints on cutlery. This evidence can be used in a court of law, but since the research behind the concept is not vast it is mostly only used "for personal identification of a criminal in the court of law when no other evidence is available" according to the study by (Sharma, Sharma, Wadhwan, & Aggarwal, 2016).

However, the database for lip prints is limited since it has not been used a great deal. If lip prints were proven to be hereditary then the limitations of the database would not prove a challenge to law enforcement. Instead of using a database of previously collected lip prints from known criminals, hereditary lip prints could be found by simply collecting samples from a suspect´s biological family, making cases such as the search for Jane/John Doe's identity much simpler. Especially since there are so many Jane/John Doe's that the investigators never find the true identity of. Jane Doe and John Doe are names used when the identity of the individual is unknown". In one year "an estimated 4,400 unidentified bodies are found and about 1,000 of them remain John or Jane Doe cases after a year passes" according to the research (Gomulka, 2021), leaving over thousands of families each year without the closure they deserve.

Background information

When I tried to research this specific topic, there were not a lot of sources that came up. Very few researchers had investigated lip prints, despite their potential as a genetic marker and identification method. The research that has been done on the hereditariness of lip prints shows that there is no consensus among the scientific community: just as many papers and investigations highlight the hereditariness of lip prints as those that discourage any connection. A study done by Yadava in 2022 suggests that a child is 61.4% likely to get one specific type of lip print if the parent has the same (Yadava. 2022), a statistic that led me to research the lip prints of 7 different families to see if there is any connection between the parent's and the child's lip prints.

One of the first few people who saw the potential in the research into lip prints were Suzuki and Tsucihashi. Suzuki and Tsuchihashi were two Japanese scientists who extensively researched the groves and wrinkles presented on the inner lining of the lips. When they started out, the research on lip prints was minimal. No other scientists had fully realized the potential and impact that lip prints could have on future

forensic evidence and genetics. Suzuki and Tsuchihashi, knowing the potential of lip prints, started studying these prints. One of their first studies was based on the individuality of lip prints: they compared multiple sets of twins and reported that "although the lip print patterns of the uniovular twins are duplicate, in detail. No two of them are identical." (Tsuchihashi 1974). These results opened a new door in genetics as well as cheiloscopy, a forensic technique that studies the identification of individuals based on their lip prints. This study also identified a way of *classifying* lip prints. In our modern day, the Suzuki and Tsuchihashi classifications are the most common ones in cheiloscopy and include six different lip types: Type I (full vertical), Type I' (partial vertical), Type II (branching), Type III (intersection), Type IV (reticular) and type V (other types of grooves). These methods are applied by dividing a lip print into eight different sections, and then analysing the different sections like it is shown in the picture below.

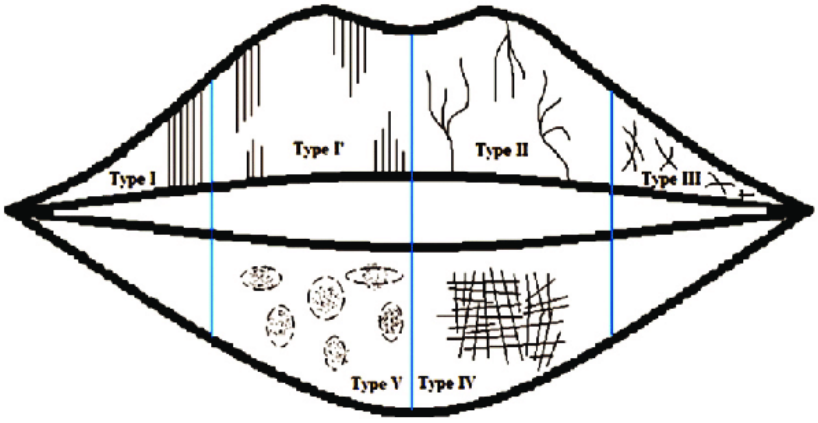

***Figure 1**: Suzuki and Tsuchihasi's classification (UDIN)*

The eight sections in this example are upper left corner (ULC), upper left middle (ULM), upper right middle (URM), upper right corner (URC), lower left corner (LLC), lower left middle (LLM), lower right middle (LRM), lower right corner (LRC).

