

The World May Never Know Unwrapping the Mystery of the Tootsie Pop

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ABSTRACT

There is a surprising amount of research available on the number of licks it takes to reach the center of a Tootsie Pop (Zyra, 1996; Waksman, 2009; Tootsie Roll Industries, n.d.). Yet, many of these studies have a large amount of inconsistency in the number of licks it actually takes. I conducted research in order to mathematically find how many licks it takes to dissolve each millimeter of a Tootsie Pop. With that number, I determined that two different methods of licking resulted in 124.74 and 39.91 licks per millimeter to reach the center. Combining the more effective 39.91 licks per millimeter method with the average width of a Tootsie Pop, 8 millimeters, I concluded that the average number of licks to reach the center of a Tootsie Pop is 319.28. Discovering that Heid (2013) had licked the thicker side of the Tootsie Pops during his research I adjusted the average width from 8 to 10.5 millimeters. Using this final piece of data I determined that my new average number of licks, 419, confirmed Heid's average of 417 licks.

Key Words: Tootsie Pop, LPmm, Heid, licks, Tootsie Roll, Miley

Literature Review

Life is filled with many great mysteries, but perhaps the greatest question of them all is, "How many licks does it take to get to the center of a Tootsie Pop?" This question has been a popular advertising campaign of Tootsie Roll Industries since 1970, and a consistent answer hasn't been discovered (Tootsie Roll Industries, n.d.). The literature I found on this subject consisted of Internet-based sources found through a Google search, as there are very few useful scholarly sources. The literature focused on licking tests, which were performed to find an exact number of licks required to reach the Tootsie Roll center. These tests produced inconsistent results (Zyra, 1996; Waksman, 2009; Heid, 2013; Tootsie Roll Industries, n.d.).

Zyra (1996) conducted an experiment using students attending Swarthmore College in Pennsylvania. Twenty-two trials were carried out in which each participant would lick one or both sides until the Tootsie

Roll center was exposed. Each participant was given an index card to tally how many licks they had taken, with the ground rule set that the sucker could not be placed fully into their mouths. The study found that the amount of licks to reach the center ranged from 70-222 licks. The average number of licks comes out to be 142.

Waksman's (2009) tests involved 22 trials of how many licks it takes to reach the center of a Tootsie Pop. New information was also given with each trial such as color, date, and on some occasions, the amount of time the trial took. The end goal of the experiment was defined as when the texture, taste, and discoloration of the Tootsie Roll were visible. The limitation of not placing the sucker completely in the mouth was also a restriction for this experiment. The experiment involved licking both sides of the sucker back and forth, while counting the total licks before both sides had reached the goal. The results of the total licks to reveal both sides were 508, while the average for one side was 254.

Heid (2013) gives an overview of previous research before the experiment is explained. Heid (2013) details the two types of testing methods, which have been used: licking machines and human lickers, and presents the data of well-known tests of both kinds. Purdue, the University of Michigan, and Harvard all created licking machines and found the average to be 364, 411, and 2255 licks, respectively, to reach the center. Purdue, Swarthmore, and Cambridge conducted human tests that found 252, 144, and 3481 licks, respectively.

This wide range of results led Heid (2013) to pursue an experiment, which tested the effects of the force of the lick, temperature of the licker's mouth, pH level of saliva, and the solubility of saliva. The only one of these tests that gave measurable results was the solubility of saliva, which had little to no effect on the average licks. The 70 participants ended up with an average of 361 licks, with the highest number of licks being 1087. Heid (2013) then concluded that the amount of licks does not depend on the person licking, but on how centered the Tootsie Roll is in relation to the Tootsie Pop, and therefore, which side the participant starts licking on.

Unhappy with the standard deviation of 186 that he had found, Heid (2013) sliced the Tootsie Pops open and found that size of the Tootsie Roll center varied between suckers. Heid (2013) found the thick, banded, longitudinal side of the Tootsie Pop to have more consistent measurements. With this in mind, Heid (2013) began a new series of tests, in which participants licked along the thick, banded, longitudinal side of the Tootsie Pop. The test results were much more consistent and

only had a standard deviation of 39 licks (2013, Heid). Heid (2013) concluded that the average number of licks to reach the center of a Tootsie Pop is 417.

