Has God Signed My Dollar Store Mug?

The search for aesthetic ratios in the relationship between body and handle in assemblages of dollarware drinking vessels

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Abstract: This report summarizes the evidence for mathematical trends in certain relationships between the morphological handles of dollar store mugs with respect to the entire ceramic vessel. High R^2 values demonstrate that there is moderately strong correlation between handle and mug, and frequency data that is normally distributed reveals ratios between .3 and .4 with low standard deviation. Although this report does not claim a uniform golden rule of aesthetics beauty for mug handles, a possible relationship of thirds emerge even if the functional versus aesthetic causes for this cannot be determined.

Introduction

As I perused the shelves of the finest dollar stores in the land in search of the perfect ceramic mug I began to look past the ornate decorations and flourishes which graced these pieces and I was struck by the simple beauty of the form of the vessels, and their handles in particular. Beyond issues of (1) superficial decoration like color scheme and patterns and (2) function such as weight, comfort, lack of drip, sturdiness or heat transfer, I assume that the prototypical molds that are selected for mass produced dollar store ware must have been chosen over mug molds which were equally cost efficient, sturdy, etc., for another reason. I am interested in exploring whether or not these basic forms are chosen because of their aesthetic beauty and if this sense is derived from a mathematical harmony that exists in the mugs design, specifically, a balance between the bodies and handles of the mugs. Is there a constant ratio that is present from mug to mug or revealed in any of or all of the mug to handle measurements? If more than one "ratio of symmetry" emerges is this the result of geographic variation of the country of production, maker, seller, or functional concerns of the mug? Finally, can dollar store mugs and their handles serve as evidence for a divine or universal proportion of beauty? The question of the existence of a divine ratio is a controversial one with a long history (reference) and such a study of crappy mugs may provide evidence of a universal mathematical aesthetic form transcends economic boundaries.
However, if no proportions exist between these mugs and their handles, should we assume that the handle design is purely the product of functional or economic concern? Even unsystematic inspection of the collection revealed how many of these vessels share a sense of symmetry or balance in the mug and handle.

By ethnographic comparison, modern potters recognize that one of the most delicate and difficult processes in functional ceramic production involves creating and attaching a handle appendage that best compliments the form of the entire vessel. However the considerations of ceramic artisans may not simply be applied to the mechanized mass production of low-end goods that arrive on dollar store shelves.

Methods

Initial qualitative observation exposed a basic uniformity of the mug and handles and spurred presumptions of likely clear set of data. Two weeks were spent classifying and gathering data on the

assemblages of vessels. Initial measurement problems required the classification of handle types that would be measured according to various morphological characteristics. To ensure accuracy of measurements we decided to distinguish between mugs that have "C"-shaped handles and those that have "1/2 heart"-shaped handles. "C shaped" handles are defined as those that have observable inside angles that are equal at both points of appendage (figure 1), while "1/2 heart-shaped" handles have varying appendage angles on top and bottom (figure 2).

Figure 1: Exemplifying a "C-Shaped" handle

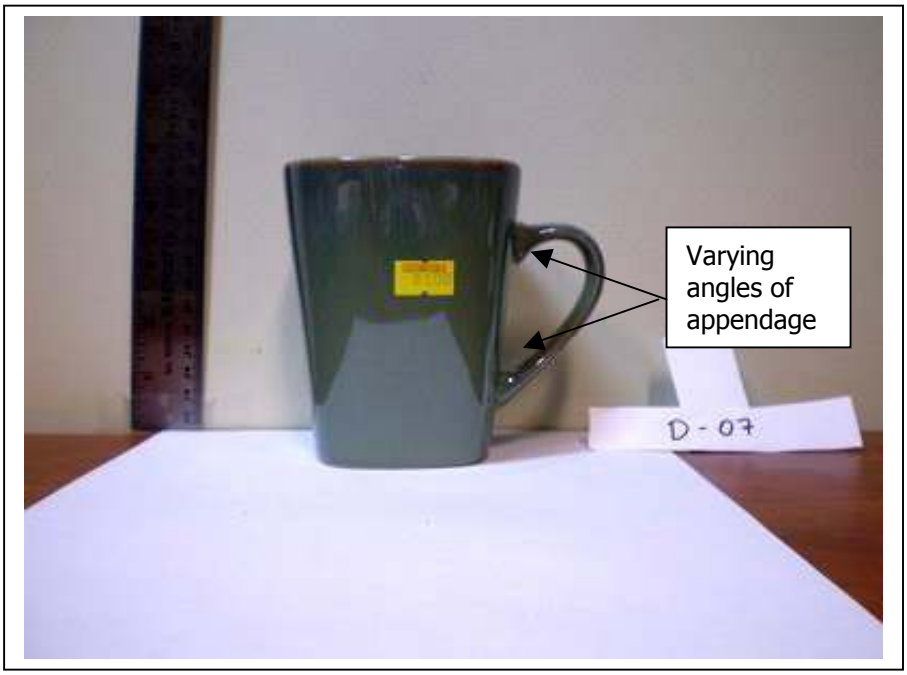


Figure 2: Exemplifying "1/2 heart- shaped" handle

Although certain mugs escaped this simple system of classification (Figure 3), these two types proved to be useful and sufficient for measuring the greatest amount of handle data. Especially difficult to measure and classify were mugs with special grips for comfort or protection from heat like the D-10 "$" handle or handles with a jutting out thumb rest and decorative handles such as animal iconography.

Figure 3: Certain mugs escape simple typology and/or prove difficult to measure.

Specifically, the ½ heart and C Shape classifications were important for the following handle measurements that were chosen with regard for the flexibility of this data for answering multiple research questions:

Breadth: The breadth of the handle measures the width when you are looking at the mug straight on.

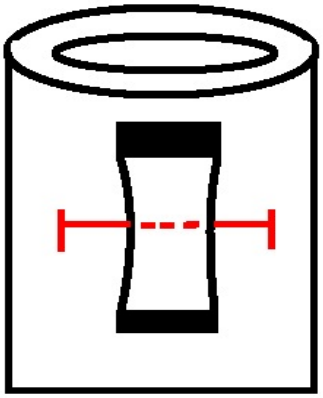


Figure 4: Measurement of Breadth

"Pinch": This measurement, as described in the name, quantifies the thickness of the handle from the inside edge to the outside edge that is felt between the fingers. Issues of measurement, including some mugs which had varying thicknesses, caused difficulty in taking this measurement. To solve this issue, and to ensure that the furthest possible measurement of the handle was taken, the ½ heart shapes were measured at the angle under the curve and the C-shaped handles were recorded at the furthest point from the mug external wall.

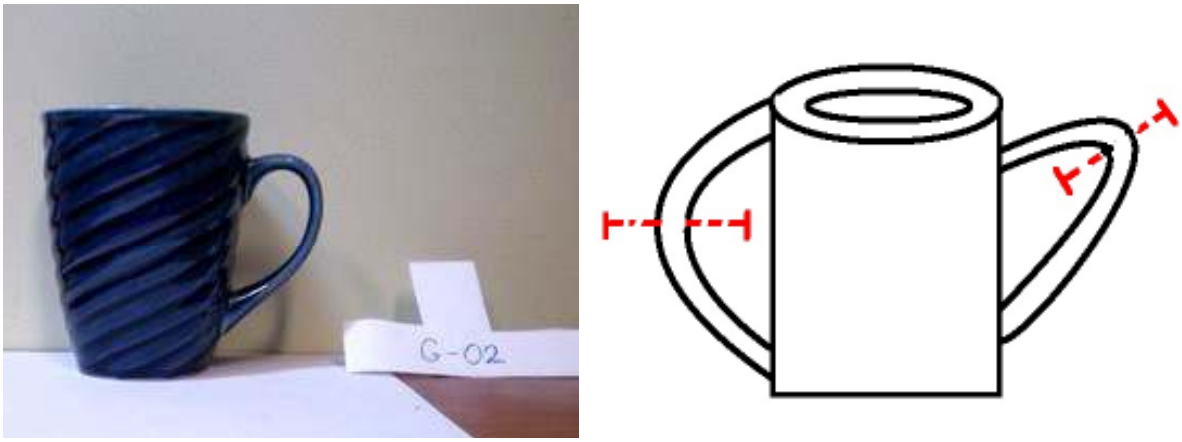


Figure 5: Measurement of "Pinch"

Maximum Width: This measurement was fundamentally based on the classification of the mug based into the C and ½ heart shape types. In order to uniformly determine the size inside the handles, where fingers normally go, the measurement need to be based on the type of handle. Handles' maximum widths were measure from the middle of the outside wall of the mug to the furthest inside point of the handle. For c shapes this was parallel, but not for so for ½ hearts, which were measured to the inside wall of the handle just under the curve.

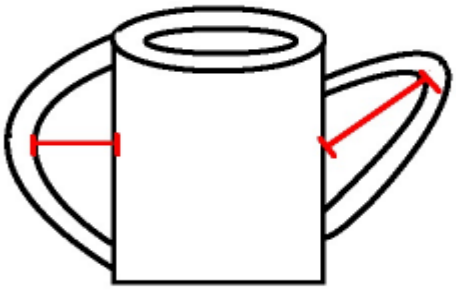


Figure 6: Maximum Width inside handle

Total Length of the mug handles was taken by measuring the height of the handle based on the two types. The distance from the lowest point where the handle was conjoined with the mug was measured to the highest edge of the mug handle. In the case of ½ heart shaped mugs, the highest point was not connected to the body of the vessel.