Research Question

To what extent will the biological mother´s lip prints in ULC, ULM, UR, URC, URC, LLC, LLM, LRM, and LRC affect what type of lip prints their children (participants) will have in those 8 sections?

Hypothesis

If lip prints are hereditary, then there should be a correlation between the mother's lip print pattern and the children in the 8 different lip sections.

Variables

In this investigation, the **independent variable** refers to the different families and family members. This includes 7 different families, with a total of 7 mothers and 13 children. Each child's lip print in the eight different sections is compared to their mother's, meaning that the dependent variable in this investigation would be determining the pattern of wrinkles in person. The dependent variable is measured by identifying which lip print type from Suzuki and Tsuchihashi's classification of each of the different 8 sections for each person are.

Controlled Variable	**How will it be controlled?**	**Why it is important to control this variable?**
The type of tape used.	If different types of tapes are used for each participant, it could affect the preciseness of the lip print that is extracted or cause differences in the analysis.	The same type and amount of tape is used for each participant.
Type of lipstick.	If the type of lipstick is different for each participant, it can determine how much of the lip print is transferred. Some lipsticks transfer more easily, or some are "transfer-proof". And the colour can especially make a difference in how much of the lip prints is shown.	To keep it controlled, only one type of lipstick will be used on all participants
Amount of time the lipstick was left to dry before it was removed with tape.	If the lipstick does not get enough time to dry it could affect the way, it transfers to the cellophane tape.	Based on other studies, the ideal time to take the lip print is 2 minutes after it has been applied. This time frame must be kept constant for all participants.

Materials

- Saline cotton wipes
- Disposable lip applicator
- Dark red coloured matte lipstick (W7)
- Baking sheet
- Cellophane tape
- Magnifying lens

Safety

This investigation did not include any of safety hazards or dangerous material. However, since human participants were used, a consent form was made (see in appendix 2), which every participant had to sign before their lip prints could be extracted. However, if the participants felt like they were unsafe or disapproved of this investigation they could withdraw their consent and results at any moment.

Procedure

When I was studying how to do this experiment, I looked at multiple different experiments, methods, and materials. I had different trial runs on if light lipstick worked well. Or if I should choose liquid lipstick or solid lipstick. I also did a not so common way of classifying the lip prints. Most of the places I saw divided them into either 2,4, or 6, however, when I did more research, it was obvious that I would need to divide it into 8 sections for a more in-depth analysis.

1. The upper and lower lips of the participants are cleaned first using the saline cotton wipes.
2. Then using the disposable lip applicator, the dark red lipstick was applied evenly on both the lips.
3. Then the participants are told to rub their lips together so the lipstick can spread out evenly.
4. To make sure the lipstick is fully dry, the participants are told to wait at least 2 minutes before moving their lips.
5. Then the cellophane tapes are folded in half where the sticky side is on the outside
6. Then the tape is put in between the lips of the participants so the lipstick can rub off onto the tape.
7. Then the tape is put onto thin baking paper to make a permanent record so it could be used later for evaluation of lip prints
8. Then the lip prints are examined based on the Suzuki and Tsuchihashi types.
9. Then the lip print is divided into eight sections, upper left corner, upper left middle, upper right middle, upper right corner, lower left corner, lower left middle, lower right middle, and lower right corner.
10. Then the different sections are examined with a magnifying lens to see which lip type they are.
11. The different types of lip prints:
    a. Type I – A clear cut groove running vertically across the lip.
    b. Type I’ – Partial length groove of type I
    c. Type II – A branched groove
    d. Type III – An intersected groove
    e. Type IV – A reticular pattern

f. Type V – Undetermined.