Tootsie Roll Industries (n.d.) provides general information about their product and attempts to reach the center. The information consists of questions, which Tootsie Roll Industries are frequently asked. Different questions, such as how the company got its name, or simpler questions like, "Do any of your products contain nuts" are also addressed. Some facts about production are included on this page, specifically that 64 million Tootsie Rolls are manufactured every day. The actual question, "How many licks does it take to get to the center of a Tootsie Pop," is answered with the vague statement that it depends on the size of the mouth and the amount of saliva. Since the commercial aired in 1970, Tootsie Roll Industries has received over 20,000 letters from children who claim to know how many licks it takes. The average for these attempts is between 600-800 licks, with lows around 100 and highs reaching around 5,800. Each child that sends them a letter stating they completed the challenge is presented with a certificate with the signature of "Mr. Owl's" feet.

With the average number of licks ranging from 142 to 3481, the current literature fails to come to a conclusive answer to the question, "How many licks does it take to reach the center of a Tootsie Pop." Heid (2013) identified an inconsistency in the size of the Tootsie Roll center, which could have been the cause of the variation of other studies, as well as his own. Current literature lacks a consistent and mathematical approach towards finding the average number of licks and has not taken the variation in Tootsie Pop width into consideration (Zyra, 1996; Waksman, 2009; Heid, 2013; Tootsie Roll Industries, n.d.).

Purpose Statement

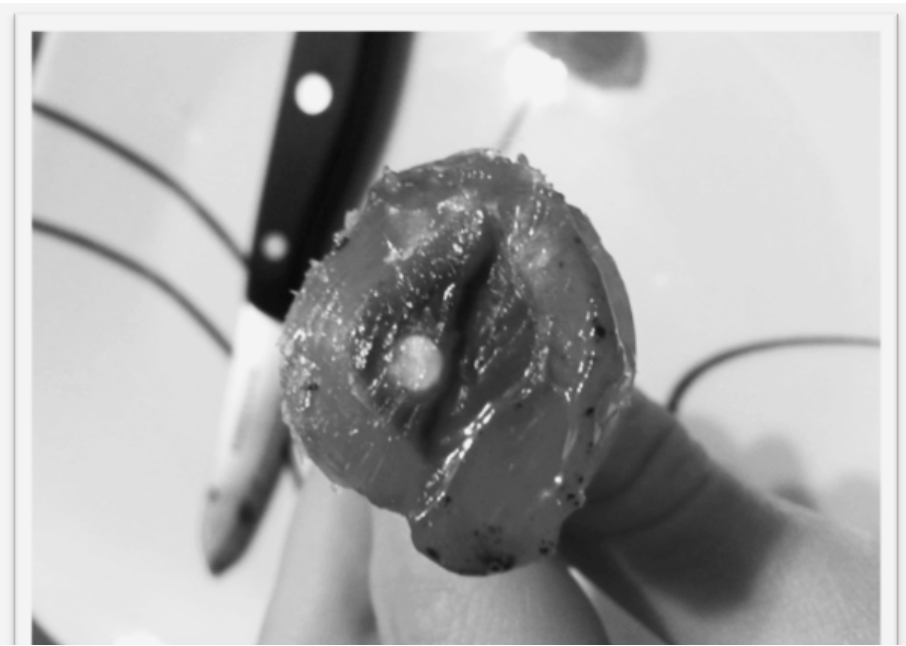
The purpose of this research was to determine the average licks per millimeter by dividing the average number of licks by the distance to the center of the Tootsie Pop. With Heid's (2013) discovery that not all Tootsie Pops are equal in size, the location of the Tootsie Roll seemed to have a significant role in the number of licks required to reach it. Using the licks per millimeter (LPmm), the average number of licks would be possible to calculate based on the average size of a Tootsie Pop.