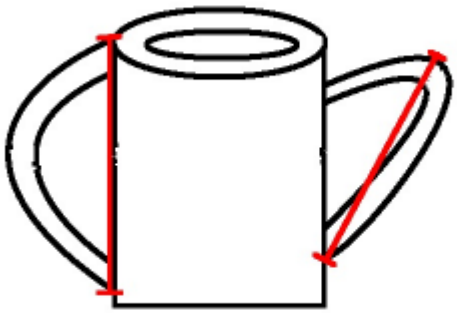


Figure 7: Total Length Measurement

This "C" and "½ Heart" shaped handle classification scheme was necessary to determine any "aesthetic ratio" since handles' relationship to the mug body differ depending on shape type (i.e. the length to the furthest point on a "1/2 heart" shaped handle is not at the mid point like in a "C" shaped one).To ensure uniformity of measurements each member of the group specialized in one particular dimension of measurement. Even while working with the simplest "pinch" dimension, issues arose as I attempted to negotiate the unique morphologies of C and ½ Handles, in addition to the irregularities of the handle surfaces that are likely a result of the poor quality of these mugs. I found that wiggling the caliper slightly and sliding it just under the curve of the "1/2 heart" handles allowed for the best possible measurement. By specializing in one measurement, each team member was able to minimize variability in measurement.

The primary relationship that is being examined in this report is the relationship of the arcing handle (a) to the width of the mug from the edge of the handle to the furthest wall. Insight into this relationship was only gained by adding together the measurements of Pinch and Inside Width from above, for a total sum that is call "Handle" hereafter (see appendix A).

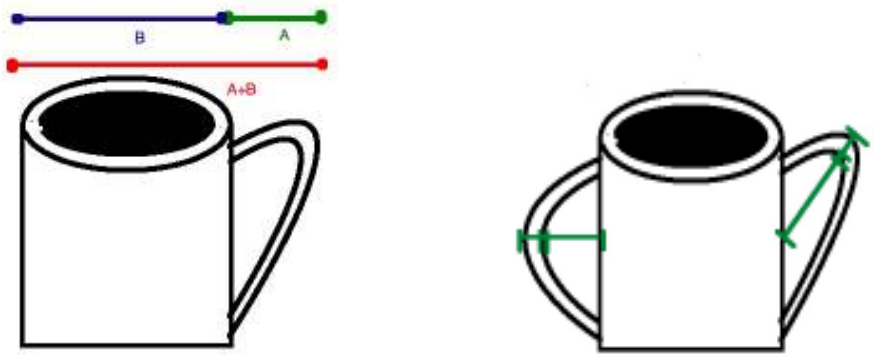


Figure 8: The primary handle:mug relationship being studied and handle sum

The "B" line segment above, is analyzed both from the top external diameter as the diameter of the base. Because so many of these mugs, either intentionally or not, have different top and base diameters, this variation may prove to expose different ratios, or a ratio may emerge from one and not the other. In general, from initial observation the top diameter seems like a more of a consistent measurement since it is not subject to drastic slopes from rounded designs or frustum shape like the base diameter is.

Results

Scatter plots and linear regression were used initially to determine if any correlations existed in the data. When it was apparent that strong relationships between the handle and the mug calculated with both top and bottom diameter did exist, histograms where charted to determine the frequency of ratios. Since all of this frequency data is normally distributed around certain means with low standard deviations, we can conclude that there are ratios of significance that emerge. Since handle measurements, as explained above, were taken based on the classification into C and ½ heart shaped types, it has been relevant in the analysis of this data to distinguish between these two forms. The analysis of data is organized below starting with all of the handles in relationship to the top (measurement A/(A+BTop)) followed by a divided analysis of C and ½ heart handles. This organization is then repeated with B measurement taken from the bottom diameter

Handles/ (A+B Top)

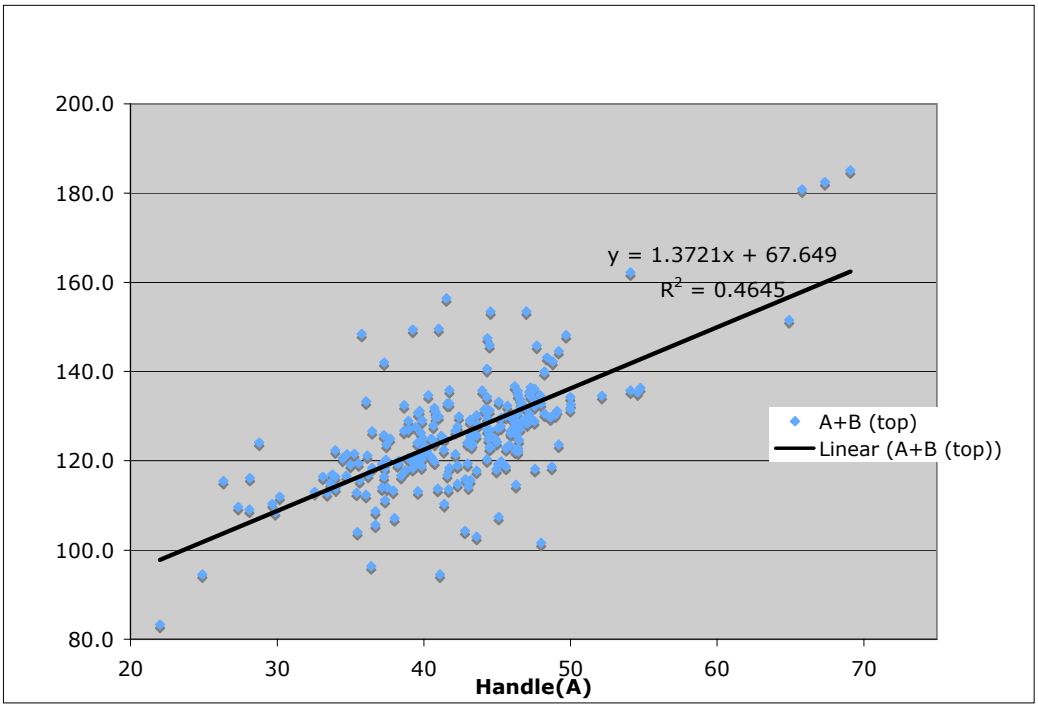
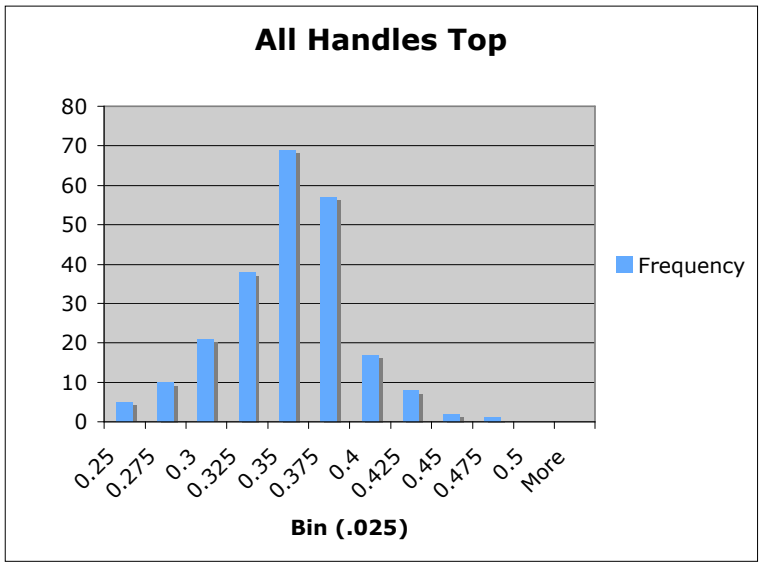


Figure 9: Scatter plot data for all handles using the top diameter
This figure, for example shows a relatively strong r^2 value of .4645, confirming that the relationship between handles and the top external diameters of the mugs to which they are attached are not random. The strong clustering of data, hovering right at the line of regression could possibly reflect an idealized form or mould that is used for many of these vessels.



Bin	*Frequency*
0.25	5
0.275	10
0.3	21
0.325	38
0.35	69
0.375	57
0.4	17
0.425	8
0.45	2
0.475	1
0.5	0
More	0

count	90
min	0.472440945
max	0.4724
avg	0.345044158
median	0.35090247
stdev	0.043480607

Figure 10: Histogram data and statistics for all top handles using top diameter
These data are most frequent in the .375 bin and represent a normal distribution. A small Standard Deviation of .0434 surrounds the mean at .345. The mug I-18 reflects this mean.

Figure 11: Figure I-18 reflects the average handle:mug ratio when the top diameter is used.