Figure: 2. The lip prints of family 4

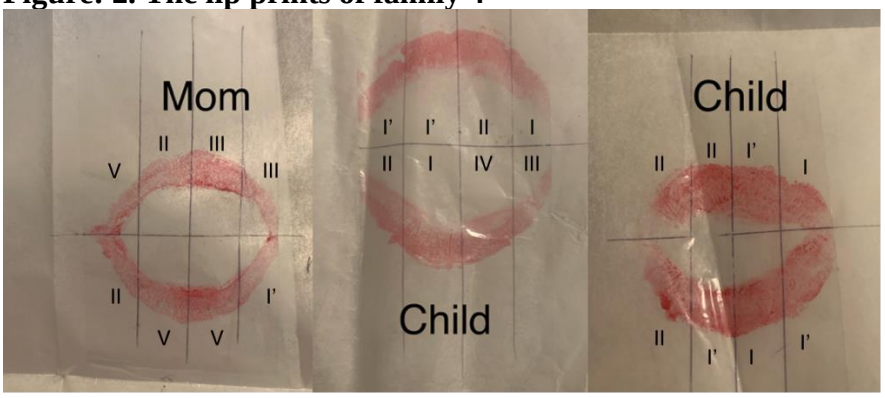

Figure 2: Example of how the lip prints were analysed, with the 8 different sections labelled.

Raw Data

Figure: 3.1 Type of lip print of family 1

Family 1	ULC	ULM	URM	URC	LLC	LLM	LRM	LRC
Mom 1	III	I'	I'	I'	II	V	IV	III
Participanta	III	I'	II	III	I	IV	I	III
Sister	IV	I'	V	II	II	I'	III	I'
Similarities	1	2	0	0	1	0	0	1
Possiblilities	2	2	2	2	2	2	2	2

Figure: 3.2 Type of lip print of family 2

Family 2	ULC	ULM	URM	URC	LLC	LLM	LRM	LRC
Mom 2	III	V	V	I	II	I'	III	I
Participant	II	I	IV	I´	II	V	II	I
Brother 2	I'	I'	II	I'	V	III	III	I
Similarities	0	0	0	0	1	0	1	2
Posibilities	2	2	2	2	2	2	2	2

Figure: 3.3 Type of lip print of family 3

Family 3	ULC	ULM	URM	URC	LLC	LLM	LRM	LRC
Mom 3	I	I	V	II	III	IV	II	II
Particiapnt	IV	V	V	II	I'	V	IV	I
similarities	0	0	1	1	0	0	0	0
posibilities	1	1	1	1	1	1	1	1

Figure: 3.4 Type of lip print of family 4

Family 4	ULC	ULM	URM	URC	LLC	LLM	LRM	LRC
Mom 4	V	II	III	III	II	V	V	I'
Participant	I'	I'	II	I	II	I	IV	III
Sister	II	II	I'	I	II	I'	I	I'
Similarities	0	1	0	0	2	0	0	1
Posibilities	2	2	2	2	2	2	2	2

Figure: 3.5 Type lip print of family 6

Family 6	ULC	ULM	URM	URC	LLC	LLM	LRM	LRC
Mom 6	I'	IV	III	I'	V	IV	II	III
participant	I'	I	I'	V	V	IV	V	IV
similarities	1	0	0	0	1	1	0	0
posibilities	1	1	1	1	1	1	1	1

Figure: 3.6 Type lip print of family 7

Family 7	ULC	ULM	URM	URC	LLC	LLM	LRM	LRC
Mom 7	I'	V	III	V	I	V	IV	I'
Participant	II	I	III	V	III	V	II	I'
Sister	V	I	I	I'	I'	I'	I'	II
Brother	I	I'	I'	II	V	V	I'	I'
Similarities	0	0	1	1	1	2	0	2
Posibilities	3	3	3	3	3	3	3	3