Method

The research was divided into three stages. The first stage of the research was conducted in order to find initial data regarding the proportions of the Tootsie Pops. Licking tests were also carried out by myself to

determine an average number of licks to the center of the Tootsie Pops, as well as the average number of licks to clear an entire side of the sucker-off. These two averages were recorded to account for possible variations in the perceived reaching of the Tootsie Roll center done in previous research. The average number of licks was then divided by the measurements of the Tootsie Pops' shell width to determine the LPmm. The second stage of research had 20 participants perform the lick test in order to compare the average number of licks to the first stage of research. The third stage involved cutting each of the Tootsie Pops from stage two in half with a heated knife to determine the width of the Tootsie Pops and calculate the LPmm to compare with the LPmm from stage 1.

PICTURE 1



Five Tootsie Pops were sliced in half across the width of the sucker using a heated knife at the start of the first stage as seen in the picture above. Measurements were taken of the overall width, height, and length of the Tootsie Pop, as well as the width of the candy shell. Tootsie Roll dimensions was also measured. After each of the first five Tootsie Pops was sliced in half, I licked each of them to the center, noting the number of licks it took to reach the center, along with the number of licks it took to clear an entire side of the candy shell away from the Tootsie Roll. The number of licks was then divided by the shell width licked through,

which gave a measurement in LPmm. After the initial tests were complete I concluded that the average LPmm to the center of the Tootsie Pop was 137.81 and 175.31 LPmm to clear away the entire side of the sucker. The second stage of research began with each participant receiving a sheet of instructions for the individual licking tests. Participants were to count each lick and mark down the number of licks to reach the center of the Tootsie Pop, as well as how many licks it took to clear an entire side off of the Tootsie Pop shell. The participants were not allowed to place the entire sucker in their mouth at any time. A plastic bag was given to each participant and every test sucker was collected after the test was completed. The participants that carried out the test were all college students between the ages of 19-29 of both sexes. Thirteen tests were carried out during the second stage of research.

Once each of the test suckers was collected and the number of licks was recorded, the third stage of research began. The sucker was sliced in half with a heated knife and measurements of the remaining widths were taken and compared with the average width from the first group of Tootsie Pops. This comparison provided an approximation of how many millimeters of candy shell were licked through. The number of licks to reach the center was then divided by this approximate thickness to produce a measure of LPmm. The measure of LPmm from the second stage was then compared to the initial data from the first stage of research.

RESULTS

The results of the first stage of research are in Table 1 below. The first number in the Licks and LPmm columns is the initial point at which the Tootsie Roll is revealed, while the second number represents an entire side being revealed. The LPmm from A3 was thrown out as a result of a poor knife cut.

TABLE 1

T#	Shell Width	Licks	LPmm
A1	5mm	600~850	120~170
A2	8mm	1100~1350	137.5~168.75
A3	8mm	1750~2000	218.75~250
A4	8mm	1150~1400	143.75~175
A5	8mm	1200~1500	150~187.5

The data in Table 2 contains the measurements taken from the first group of Tootsie Pops. There are no measurements for Tootsie Pop A1. The averages for each category are listed at the bottom of Table 2.

TABLE 2

Sucker Length	Sucker Width	Sucker Height	Tootsie Roll Length	Tootsie Roll Width	T#
29mm	26mm	30mm	20mm	10mm	A2
30mm	25mm	30mm	20mm	10mm	A3
30mm	27mm	30mm	15mm	13mm	A4
29mm	27mm	30mm	15mm	11mm	A5
Ave. Sucker Length	Ave. Sucker Width	Ave. Sucker Height	Ave. Tootsie Length	Ave. Tootsie Width	
29.5mm	26.25mm	30mm	17.5mm	11mm	

Twenty participants were recruited to lick to the center of the Tootsie Pop while recording their licks. After two weeks, nine of the test suckers were received with the recorded number of licks. Eleven participants became impatient with the process and ate the sucker in a similar fashion to the original commercial. Table 3 contains the data from the second stage of research, which involved the tests of the participants. Tests B10-B13 were carried out personally after a discovery into alternative licking styles. The Shell Width Approximation is obtained by subtracting the Remaining Width from the Average Sucker Width.