C-shaped Handles: A+BTop)

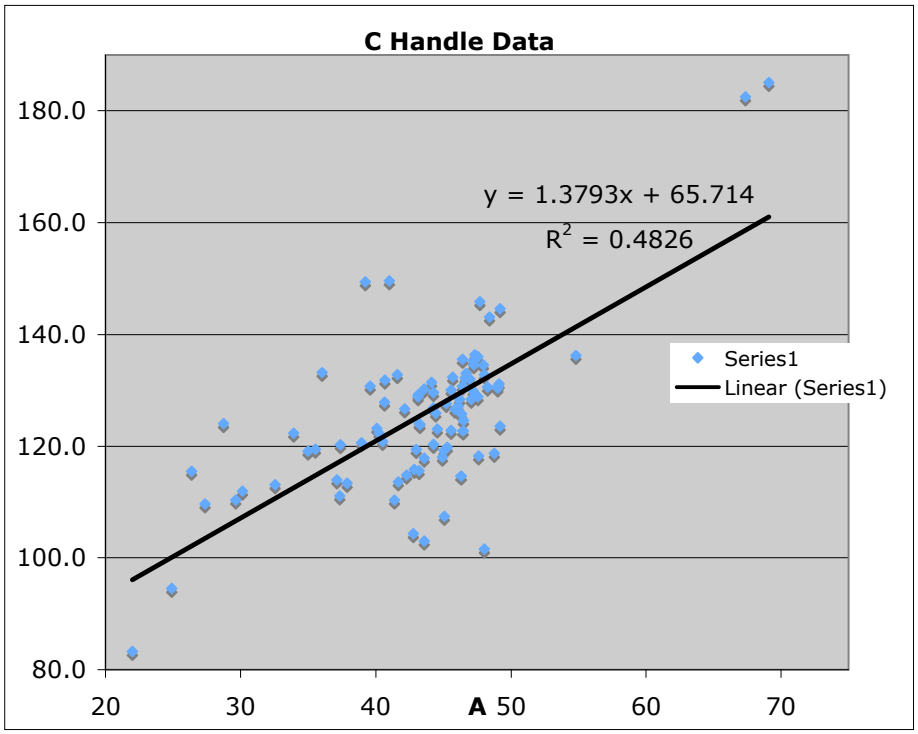


Figure 11: Scatter plot of C top data.

When we isolated the C shaped handles the correlation coefficient goes up from .4645 to .4826 although the mean remains the same as the mean for the entire data set.

Bin	*Frequency*
0.25	3
0.275	7
0.3	4
0.325	6
0.35	23
0.375	32
0.4	7
0.425	7
0.45	0
0.475	1
0.5	0
More	0

count	90
min	0.472440945
max	0.4724
avg	0.345044158
median	0.35090247
stdev	0.043480607

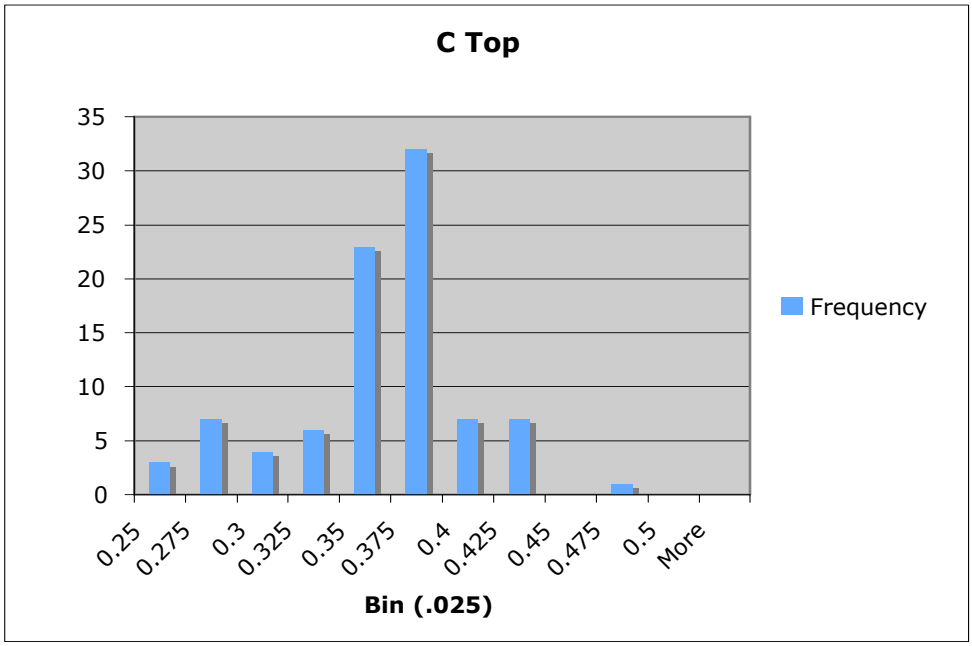


Figure 12: histogram of C top data (For full table see appendix B)

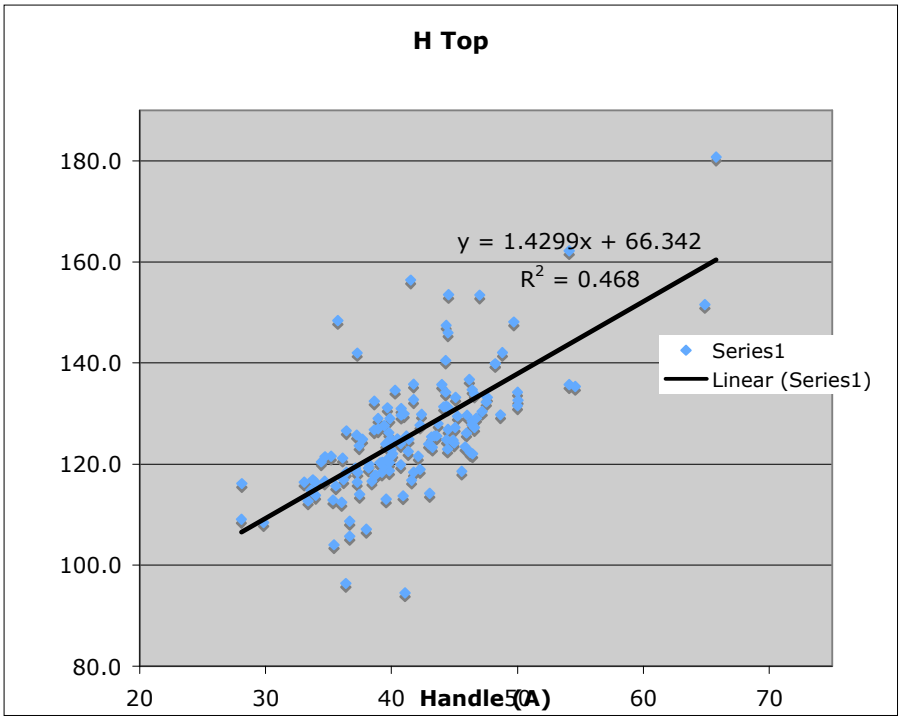
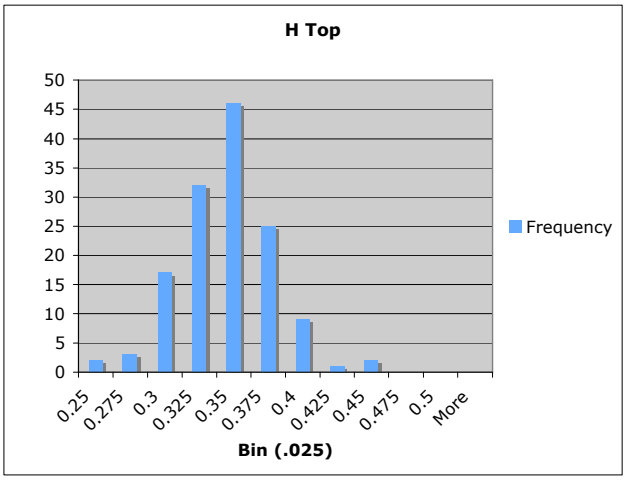


Figure 13: Scatter data for the isolated ½ heart handles.

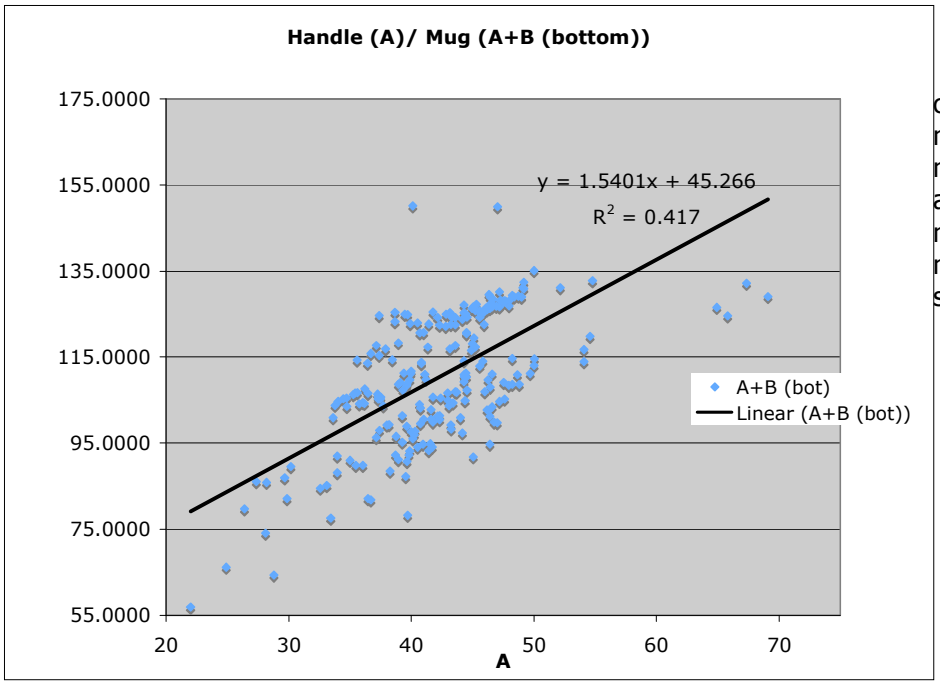
Bin	*Frequency*
0.25	2
0.275	3
0.3	17
0.325	32
0.35	46
0.375	25
0.4	9
0.425	1
0.45	2
0.475	0
0.5	0
More	0



count	137
min	0.240821826
max	0.43469064
avg	0.330888905
median	0.329618517
mode	0.345012513
stdev	0.032536792

Figure 14: The frequency and distribution data for isolated ½ heart shaped handles.
These statistics show the ½ heart influence that is exerted over on the smaller sample of c shaped handles. The regression of total top handles was skewed towards these ratio before the typologies were isolated. It is of note that the mean, median and standard deviation are smaller among the half heart handle data. This may reflect the method of data collection that is mentioned above which was more often measured greater area under the curve of half heart based on morphological concern.