Figure: 3.7 Type lip print of family 8

Family 8	ULC	ULM	URM	URC	LLC	LLM	LRM	LRC
Mom 8	I	V	I	II	I	II	III	I'
Participant	I	III	II	II	V	III	IV	III
Brother	III	I	I	I	II	IV	IV	I'
Similarities	1	0	1	1	0	0	0	1
Posibilities	2	2	2	2	2	2	2	2

Figure: 4. the chi square test done on pattern I

Pattern I		Children		
		present	absent	total
Mothers	present	4	10	14
	absent	16	74	90
	total	20	84	104

Figure 4: This is an example of how the first step of the chi square test was done on pattern I, the rest of the patterns are in appendix 1.

Processed Data Table

Figure: 5. The chi square test on the different lip patterns

Pattern I			Children	
			Present	Absent
Parents	Present	O	4	10
		E	2,69230769	11,3076923
		((O-E)^2)/E	0,63516484	0,15122972
	Absent	O	16	74
		E	17,3076923	72,6923077
		((O-E)^2)/E	0,09880342	0,02352462
X^2 =	0,9087226			

Pattern II			Children	
			Present	Absent
Parents	Present	O	7	8
		E	2,88461538	12,1153846
		((O-E)^2)/E	5,87128205	1,3979243
	Absent	O	13	76
		E	17,1153846	71,8846154
		((O-E)^2)/E	0,98954192	0,23560522
X^2 =	8,49435349			

Pattern IV			Children	
			Present	Absent
Parents	Present	O	1	8
		E	0,95192308	8,04807692
		((O-E)^2)/E	0,00242813	0,0002872
	Absent	O	10	85
		E	10,0480769	84,9519231
		((O-E)^2)/E	0,00023003	2,7208E-05
X^2 =	0,00297257			

Pattern I'			Children	
			Present	Absent
Parents	Present	O	7	10
		E	4,25	12,75
		((O-E)^2)/E	1,77941176	0,59313725
	Absent	O	19	68
		E	21,75	65,25
		((O-E)^2)/E	0,34770115	0,11590038
X^2 =	2,83615055			

Pattern III			Children	
			Present	Absent
Parents	Present	O	4	14
		E	2,25	15,75
		((O-E)^2)/E	1,36111111	0,19444444
	Absent	O	9	77
		E	10,75	75,25
		((O-E)^2)/E	0,28488372	0,04069767
X^2 =	1,88113695			

Pattern V			Children	
			Present	Absent
Parents	Present	O	5	16
		E	2,82692308	18,1730769
		((O-E)^2)/E	1,67046049	0,25984941
	Absent	O	9	74
		E	11,1730769	71,8269231
		((O-E)^2)/E	0,42264663	0,06574503
X^2 =	2,41870156			

Figure 5: The figure shows the O (observed frequency) and the E (Expected frequency) which is calculated by using the chi square test. (This is shown in appendix 1). The $\chi 2$ shows the chi square statistic value of each pattern.

Figure: 6. Results of the chi square test on each pattern in one table

Patterns	Observed	Expected
I	4	2,69230769
I'	7	4,25
II	7	2,88461538
III	4	2,25
IV	1	0,95192308
V	5	2,82692308

Figure 6: Table with the condensed information from figure 5.