TABLE 3

T#	Licks to Center	Licks to Clear	Remaining Width	Shell Width Approximation	LPmm to Center	LPmm to Clear
B1	1350	1500	18mm	8.25mm	163.64	181.82
B2	1850	2300	17mm	9.25mm	200.00	248.65
B3	312	825	18mm	8.25mm	37.82	100.00
B4	1000	2150	17mm	9.25mm	108.11	232.43
B5	755	1952	15mm	11.25mm	67.11	173.51
B6	700	1146	18mm	8.25mm	84.85	138.91
B7	131	318	20mm	6.25mm	20.96	50.88
B8	428	500	18.5mm	7.75mm	55.23	64.52
B9	514	732	18mm	8.25mm	62.30	88.73
B10	90	180	24mm	2.25mm	40.00	80.00
B11	180	330	17mm	9.25mm	19.46	35.68
B12	390	510	17mm	9.25mm	42.16	55.14
B13	300	510	19mm	7.25mm	41.38	70.34

DISCUSSION

After completing the first stage of research, it seemed that the number of licks I had gotten was much higher than most of the other research done. Previous research had taken between 142 to 417 licks on

average to reach the center with two extreme averages of 2255 and 3481 licks (Zyra, 1996; Waksman, 2009; Heid, 2013; Tootsie Roll Industries, n.d.). During my first stage of research it had taken between 600 to 1750 licks to reach the Tootsie Roll center, and between 800 to 2000 licks to clear an entire side of the Tootsie Pop. Because of Heid's (2013) information regarding the placement of the Tootsie Roll center, I decided to ignore the number of licks it took, as it is relative to the thickness of the candy shell. I was confident that the number of licks was perhaps a result of thicker shells. Taking the average LPmm of the first five tests, I found that the average LPmm to reach the center was 137.81 and 175.31 LPmm to clean away the entire candy shell on the same side. As the measurement of LPmm was fairly consistent with a standard variation of 12 LPmm, I was confident that these numbers would be backed up when compared with the results from stage two.

Once the data from the first stage was recorded, the second stage of research began. The results that I received from the participants were not what I had expected. While a few of the results were in line with the data obtained from the first stage of research, the vast majority of them weren't even close. The LPmm to reach the center ranged from 20.96 to 200 while the LPmm to clear a side of the Tootsie Pop ranged from 50.88 to 248.65. Tests during the first stage took around 1500 licks to clear a side but one participant had managed to clear the entire side off of the Tootsie Pop in only 318 licks. This disparity in licks was even more puzzling, as the suckers I had received back had all been done in accordance with the instructions I had distributed. I theorized that either the participants had miscounted due to human error, or I had miscalculated.

It wasn't until I talked with one of my final participants that I had a revelation. This particular participant had asked if it mattered whether they put their tongue back in their mouth in between licks. The results were astounding. A task that once took 1500 licks now took a mere 330 licks to complete. It turns out that bringing the tongue back in the mouth between each lick dramatically increases licking efficiency. I continued the tests from stage two and recorded tests B10 through B13, for a larger sample size, with my newfound knowledge.

I went back over participants B1 through B9 and asked each of them whether they brought their tongue back in their mouths between licks. I was then able to categorize each test from stage one, as well as stage two, based on whether the participant put their tongue back in their mouth between licks, or kept their tongue hanging out the whole time, which I dubbed the "Miley" method. Nine of the tests were done using

the Miley method, while the other eight placed their tongues back in their mouths between licks. Taking the average number of licks from the five tests in, which the participants utilized the Miley method, I found that their LPmm was 124.74 to reach the center and 195.06 to clean a side off of the sucker. This was quite close to the original data from stage one of 137.81 and 175.31 LPmm. When averaging the tests, which did not utilize the Miley method, I found that it took 39.91 LPmm to reach the center and 68.16 LPmm to clear a side of the sucker off. This means that the Miley method of licking requires between 2.73-3.27 times more licks than placing the tongue back in the mouth between licks. This revelation into different licking methods creates consistency within both methods and makes sense of seemingly inconsistent data.