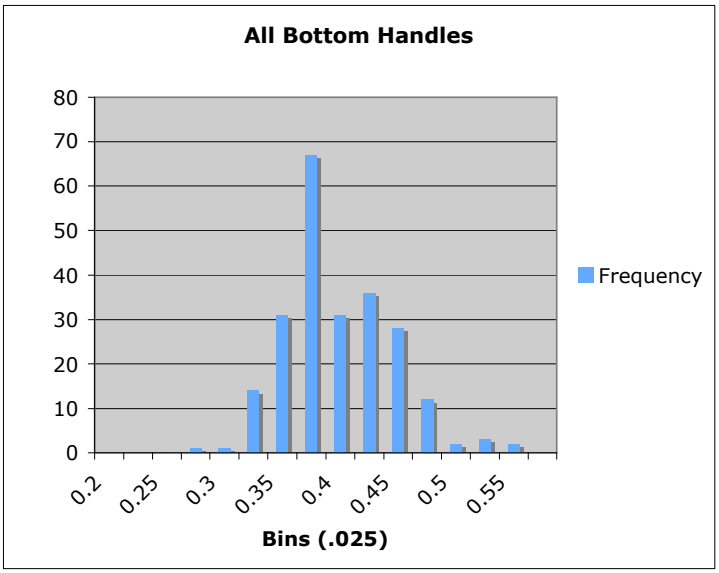
Measurement A/(A+B Bottom)



count	228
min	0.267048482
max	0.535243997
avg	0.385417362
median	0.374950529
mode	0.379844961
stdev	0.045955988

Figure 15: Scatter data for handle: total mug ratio where B is measured from bottom diameter.

These data do not have as strong of a correlation as the numbers derived from measurements based on top diameter. An interesting feature in this graph, unlike the graphs above is that there are clusters of data points below and above the line of regression, but not along it. This may reflect a difficulty in measurement of base diameter, or it may reflect a difference between the general forms of the mugs (such as curving pedestals or fulcrum shapes). There are also many more outliers in this scatter plot than in any of the other graphs that have been examined although this may reflect a larger sample of "½"s.

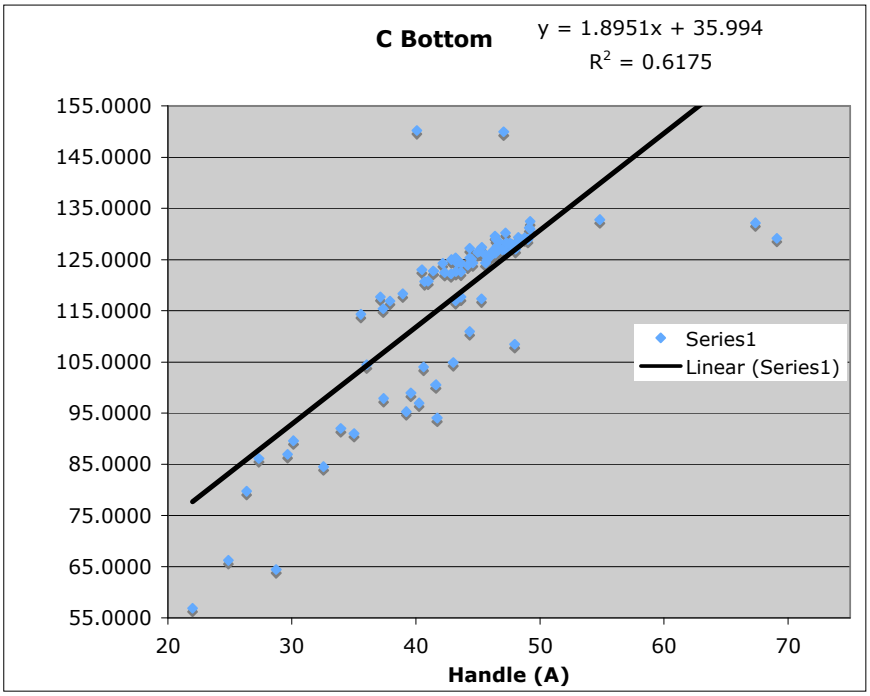


Bin	*Frequency*
0.2	0
0.225	0
0.25	0
0.275	1
0.3	1
0.325	14
0.35	31
0.375	67
0.4	31
0.425	36
0.45	28
0.475	12
0.5	2
0.525	3
0.55	2
More	0

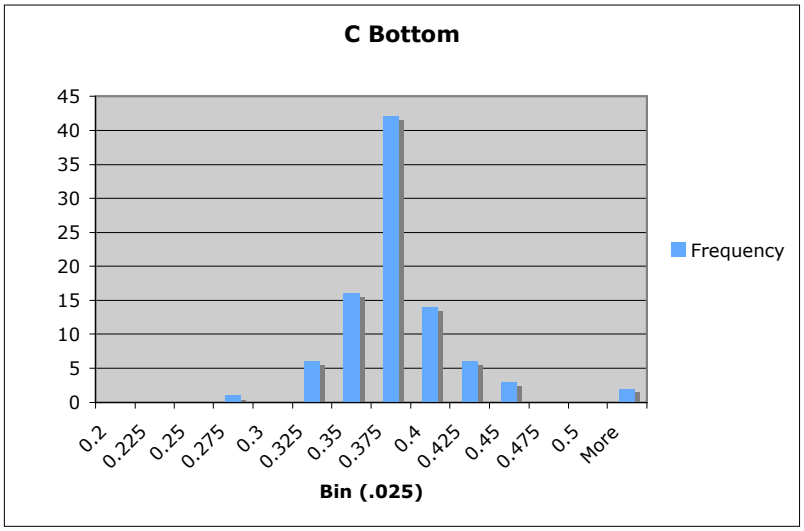
Figure 16: The frequency and statistical data for all handle:mug ratios measured from bottom

These data reflect a very high, normally distributed frequency surrounding the .375 bin. The average of .385, and the bin frequency seem to point to an attempted ratio of 4/10.

C Isolated:



count	90
min	0.267048482
max	0.535243997
avg	0.367808164
median	0.365814354
mode	0.379844961
stdev	0.036937712

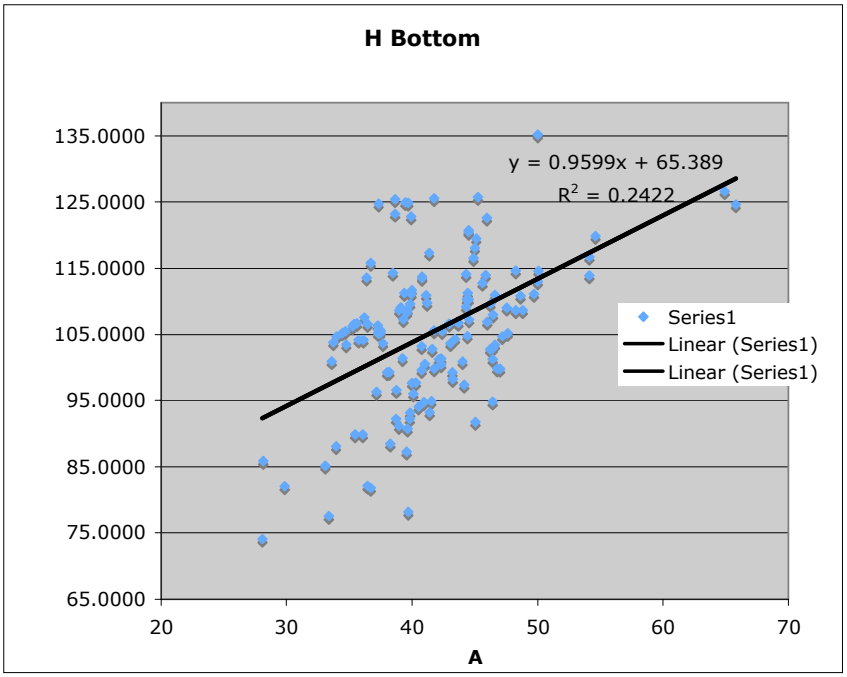


Bin	*Frequency*
0.2	0
0.225	0
0.25	0
0.275	1
0.3	0
0.325	6
0.35	16
0.375	42
0.4	14
0.425	6
0.45	3
0.475	0
0.5	0
More	2

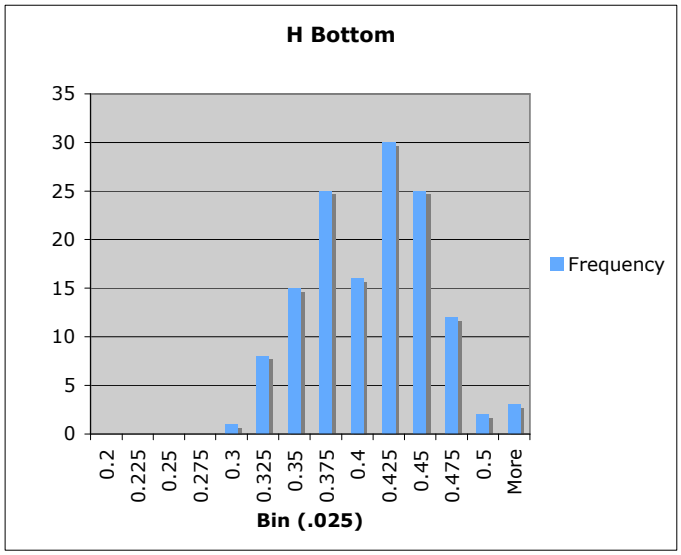
Figures 17: C data scatter, frequency and statistics

When the C shaped handles are removed from the data calculated with the base diameter, the average ratio decreases from the total data set. Much more definite clusters emerge from these graphs, possibly explaining the trend in the general data chart. The standard deviation has significantly decreased for the c measurements frequency, and this should be taken either as sound evidence the existence of an optimal ratio based on handle type or a bias of measurement.