Figure: 7. Graph made from the data in figure 6

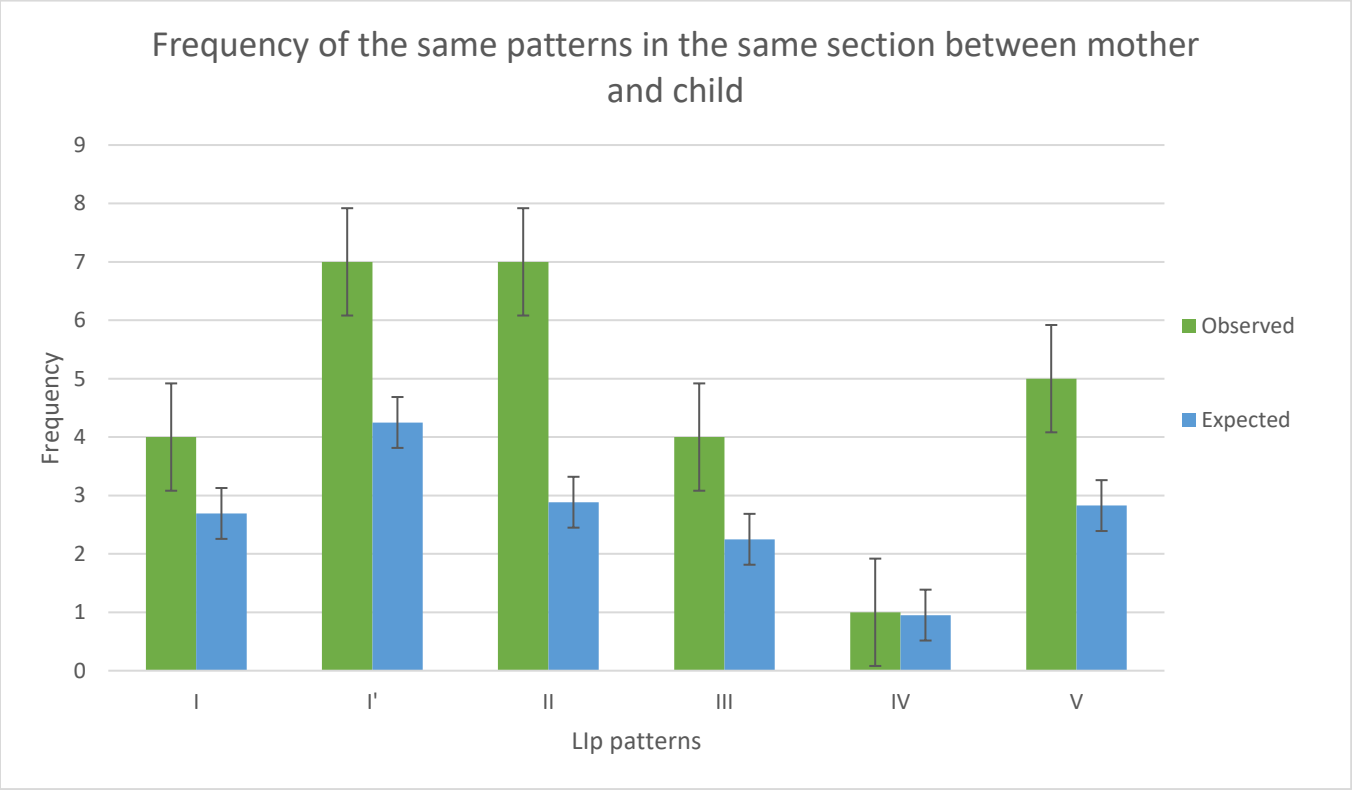

Figure 7: This figure shows the frequency of each similar pattern between mother and child. Stander deviation bar added. Observed means the observed frequency. Expected means the expected frequency.

Figure: 8. The chi square statistic value and the p value of each pattern

	Patterm I	Pattern I'	Pattern II	Pattern III	Pattern IV	Pattern V
χ2 Value	0,909	2,84	**8,49**	1,88	0,00297	2,42
df	1	1	1	1	1	1
P-value	0.341	0.0922	0.00356	0.170	0.957	0.120

Figure 8: The table showes the chi-square and p values of the different lip patters. In bold you can see the chi square number that is significant, which means that the number is high enough to accept the alternative hypothesis instead of accepting the null hypothesis.