As a result of Tootsie Pops having irregular centers, it can be hard to pinpoint an exact number of licks required to reach it. Using the average dimensions of Tootsie Pops found from the first series of tests, the center of the perfect Tootsie Pop is 7.625 millimeters from the outside of the shell. Averaging all 17 tests found a similar result of 7.868 millimeters. Assuming that Tootsie Roll Industries intends for the width on both sides of the Tootsie Pop to be a perfect 8 millimeters, it would take approximately 319.28 licks to reach the center or 1044.4 licks using the Miley method. This is slightly lower than Heid's (2013) 417-lick average but unlike Heid, my tests were done using the side of the Tootsie Pop without the thick, banded part of the candy shell, which is smaller.

I measured how thick the band on the Tootsie Pop was, finding it to be 2.5 millimeters thick. This means that the average distance to the Tootsie Roll center of the thick, banded side of the Tootsie Pop is found by adding the 2.5 millimeters to the average unbanded side of 8 millimeters. I multiplied my calculated LPmm of 39.91 in with the distance to the Tootsie roll center, 10.5 millimeters, which Heid would have licked through. The results were incredible. Using my LPmm I found that it would take Heid approximately 419.06 licks to reach the center of the Tootsie Pop, which is a mere two licks off of what his research actually found. The data, which I have collected, gives Heid's (2013) work much more credibility. Not only did his work feature a very small standard deviation, but is now backed up based upon my personal research into LPmm.

With these two pieces of information in mind, it can be said that an average sized Tootsie Pop requires about 419 licks to reach the center when placing the tongue back in the mouth between licks and licking along the thick, banded, longitudinal side of the sucker. Licking along the adjacent unbanded side of the Tootsie Pop while placing the tongue

back in the mouth between licks requires about 319.28 licks to reach the center. LPmm can also be used to determine how many licks it will take to reach the center of even the most irregular Tootsie Pop, such as Tootsie Pop B10 found in Table 3 in the Results section. I licked this Tootsie Pop myself and noted beforehand that the stick was diagonal within the sucker, bringing the Tootsie Roll almost to the surface. Even with a Tootsie Pop that bizarre, the LPmm still came out to 40. This concept can also be applied to more outrageous situations.

Suppose the earth was made of Tootsie Pop, how many licks would it take to reach the center? This is not the type of question, which comes to mind often, but out of curiosity I decided to do the math. On average, the distance to the Earth's core is 6.371 billion millimeters. Using the Miley method it would take approximately 832 billion licks to reach the center and 254 billion licks while placing the tongue back in the mouth between licks.

Limitations and Implications for Future Research

Measurements were done using a ruler, which opens up the possibility of human error while measuring. Expensive equipment could be used to reach a better measurement. While the results from these tests were consistent with one another, the sample size of participants was rather low. I would encourage others to lick while trying either method and then measure the distance and compare the LPmm to my data. While my research has backed up Heid's (2013) research, more tests need to be done to ensure truly accurate results.

CONCLUSION

With the work that Heid (2013) did finding the average amount of licks to reach the center to be 417 and my research saying 419, it can be safe to assume these can be very reliable answers to the question, "how many licks does it take to get to the center of a Tootsie Pop?" If the Tootsie Pop is irregularly shaped, the 39.91 LPmm can be a reliable way to create an estimation of how many licks it will take to reach the center. For those bold enough to use the Miley method, 124.74 LPmm should give a close approximation. Next time someone answers this question with "the world may never know," don't be a sucker; the answer is approximately 419 licks.

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