H isolated:



count	137
min	0.299398798
max	0.528089888
avg	0.396896259
median	0.401903036
stdev	0.047887239



Bin	*Frequency*
0.2	0
0.225	0
0.25	0
0.275	0
0.3	1
0.325	8
0.35	15
0.375	25
0.4	16
0.425	30
0.45	25
0.475	12
0.5	2
More	3

Figure 18: Scatter, Frequency and statistics for isolated ½ handle data

Isolation of the ½ heart shaped data reveals a ratio that is greater than .4. This, as stated above, likely reflects the decisions that went into measurement of this type of handle. The standard deviation is highest in this category, and so this data is less telling of a ratio based on mean since the frequency data is not a drastically concentrated towards one bin.

Discussion

The clarity of these data is surprising considering that we are dealing with cultural archaeological data. This being said, we cannot ignore the significance in the purity of normally distributed combined with such small standard deviation. It is highly interesting, although not necessarily statistically significant that all of these mean data are so close together (from approximately .3-.4) This study has not

determined a statistical method of measuring precisely the significance, or possibility that the data reflect a relationship of 1/3 and this is a challenge in moving forward with more studies like it. It has also proven extremely difficult to demonstrate outright that these converging ratios reflect an idealized relationship of harmony based on aesthetic balance. This study has not been able to distinguish the aesthetic concerns that cause such a ratio from functional ones. Although no number like phi has magically revealed itself in the data, a strong point has been brought forward regarding the ratio of beauty, in that it should not be expected to be found in these assemblages of ceramic ware because they are the cheapest of cheap product. Maybe more clear ratios can be found in samples of higher end products.

The above findings only reflect a starting point for an expandable research design. This earliest stage in dollarware handle ratios has been restrained by time limitations and would benefit from exploring other relationships that could reveal more and stronger ratios. Since geographic variation of dollarware mug production was not apparent, it has not be possible to determine if the ratios that are emerging are universal or geographically determined, which could be of future ethnographic interest. In retrospect, many functional and aesthetic concern were overlooked and this study would benefit from a future refined study including exploration of stackability of these mugs handles, which is likely of primary concern for dollar store producers who need to be able to fit as many mugs on their shelves as possible in the simples and efficient manner. After fully treating some of the unworked raw data that has been recorded here, a more complex measurement of the area underneath the curving handle could be the illuminating if research is to continue. The data should be sorted even further based on types of vessels and not on the types of handles alone (i.e. frustum, bowl and cylindrical mugs likely have unique aesthetic relationships to their handles.) A comparative collection (like the assemblage N which was not a focus of this study) would have certainly brought more light to the mug/handle relationships and I recommend exploring assemblages of higher end ware that are not mass produced, so that the origin of maker and intended locale more about handles can be determined on what is known as the highest quality of ceramic work.

References

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Appendix A: Handle Data (Including the "Handle" sum of Pinch + Inside Max Width)

Specimen	Shape type (C=0, H=1)	Max Length	Pinch	Width	Breadth	Handle (pinch+width)
A-01	0	59.5	7	39.4	16.2	46.4
A-02	0	58.15	7	37.3	14.2	44.3
A-03	0	58.25	6.95	40	16.2	46.95
A-04	0	58.25	6.35	40	16.4	46.35
A-05	0	58.25	7.55	40	14.7	47.55
A-06	0	57.4	6.45	41.1	16.2	47.55
A-07	0	29.9	5.15	22.2	12	27.35
A-08	0	15.35	4.9	20	11	24.9
A-09	0	21	7.35	25.2	15	32.55
A-10	0	32.1	7.9	32.2	14.4	40.1
A-11	1	63.05	7.5	36.1	14.6	43.6
A-12	1	51.65	5.55	34	9	39.55
A-13	0	38.15	7.6	36	12.3	43.6
A-14	0	39.25	7.15	36	12.3	43.15
A-15	1	75	8.6	41.1	17.4	49.7
A-16	1	63.1	7.35	42.7	15.4	50.05
A-17	1	53.15	6.55	35	15.4	41.55
A-18	1	59.2	7.1	36.6	14.1	43.7
A-19	1	44.5	9	34.4	16	43.4
A-20	1	46.35	4.75	30.5	11.7	35.25
A-21	1	60	6.85	39.9	14	46.75
B-01	1	44	4.7	30	12	34.7
B-02	0	55.1	6.05	42.2	14.4	48.25
B-03	0	54.25	6.3	42.7	14.7	49
B-04	1	36.85	12.15	36.1	20	48.25
B-05	1	60.5	6.3	48.3	13.1	54.6
B-06	0	51	6.75	32.2	14.2	38.95
B-07	1	55.95	5.05	32.1	13	37.15
B-08	1	58.15	8.8	37.6	16	46.4
B-09	0	53.35	5.75	34.9	19.2	40.65
B-10	0	51.1	7.4	41.6	14.3	49
B-11	1	43.8	6.8	35.5	14.1	42.3
B-12	1	60.5	7.1	36.1	17.2	43.2
B-13	1	46	4.3	31.1	12	35.4
B-14	1	43.4	7.15	35	14.4	42.15
B-15	1	60.05	7.25	36	17	43.25
B-16	0	49.6	6.1	36.9	19.1	43
B-17	1	60.05	5.3	34.3	12.3	39.6
B-18	1	38	8.9	36.1	16.6	45
B-19	0	51.4	7.45	39	14.3	46.45
B-20	1	41.8	7.55	33.8	15	41.35
C-01	0	54	6.25	33	20.4	39.25
C-02	1	27.5	4.75	31.7	9	36.45
C-03	1	55.6	5.9	39.2	14	45.1
C-04	1	27.7	7	26.1	15.1	33.1

C-05	1	41.4	7.25	32.7	14.6	39.95
C-06	1	62.05	6.6	40	15.5	46.6
C-07	0	51.95	4.6	35	16.2	39.6
C-08	0	49	5.1	29.9	19.4	35
C-09	1	31	5.75	37.2	11.7	42.95
C-10	1	43	4.2	32	11.4	36.2
C-11	1	43.3	4.5	31.1	12	35.6
C-12	1	52.4	5.1	34	12.2	39.1
C-13	1	18.65	7	21.1	10.5	28.1
C-14	1	61.4	4.5	32.2	12.5	36.7
C-15	1	57	7.2	38.8	14.3	46
C-16	1	32.25	5.7	27.7	9.6	33.4
C-17	1	67.4	6.5	38.4	13.4	44.9
C-18	1	55.05	6.4	27.2	14.3	33.6
C-19	0	57.1	4.55	29.4	16.2	33.95
C-20	1	59.4	5.1	37.2	11.4	42.3
D-01	0	55.4	6.5	41.1	15.5	47.6
D-02	0	52.55	6	42	19	48
D-03	0	68.75	7.1	37.2	20.6	44.3
D-04	0	51.6	6.3	38.8	14.1	45.1
D-05	1	46.05	6.7	39.9	14	46.6
D-06	0	53.9	6	37.6	12.5	43.6
D-07	1	54	6.85	39	16.3	45.85
D-08	1	49.35	5.8	32.2	12.3	38
D-09	0	54.1	6.7	40.5	15	47.2
D-10	$	25.2	10.65	41.5	14	52.15
D-11	1	34	4.2	35.5	11	39.7
D-12	0	54.85	7.15	41.6	15.2	48.75
D-13	1	47.3	5.5	35.6	15.3	41.1
D-14	0	54	6.4	37.2	13.7	43.6
D-15	0	28.35	5.4	32	13.4	37.4
D-16	0	51.6	5.5	36.1	13.1	41.6
D-17	1	61.35	6.6	35	13.4	41.6
D-18	0	52.2	5.7	36	13	41.7
D-19	1	60.05	6.85	37.3	13.5	44.15
D-20	1	27.8	6.45	36.6	12	43.05
E-01	0	58.65	9.1	40	20.1	49.1
E-02	1	76.3	7.65	41	17.5	48.65
E-03	0	52.45	6.95	38	14.5	44.95
E-04	1	62	6.25	32.7	13	38.95
E-05	1	78.7	7.7	41.1	18.2	48.8
E-06	0	52.3	6.85	37.7	15.1	44.55
E-07	0	51.1	6.75	39.9	15.4	46.65
E-08	1	76.45	7.55	40	17.2	47.55
E-09	0	53	6	39.9	14.6	45.9
E-10	1	59.85	6.35	38	13.2	44.35
E-11	0	51.7	6.55	37.6	13.6	44.15
E-12	1	59.15	8.25	36.1	15.7	44.35
E-13	1	76.75	7.8	42.2	17.7	50
E-14	0	52.2	5.6	37.2	13.7	42.8