Analysis

The figures above show the process of analysing the lip prints of the different participants. In figure 3 in the different tables, I have sorted the different lip types of each family and person into the 8 different sections. To see if any of the families had any correlation, I used the method 'similarities and possibilities'. I sectioned it into the different 'possibilities' of a match. Meaning that in each column there was at least 1 possibility of there being a match between the parent and the child. If one child had the same lip print as the mother, I put a 1 into similarities, meaning that there was one match. However, as you can see in some figures there was a 2 in similarity. This meant that 2 siblings had the same lip pattern as their mother.

Analysing this data, with little to no research to back it up made it difficult to find anomalies. So, no outliers or anomalies were found. Nevertheless, the data had to be analysed in at least one way. Since I am looking at similarities and the correlation between the mothers and the children's lip patterns in the 8 different sections, a chi-square test was found to be the best alternative. Especially since a chi-square test is normally used to find either a positive or a negative association in nature between species. The chi-square test was used to calculate the differences between the observed and the expected data to see if there is a correlation between the two species but in my case the two different generations. First, I analysed figure 3. I started with making a table for the chi square test by dividing it into if the pattern was present on both the mother and the child in one section if it was only present on the mother and not the child, and so on. This is visible in figure 4. And just like in figure 3, I am only counting the similarities here. Meaning that for example if a mother and her two children had the same pattern in the same section, I counted it as a 2 instead of 3. In table 7 it can be seen the result of the chi-square test. Each pattern has been analysed by comparing its observed (O) and expected (E) frequency. Which is equated to the $\chi 2$ value for each pattern. That same table was used to create the graph below. Figure 7 compares the expected value and the observed value in a more visual way which can make it easier to understand.

Discussion

In figure 7 the chi-square statistical value, degrees of freedom (df), and the p-value are shown. For this investigation, the df was 1 since only two variables were compared to each other. After that from the Percentage Points of the Chi-Square Distribution table, the significance level of 0.05 was used to ensure that the risk of a false correlation was only a 5% risk. This meant that for the numbers to be significant and to be able to reject the null hypothesis, the chi-square value needed to be greater than 3.84. In this case patterns I,

I', III, IV, and V were all not significant which means that there is no correlation between the lip pattern of the mother and the children in these patterns. However, pattern II had a significant value. This is also visible in figure 7, because of the great difference between the expected and the observed frequency. A big difference between these two frequencies equals to a statistically significant value, which means you reject the null hypothesis and accept the alternative one. This is also supported by pattern II's p-value, which is less than 0.05, which is evident in table 8. In this case, since only one of the patterns has a significant value, it is suggested that we accept the null hypothesis and reject the alternative one. Meaning that based on the data from this investigation there is no correlation between the mothers and the child's lip prints. Resulting in lip prints not being hereditary based on the data from the experiment.

Conclusion

The purpose of this lab was to analyse if the biological mother's lip print pattern would affect how the children's lip print came out. As seen in graph 7 there was a not considerable correlation between the parent's lip prints and the children. Even though pattern II had a significant Chi-square value of **8,49** p-value, **0.00356**, which in most cases would mean that there is a correlation, unfortunately, in this case is unfortunately not enough patterns with a significant $\chi 2$-value for the alternative hypothesis to be accepted. This shows that in the end there is no significant correlation in the genetics between mothers and children when it came to if children inherited their lip prints from their parents. Meaning that it is the null hypothesis that is accepted for our data. Which suggests that it is our environment that shapes our lip prints. Factors such as aging, UV light, smoking, and soars could affect our lip print more than genetics do.

Nevertheless, compared to other scientific experiments and papers regarding the hereditariness of lip prints, mine stands out. Most of the papers, like (Devi, A. 2015) and (Yadava, T. 2022) find a significant correlation between the parent's lip prints, and the children. However, in my case, it was the opposite. My p-values showed that there was no significant correlation between the lip prints. However, a reasoning could have been the limitations of this investigation like; a small sample size, and not having a diverse sample group.