E-15	0	52	6.3	40	14.5	46.3
E-16	1	46.6	4.9	31.5	12.7	36.4
E-17	1	60.35	6.2	39.4	13.2	45.6
E-18	0	52.6	6.7	36.6	14.5	43.3
E-19	1	43.65	5.65	30.5	12.7	36.15
E-20	1	81.45	9.1	45	19.2	54.1
F-01	0	43	27.1	42	17.5	69.1
F-02	0	41.15	4.85	25.3	7.7	30.15
F-03	0	60	6.25	41.7	16.3	47.95
F-04	1	53	4.85	35	11	39.85
F-05	1	54.45	8.45	39.8	19.2	48.25
F-06	0	21.7	4.65	25	10.3	29.65
F-07	1	56.2	12.2	52.7	15	64.9
F-08	1	54.7	7.6	40	19.3	47.6
F-09	1	47.4	7.7	33.3	14.2	41
F-10	1	61.3	9.45	37	15	46.45
F-11	0	33.1	26.25	41.1	16	67.35
F-12	1	52.1	3.25	36.6	11.6	39.85
F-13	1	56.25	7.4	38.8	18.5	46.2
F-14	1	55.3	8.2	39	19	47.2
F-15	1	30.45	9.4	34.9	15.6	44.3
F-16	1	73.65	7.25	38	21.5	45.25
F-17	0	60.3	6.2	39.4	15.6	45.6
F-18	1	38.05	7.3	32.7	14.1	40
F-19	1	47.6	6.35	34.4	14.1	40.75
F-20	0	48	6.5	48.3	14.2	54.8
F-21	1	53.15	3.8	35.5	12.2	39.3
G-01	1	52.8	6.15	34.8	14.1	40.95
G-02	1	52.8	5.45	34.2	13.3	39.65
G-03	1	52.8	6.1	34.4	14	40.5
G-04	1	59.4	5.25	34.4	13	39.65
H-01	0	50.7	7.25	35.6	15	42.85
H-02	0	50.7	7.6	37.7	16	45.3
H-03	0	44.55	6.85	30.5	15.3	37.35
H-04	0	49.15	6.6	36.6	15.2	43.2
H-05	0	50	6.8	35.5	16	42.3
H-06	0	51.5	6.3	35.1	14	41.4
I-01	0	57.05	6.8	33.9	15.2	40.7
I-02	0	55.45	7.6	40.1	15.3	47.7
I-03	1	48	4.6	29.4	12	34
I-04	0	9.15	9.35	19.4	6.3	28.75
I-05	1	37.4	10.9	36.1	17	47
I-06	0	58.8	6.4	40	15.1	46.4
I-07	0	58.1	8	40	17.6	48
I-08	1	52.6	5.5	38.9	20	44.4
I-09	1	55.5	12.1	53.7	18.5	65.8
I-10	1	46.55	4.35	29.4	12.1	33.75
I-11	1	46.7	4.45	30	12	34.45
I-12	0	46.25	8.75	38.3	18.1	47.05
I-13	0	58.75	8.3	32.7	17.6	41

I-14	0	50	7.6	41.6	14.5	49.2
I-15	0	51.05	7.9	40.5	14.3	48.4
I-16	1	61.2	6.3	37.7	15.6	44
I-17	1	64.95	4.15	31.9	11.7	36.05
I-18	0	54.6	6.3	39.4	14.4	45.7
I-19	0	59.2	6.1	40	15.1	46.1
I-20	0	60.1	6.25	39	14.3	45.25
J-01	1	51.5	7.55	37	15.5	44.55
J-02	1	47.55	5.4	37	11.5	42.4
J-03	0	52.1	5.7	32.2	14.5	37.9
J-04	1	47.65	5.5	39	11.4	44.5
J-05	1	36.3	9.55	32.2	12.6	41.75
J-06	0	51.5	7.1	36.1	14.6	43.2
J-07	0	54.45	7.3	39.3	15.1	46.6
J-08	1	39.25	7	39.4	13.5	46.4
J-09	1	52.3	6.05	32.2	15.1	38.25
J-10	1	27.15	4.5	32.2	13.3	36.7
J-11	0	23.6	8.65	17.7	15.3	26.35
J-12	1	46.6	7.05	21.1	14.1	28.15
J-13	0	52.95	6.05	31.1	14.6	37.15
J-14	1	59.2	6.75	37.7	15.2	44.45
J-15	1	32.1	6.25	35.5	12.1	41.75
J-16	1	25.2	5.15	28.8	8.6	33.95
J-17	0	42.3	11.65	24.4	22	36.05
J-18	1	47.5	6.6	43.4	13.2	50
J-19	1	48.6	6.2	31.5	11.5	37.7
J-20	1	50.25	6	32.7	14.7	38.7
K-01	0	52.6	6.5	34	14.1	40.5
K-02	0	52.15	7.05	38	14.2	45.05
K-03	0	49.9	7.25	37.2	15.1	44.45
K-04	0	55	7.2	42	15.7	49.2
K-05	1	41.45	6.05	29.4	13.4	35.45
K-06	1	58.8	6.05	39.9	14.1	45.95
K-07	1	63.1	6.35	39.9	14.1	46.25
K-08	1	59.45	5.7	38.8	14.3	44.5
K-09	1	44.7	6.4	34.8	13.4	41.2
K-10	1	49.05	6.4	33	15.7	39.4
K-11	0	53	6.6	37.7	15	44.3
K-12	1	50.3	7	39.4	13.3	46.4
K-13	0	50.3	6.75	40.5	15	47.25
K-14	1	57.05	6.2	38.3	14.5	44.5
K-15	1	52.25	7.05	38	13.2	45.05
K-16	1	46.3	6.5	33.8	14.1	40.3
K-17	1	61.45	6.3	38	13	44.3
K-18	0	14.4	4.8	17.2	9.6	22
K-19	1	40.55	3.85	26	8.3	29.85
K-20	0	28.1	5.85	34.4	14.1	40.25
L-01	0	56.5	7.5	39.8	15	47.3
L-02	0	55.3	6.8	38.8	14.2	45.6
L-03	1	51.4	4.6	33.6	11.2	38.2

L-04	1	51.95	4.55	34.7	12	39.25
L-05	1	51.55	5.25	35.5	11.4	40.75
L-06	0	50.1	7.05	36.1	14	43.15
L-07	0	49.85	7.7	38.8	14.5	46.5
L-08	1	42.05	6.65	32	15	38.65
L-09	1	42.5	6.75	32.2	13.1	38.95
L-10	1	43.4	6.55	32.2	16	38.75
L-11	1	43.85	7.35	34.4	15.1	41.75
L-12	1	43.5	5.3	32	12.2	37.3
L-13	1	43.4	5.5	32	12.5	37.5
L-14	1	55	5.8	35	12.4	40.8
L-15	1	57.2	5	35	12.3	40
L-16	1	54.7	5.8	35	13	40.8
M-01	1	51.7	6.8	33.3	14	40.1
M-02	0	52.2	6.4	39.8	14.4	46.2
M-03	1	58.75	5.15	33.3	17	38.45
M-04	1	58.75	5.8	34	12	39.8
M-05	1	38.75	6.85	30.5	14	37.35
M-06	0	60	7.2	40	16.3	47.2
M-07	1	53.65	7.4	29.9	11	37.3
M-08	1	40.7	7.7	32.2	15	39.9
M-09	1	40.85	7.45	32	15.2	39.45
M-10	1	77.4	6.9	47.2	18.5	54.1
M-11	1	55.25	4.75	30	10.5	34.75
M-12	1	52.1	6.35	29.4	11.4	35.75
M-13	1	51.9	6.15	31.1	11.1	37.25
M-14	1	38.1	6.65	32	14.2	38.65
M-15	1	50.55	6.35	31.1	11.4	37.45
M-16	1	41.15	5.35	31.1	12.1	36.45
M-17	1	40.6	6.4	33.3	15.1	39.7
M-18	0	51.25	6.65	35.5	15.2	42.15
M-19	1	30	4.2	37.2	7	41.4
M-20	0	52.4	6.15	29.4	17	35.55

Appendix B Sorted Data based on C/ ½ heart Typology and A/(A+B Top)

TOPS					
C		H		$	
Specimen	A/(A+B)	Specimen	A/(A+B)	Specimen	
J-11	0.2282	M-12	0.2408	D-10	0.3876
I-04	0.2318	J-12	0.2424		
A-07	0.2494	C-13	0.2576		
C-01	0.2626	M-07	0.2627		
A-08	0.2635	A-17	0.2656		
K-18	0.2641	K-19	0.2752		
F-06	0.2687	C-04	0.2844		
F-02	0.2692	I-11	0.2860		
J-17	0.2706	M-11	0.2861		
I-13	0.2741	C-02	0.2880		
C-19	0.2776	I-10	0.2887		
A-09	0.2879	A-20	0.2900		
C-08	0.2938	J-01	0.2901		
M-20	0.2977	J-16	0.2915		
C-07	0.3030	M-14	0.2919		
I-01	0.3088	C-18	0.2926		
D-15	0.3111	M-13	0.2962		
D-16	0.3133	C-16	0.2964		
B-09	0.3180	B-01	0.2976		
B-06	0.3231	E-19	0.2984		
A-10	0.3258	I-03	0.2988		
J-13	0.3260	K-16	0.2994		
I-02	0.3269	E-12	0.3006		
K-20	0.3292	J-19	0.3018		
M-18	0.3328	L-09	0.3021		
L-06	0.3341	M-17	0.3028		
J-03	0.3344	M-15	0.3031		
A-13	0.3349	K-14	0.3048		
A-14	0.3349	L-08	0.3050		
K-01	0.3353	I-05	0.3062		
E-11	0.3360	E-04	0.3068		
H-03	0.3360	L-11	0.3076		
I-15	0.3381	C-11	0.3078		
I-14	0.3402	M-16	0.3080		
D-03	0.3420	M-09	0.3093		
I-06	0.3422	M-08	0.3093		
I-18	0.3454	C-10	0.3097		
L-01	0.3468	L-16	0.3115		
J-06	0.3484	B-07	0.3115		
D-09	0.3488	B-13	0.3137		
A-02	0.3492	J-05	0.3145		
A-05	0.3495	L-14	0.3146		
E-18	0.3498	F-15	0.3153		
E-07	0.3506	M-04	0.3154		
L-02	0.3506	M-05	0.3156		
K-13	0.3512	F-09	0.3156		

J-07	0.3526	J-09	0.3189
K-03	0.3531	A-12	0.3191
I-20	0.3545	C-05	0.3197
A-01	0.3550	L-03	0.3203
A-03	0.3558	L-12	0.3204
F-03	0.3562	I-17	0.3208
M-02	0.3598	G-03	0.3241
B-16	0.3603	I-16	0.3243
I-07	0.3614	C-12	0.3253
E-06	0.3620	L-15	0.3257
I-19	0.3626	J-02	0.3265
E-09	0.3627	F-21	0.3267
M-06	0.3636	K-09	0.3282
I-12	0.3666	G-04	0.3284
D-18	0.3672	G-02	0.3284
K-11	0.3682	L-05	0.3285
H-05	0.3685	D-11	0.3286
A-04	0.3686	M-01	0.3287
F-11	0.3690	J-20	0.3288
A-06	0.3690	L-10	0.3288
B-02	0.3695	L-13	0.3289
H-01	0.3700	F-18	0.3292
D-14	0.3701	M-03	0.3296
F-17	0.3713	K-10	0.3297
F-01	0.3733	K-17	0.3301
L-07	0.3733	C-20	0.3314
H-04	0.3737	F-12	0.3314
E-01	0.3745	L-04	0.3315
B-10	0.3749	M-19	0.3315
H-06	0.3753	E-20	0.3335
B-03	0.3759	A-15	0.3354
K-02	0.3781	F-04	0.3357
H-02	0.3781	D-19	0.3361
B-19	0.3784	E-10	0.3374
E-03	0.3811	C-14	0.3376
K-04	0.3981	B-20	0.3377
F-20	0.4022	F-13	0.3380
D-01	0.4027	C-03	0.3386
E-15	0.4040	J-04	0.3392
E-14	0.4104	F-19	0.3400
D-12	0.4108	K-05	0.3407
D-04	0.4199	A-18	0.3414
D-06	0.4233	E-05	0.3433
D-02	0.4724	B-08	0.3445
		B-12	0.3445
		B-04	0.3450
		F-05	0.3450
		A-19	0.3457
		C-09	0.3465
		B-14	0.3469

A-11	0.3472
J-10	0.3472
D-05	0.3483
F-16	0.3495
B-17	0.3501
B-15	0.3508
K-08	0.3508
J-15	0.3528
K-15	0.3540
D-08	0.3547
C-15	0.3549
I-08	0.3557
B-11	0.3558
D-17	0.3563
F-08	0.3574
E-08	0.3595
G-01	0.3600
C-17	0.3601
J-08	0.3613
J-14	0.3615
F-14	0.3621
A-21	0.3623
B-18	0.3625
K-12	0.3632
I-09	0.3640
K-06	0.3642
C-06	0.3664
D-07	0.3714
J-18	0.3726
E-02	0.3751
D-20	0.3771
A-16	0.3775
E-16	0.3776
K-07	0.3783
E-13	0.3802
F-10	0.3806
E-17	0.3845
M-10	0.3987
B-05	0.4035
F-07	0.4281
D-13	0.4347

Appendix C: Sorted Data based on C/ ½ heart Typology and A/(A+B Bottom)

Bottoms

C		H		$	
Specimen	A/(A+B)	Specimen	A/(A+B)	Specimen	
A-10	0.2670	M-05	0.2994	D-10	0.3976
M-20	0.3112	M-14	0.3081		
I-12	0.3138	L-08	0.3136		
J-13	0.3157	M-09	0.3157		
A-07	0.3178	C-14	0.3169		
H-03	0.3238	M-17	0.3179		
J-03	0.3242	E-16	0.3204		
B-06	0.3292	I-03	0.3247		
K-01	0.3293	M-08	0.3249		
J-11	0.3304	I-10	0.3251		
F-02	0.3367	I-11	0.3273		
I-01	0.3372	J-12	0.3278		
H-06	0.3373	B-01	0.3289		
M-18	0.3392	A-20	0.3318		
I-13	0.3394	B-13	0.3321		
F-06	0.3410	L-11	0.3325		
H-01	0.3428	C-18	0.3330		
L-06	0.3442	C-11	0.3336		
J-06	0.3453	M-11	0.3359		
J-17	0.3453	M-03	0.3362		
H-05	0.3454	C-10	0.3364		
E-18	0.3484	M-16	0.3421		
A-02	0.3484	M-12	0.3433		
E-14	0.3502	E-19	0.3470		
D-06	0.3509	M-13	0.3503		
H-04	0.3522	B-20	0.3524		
K-11	0.3536	L-12	0.3529		
K-03	0.3555	K-10	0.3542		
D-14	0.3556	M-07	0.3546		
K-02	0.3557	L-13	0.3551		
H-02	0.3557	M-15	0.3562		
E-03	0.3558	L-15	0.3581		
D-04	0.3564	C-12	0.3584		
E-11	0.3565	E-04	0.3585		
A-04	0.3576	L-14	0.3588		
E-06	0.3583	C-05	0.3594		
B-19	0.3602	L-16	0.3595		
F-17	0.3625	F-16	0.3598		
M-06	0.3625	F-12	0.3634		
E-07	0.3632	J-19	0.3638		
I-19	0.3644	K-19	0.3638		
L-07	0.3647	G-04	0.3646		
E-15	0.3651	B-17	0.3657		
A-01	0.3653	F-21	0.3663		
I-18	0.3656	K-08	0.3685		
E-09	0.3660	K-14	0.3693		

M-02	0.3664	J-18	0.3699
L-02	0.3669	D-13	0.3704
I-06	0.3674	K-06	0.3746
J-07	0.3678	K-09	0.3752
K-13	0.3684	C-03	0.3774
L-01	0.3690	C-13	0.3792
A-14	0.3691	B-18	0.3812
C-19	0.3692	D-08	0.3831
A-03	0.3701	L-03	0.3847
A-13	0.3705	C-17	0.3852
A-05	0.3711	J-16	0.3855
I-14	0.3715	B-07	0.3858
D-01	0.3716	L-04	0.3873
A-06	0.3723	F-15	0.3883
D-09	0.3725	C-04	0.3890
I-02	0.3727	K-05	0.3945
B-02	0.3730	L-05	0.3951
E-01	0.3742	J-15	0.3952
I-07	0.3747	J-14	0.3996
I-15	0.3752	I-17	0.4012
K-04	0.3759	L-10	0.4013
A-08	0.3762	J-02	0.4019
D-12	0.3772	E-12	0.4019
D-02	0.3780	E-10	0.4021
B-10	0.3798	D-07	0.4022
B-03	0.3798	C-09	0.4027
D-15	0.3821	J-04	0.4034
C-08	0.3846	E-17	0.4043
A-09	0.3853	D-17	0.4047
I-20	0.3858	K-17	0.4057
K-18	0.3866	A-11	0.4078
B-09	0.3911	F-09	0.4080
D-03	0.3995	A-18	0.4092
C-07	0.4002	F-19	0.4093
B-16	0.4099	F-18	0.4098
C-01	0.4121	K-16	0.4125
F-20	0.4127	D-20	0.4153
D-16	0.4139	J-01	0.4154
K-20	0.4152	A-19	0.4161
F-03	0.4421	B-14	0.4163
D-18	0.4435	C-20	0.4176
I-04	0.4464	M-01	0.4177
F-11	0.5096	J-05	0.4181
F-01	0.5352	J-20	0.4196
		C-06	0.4198
		B-04	0.4208
		B-11	0.4213
		K-07	0.4218
		I-08	0.4237
		L-09	0.4273

F-04	0.4278
F-10	0.4303
C-15	0.4303
C-16	0.4304
G-03	0.4306
M-04	0.4317
G-01	0.4322
J-09	0.4324
B-12	0.4355
E-08	0.4360
I-16	0.4361
A-16	0.4368
G-02	0.4369
A-17	0.4379
E-02	0.4389
B-15	0.4402
E-13	0.4425
C-02	0.4440
F-05	0.4441
M-19	0.4442
A-15	0.4473
J-10	0.4487
E-05	0.4493
F-13	0.4499
D-05	0.4507
F-14	0.4508
B-08	0.4511
F-08	0.4525
A-12	0.4533
D-19	0.4535
B-05	0.4554
J-08	0.4585
E-20	0.4635
A-21	0.4682
I-05	0.4712
M-10	0.4750
K-12	0.4895
K-15	0.4910
D-11	0.5077
F-07	0.5126
I-09	0.5281

Appendix D: Handle Types, Handle Sum, "Total Mug" measurements for top and bottom (Data useful for scatter plots)