Evaluation

The experiment had a few big limitations that could have most likely affected the results. One of the considerable ones was the sample size. In most of the studies you can see that they have a considerable number of individuals that are willing to participate in the experiment. For this experiment it was more

difficult to get many participants. Countless people were not able to join because their parents could not. Less men were also a part of the experiment because of having to use lipstick to clearly see the lip print. This put of countless of men and dads in the family of female participants. This could have affected my results, since I was looking at a smaller sample size and mostly female participants.

Another limitation in the experiment was that not all variables were possible to control. One of the variables that was not controlled, that could have affected the results was the amount of lipstick that was put on each participant. Since lipstick was used to make sure that the print was clear, it could have also affected how some lip prints became imprecise. Which in return could have affected how accurate the reading and classifications were. In some samples it was evident that the participants could have used to much lipstick, meaning that the lip print came out blotchy, instead of clear. Which would have affected the end results. One wrong classification would result in a 10% error since the sample size is already small. Nevertheless, I do not think that the limitation was significant enough to undermine the conclusion.

However, improvements could be made for a feature experiment. If a future experiment was done, I would recommend taking a bigger sample size so one piece of data would not hold such a considerable value, as it did here. Having a bigger sample size would also give a more diverse sample. Which could make the results more applicable to the larger population. A more diverse sample would also give a more accurate result.

I would also make the amount of lipstick that is put on each participant a controlled variable. Giving each participant a similar amount, more on the less side. Which could result in the lip prints being more accurate and less blotchy.

Nevertheless, there are still some strengths in this investigation. One of the strengths are how the lip prints are collected and examined. Both processes are done under controlled environments, so the lip print comes out as clear as possible. Another strength is the control variables, like how the same type of lipstick was used every time. Changing the colour of the lipstick could have led to the lip prints coming out too shear, blotchy, or indecipherable. Meaning that keep the colour and formula the same made sure that the lip prints came out the same.

An extension for this experiment could be to have a more diverse sample size. This time I only studied on the lip prints of mothers and if they could influence the lip pattern of the children. Next time adding father, and even extended family, like their grandparents on both of their family's sides. Might make the investigation more accurate when you apply it to the rest of the population.

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Appendices

Appendix 1: raw data from the first step of the chi square test

Pattern IV		Children		
		present	absent	total
Mothers	present	1	8	9
	absent	10	85	95
	total	11	93	104

Pattern II		Children		
		present	absent	total
Mothers	present	7	8	15
	absent	13	76	89
	total	20	84	104

Pattern V		Children		
		present	absent	total
Mothers	present	5	16	21
	absent	9	74	83
	total	14	90	104

Pattern III		Children		
		present	absent	total
Mothers	present	4	14	18
	absent	9	77	86
	total	13	91	104

Pattern I		Children		
		present	absent	total
Mothers	present	4	10	14
	absent	16	74	90
	total	20	84	104

Pattern I'		Children		
		present	absent	total
Mothers	present	7	10	17
	absent	19	68	87

Appendix 2: Consent form

Consent form

This consent form will provide essential information about the biology experiment I have asked you to participate in. This experiment is exploring the hereditariness of the prints on our lips, and this form will help you understand what our experiment may entail and any risks of participation. In this experiment, to extract your lip print you will have to put a bright colored substance on your lips, and then put your lips on a piece of tape so the print is transferred.

Your participation in this experiment is completely voluntary, thus you may withdraw at any time without any consequences.

Risk or discomfort: You will have to put lipstick and then tape on your lips to extract the print. The lipstick might leave a tint, if you are not comfortable with this, you are welcome to withdraw from the experiment.

You will be debriefed later if you wish to know your results.

All aspects of you participation will remain confidential (all data will be documented anonymously) and will not be divulged to any other person(s). You will not be subjected to any harm or deception at any point in this experiment and will be given the right to withdraw your personal data if wished. Your individual results will be given if requested at the end of the experiment.

If you have any further concerns about you participation in this experiment, please contact me in person.

By signing this form, you are stating you understand the information above and give your consent to participate in my biology experiment.

Signature: _____

Date: _____