Specemin	C+0,H=1	Handle	A+B Top	A+B Bot
A-01	0	46.4	130.7	127.03
A-02	0	44.3	126.85	127.17
A-03	0	46.95	131.95	126.87
A-04	0	46.35	125.75	129.61
A-05	0	47.55	136.05	128.13
A-06	0	47.55	128.85	127.73
A-07	0	27.35	109.65	86.07
A-08	0	24.9	94.5	66.18
A-09	0	32.55	113.06	84.47
A-10	0	40.1	123.1	150.16
A-11	1	43.6	125.59	106.91
A-12	1	39.55	123.95	87.24
A-13	0	43.6	130.2	117.69
A-14	0	43.15	128.85	116.92
A-15	1	49.7	148.18	111.1
A-16	1	50.05	132.6	114.59
A-17	1	41.55	156.45	94.89
A-18	1	43.7	128	106.8
A-19	1	43.4	125.54	104.31
A-20	1	35.25	121.55	106.25
A-21	1	46.75	129.05	99.85
B-01	1	34.7	116.6	105.5
B-02	0	48.25	130.57	129.35
B-03	0	49	130.35	129
B-04	1	48.25	139.85	114.65
B-05	1	54.6	135.3	119.9
B-06	0	38.95	120.55	118.3
B-07	1	37.15	119.25	96.3
B-08	1	46.4	134.7	102.85
B-09	0	40.65	127.85	103.95
B-10	0	49	130.7	129
B-11	1	42.3	118.9	100.4
B-12	1	43.2	125.4	99.2
B-13	1	35.4	112.84	106.6
B-14	1	42.15	121.5	101.25
B-15	1	43.25	123.28	98.25
B-16	0	43	119.35	104.9
B-17	1	39.6	113.1	108.3
B-18	1	45	124.14	118.05
B-19	0	46.45	122.75	128.95
B-20	1	41.35	122.45	117.35
C-01	0	39.25	149.46	95.25
C-02	1	36.45	126.55	82.1
C-03	1	45.1	133.2	119.5
C-04	1	33.1	116.4	85.1
C-05	1	39.95	124.95	111.15
C-06	1	46.6	127.2	111

C-07		0	39.6	130.7	98.94
C-08		0	35	119.14	91
C-09		1	42.95	123.95	106.65
C-10		1	36.2	116.9	107.6
C-11		1	35.6	115.65	106.7
C-12		1	39.1	120.2	109.1
C-13		1	28.1	109.1	74.1
C-14		1	36.7	108.7	115.8
C-15		1	46	129.6	106.9
C-16		1	33.4	112.7	77.6
C-17		1	44.9	124.7	116.55
C-18		1	33.6	114.85	100.9
C-19		0	33.95	122.3	91.95
C-20		1	42.3	127.65	101.3
D-01		0	47.6	118.2	128.1
D-02		0	48	101.6	127
D-03		0	44.3	129.55	110.9
D-04		0	45.1	107.4	126.55
D-05		1	46.6	133.8	103.4
D-06		0	43.6	102.99	124.25
D-07		1	45.85	123.45	113.99
D-08		1	38	107.14	99.2
D-09		0	47.2	135.32	126.7
D-10	$		52.15	134.54	131.15
D-11		1	39.7	120.8	78.19
D-12		0	48.75	118.67	129.25
D-13		1	41.1	94.55	110.95
D-14		0	43.6	117.8	122.6
D-15		0	37.4	120.2	97.88
D-16		0	41.6	132.8	100.5
D-17		1	41.6	116.76	102.8
D-18		0	41.7	113.56	94.02
D-19		1	44.15	131.35	97.35
D-20		1	43.05	114.15	103.65
E-01		0	49.1	131.1	131.2
E-02		1	48.65	129.7	110.85
E-03		0	44.95	117.95	126.35
E-04		1	38.95	126.95	108.65
E-05		1	48.8	142.15	108.62
E-06		0	44.55	123.05	124.35
E-07		0	46.65	133.05	128.45
E-08		1	47.55	132.25	109.05
E-09		0	45.9	126.55	125.4
E-10		1	44.35	131.43	110.3
E-11		0	44.15	131.4	123.85
E-12		1	44.35	147.55	110.35
E-13		1	50	131.5	113
E-14		0	42.8	104.3	122.2
E-15		0	46.3	114.6	126.8
E-16		1	36.4	96.4	113.6

E-17	1	45.6	118.6	112.8
E-18	0	43.3	123.8	124.3
E-19	1	36.15	121.15	104.19
E-20	1	54.1	162.2	116.72
F-01	0	69.1	185.1	129.1
F-02	0	30.15	112	89.55
F-03	0	47.95	134.61	108.45
F-04	1	39.85	118.7	93.15
F-05	1	48.25	139.85	108.65
F-06	0	29.65	110.35	86.95
F-07	1	64.9	151.6	126.6
F-08	1	47.6	133.2	105.2
F-09	1	41	129.9	100.5
F-10	1	46.45	122.05	107.95
F-11	0	67.35	182.51	132.15
F-12	1	39.85	120.25	109.65
F-13	1	46.2	136.7	102.7
F-14	1	47.2	130.35	104.7
F-15	1	44.3	140.5	114.1
F-16	1	45.25	129.46	125.75
F-17	0	45.6	122.8	125.8
F-18	1	40	121.5	97.6
F-19	1	40.75	119.85	99.55
F-20	0	54.8	136.25	132.8
F-21	1	39.3	120.3	107.3
G-01	1	40.95	113.75	94.75
G-02	1	39.65	120.75	90.75
G-03	1	40.5	124.98	94.05
G-04	1	39.65	120.75	108.75
H-01	0	42.85	115.8	125
H-02	0	45.3	119.8	127.35
H-03	0	37.35	111.15	115.35
H-04	0	43.2	115.6	122.65
H-05	0	42.3	114.8	122.45
H-06	0	41.4	110.3	122.75
I-01	0	40.7	131.8	120.7
I-02	0	47.7	145.9	128
I-03	1	34	113.8	104.7
I-04	0	28.75	124.03	64.4
I-05	1	47	153.5	99.75
I-06	0	46.4	135.6	126.3
I-07	0	48	132.8	128.1
I-08	1	44.4	124.84	104.8
I-09	1	65.8	180.78	124.6
I-10	1	33.75	116.9	103.8
I-11	1	34.45	120.45	105.25
I-12	0	47.05	128.35	149.95
I-13	0	41	149.6	120.8
I-14	0	49.2	144.6	132.45
I-15	0	48.4	143.15	129

I-16	1	44	135.69	100.9
I-17	1	36.05	112.37	89.85
I-18	0	45.7	132.3	125
I-19	0	46.1	127.12	126.5
I-20	0	45.25	127.65	117.3
J-01	1	44.55	153.55	107.25
J-02	1	42.4	129.85	105.5
J-03	0	37.9	113.35	116.9
J-04	1	44.5	131.2	110.3
J-05	1	41.75	132.75	99.85
J-06	0	43.2	124	125.1
J-07	0	46.6	132.15	126.7
J-08	1	46.4	128.44	101.2
J-09	1	38.25	119.95	88.45
J-10	1	36.7	105.7	81.8
J-11	0	26.35	115.45	79.75
J-12	1	28.15	116.14	85.87
J-13	0	37.15	113.95	117.67
J-14	1	44.45	122.95	111.25
J-15	1	41.75	118.35	105.63
J-16	1	33.95	116.45	88.07
J-17	0	36.05	133.23	104.39
J-18	1	50	134.2	135.18
J-19	1	37.7	124.9	103.64
J-20	1	38.7	117.7	92.22
K-01	0	40.5	120.8	123
K-02	0	45.05	119.15	126.65
K-03	0	44.45	125.89	125.05
K-04	0	49.2	123.6	130.9
K-05	1	35.45	104.05	89.85
K-06	1	45.95	126.15	122.65
K-07	1	46.25	122.25	109.65
K-08	1	44.5	126.84	120.75
K-09	1	41.2	125.53	109.8
K-10	1	39.4	119.5	111.25
K-11	0	44.3	120.3	125.3
K-12	1	46.4	127.74	94.8
K-13	0	47.25	134.55	128.25
K-14	1	44.5	146	120.5
K-15	1	45.05	127.25	91.75
K-16	1	40.3	134.6	97.7
K-17	1	44.3	134.2	109.2
K-18	0	22	83.3	56.9
K-19	1	29.85	108.45	82.05
K-20	0	40.25	122.25	96.95
L-01	0	47.3	136.4	128.2
L-02	0	45.6	130.05	124.3
L-03	1	38.2	119.25	99.3
L-04	1	39.25	118.4	101.35
L-05	1	40.75	124.05	103.15

L-06	0	43.15	129.15	125.35
L-07	0	46.5	124.56	127.5
L-08	1	38.65	126.73	123.25
L-09	1	38.95	128.95	91.15
L-10	1	38.75	117.85	96.55
L-11	1	41.75	135.75	125.55
L-12	1	37.3	116.4	105.7
L-13	1	37.5	114	105.6
L-14	1	40.8	129.69	113.7
L-15	1	40	122.8	111.7
L-16	1	40.8	130.99	113.5
M-01	1	40.1	122	96
M-02	0	46.2	128.4	126.1
M-03	1	38.45	116.65	114.35
M-04	1	39.8	126.2	92.2
M-05	1	37.35	118.35	124.75
M-06	0	47.2	129.82	130.2
M-07	1	37.3	142	105.2
M-08	1	39.9	129	122.8
M-09	1	39.45	127.55	124.95
M-10	1	54.1	135.69	113.9
M-11	1	34.75	121.45	103.45
M-12	1	35.75	148.45	104.15
M-13	1	37.25	125.75	106.35
M-14	1	38.65	132.4	125.45
M-15	1	37.45	123.55	105.15
M-16	1	36.45	118.35	106.55
M-17	1	39.7	131.1	124.9
M-18	0	42.15	126.65	124.25
M-19	1	41.4	124.88	93.2
M-20	0	35.55	119.43	114.25