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How packaging characteristics change the perception of product net weight

by

Zhonglun Wang

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Industrial Engineering

Program of Study Committee:
Richard T. Stone, Major Professor
Stephen B. Vardeman
Frank Peters

Iowa State University

Ames, Iowa

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ABSTRACT

The research is aiming at finding how packaging characteristics affect the perceived product net weight. Packaging is the interface that connect customers and products, and perceived weight is one of the defining factors at the point of purchasing. Perceived weight also influences consumption rate of the product, which may bring opportunity to food manufacturers to make their product more appealing to the target customers, it might also help to increase sales revenue, reduce food waste and combat climate change.

Three hypotheses were tested, (1) whether people perceive rigid packaging to contain more product than non-rigid packaging; (2) whether people perceive multi-pack packaging to contain more product than single-pack packaging; and (3) whether people with lower overall muscle strength tend to estimate products heavier.

Five types of tomato sauce packaging and five types of milk packaging were selected in the study, 39 people participated in the study, in addition, data from 3 participants were dropped due to data loss and equipment failure.

The result showed that the net weight of multi-pack packaging milk is perceived to be heavier than single-pack packaging milk, however, there is no perceived weight difference in the case of tomato sauce. The result also showed that the net weight of rigid packaging tomato sauce is perceived to be heavier than non-rigid packaging tomato sauce, while there is no perceived weight difference in the case of milk. And people with less muscle strength didn't perceived product weight to be heavier than people with more muscle strength.

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Mixed effect was also investigated and consisted result was shown, as milk and tomato sauce with non-rigid multi-packs (NM) were perceived to have similar net weight with rigid single-packs (RS), while non-rigid single-packs(NS) were perceived to contain less product than non-rigid multi-packs (NM) and rigid single-packs (NM=RS>NS).

The study provides a general direction for researchers and food manufactures to investigate deeper into the question that how packaging characteristics influence people's weight perception. The application of the studies could potentially be lucrative for food manufacturers, retailers in the meantime reduce food waste.

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CHAPTER 1: INTRODUCTION

Modern marketing strategy for grocery products is a well calculated science. In the past, all the grocery products were marketed to women from age 18 to 49. With the cultural and technology changes, product marketing is aiming to more and more specific population by age, diet option, annual income, and other factors. (Kesler, 1986). When people choose products at the supermarket, the first interface they experience is the package. Customers decide what to buy, and how to checkout.

Packaging is not only a space to print brand and product information. Research shows that on average, people spend 12 seconds when choosing the item in each category. 42% of shoppers spend less than 5 seconds when choosing the item and 42.1% of people did not recall the price after they placed the product in their shopping cart (Dickson & Sawyer, 1990). What is the key factor influencing customers' item selection in a short period of time?

Companies believe the key is the package; they use packaging to build the image of the brand and attract people to buy the product (Kesler, 1986). Marketers design their package to stand out from the competition. Coca-Cola changed the shape of the bottle design to potentially increase the market growth by 25 to 660 percent (Prince, 1994), Hanes designed an egg-shaped package for their pantyhose. This convenient design stands out from the competition and attracts consumers (Bloch, 1995).

Researches show that packaging characteristics can influence customer response, such as the shape of the package (Folkes & Matta, 2004; Garber, Hyatt, & Boya, 2009; Raghubir & Greenleaf, 2006; Yang & Raghubir, 2005), weight distribution of the package (Deng & Kahn,

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2009), the graphic display on the package (Garber, Hyatt, & Boya, 2008; Hurley, Galvarino, Thackston, Ouzts, & Pham, 2013).

The other significant impact from packaging is the consumption of the product. When people choose a product in the supermarket, they perceive the amount of product inside the package. This perception of product quantity influences their perceived consumption, which lead to a change in their real consumption rate of their purchase (Raghubir & Krishna, 1999). For example, people pour less toilet cleaner out of the bottle when they were given bottle contain 500 milliliter of toilet cleaner compare with people receive bottle contain 1000 milliliter of toilet cleaner (Folkes, Martin, & Gupta, 1993). Wansink (1996) made a more specific study of consumption and packaging. They found out people tend to use more when the package of the product they use is larger, and they also concluded people consume more when the unit price is low when they indirectly and directly manipulated the unit price of the products the participants were using. Moreover, they believe part of the reason people consume more with larger packaging is because participants perceived the cost of usage is cheaper.

People estimate the weight in the mind and decide how much product they plan to buy, which makes perceived weight an important factor in the packaging design. There are a lot of factors that may influence the perceived weight. These phenomena have been studied by the scientific community since the early 1890s, such as the size-weight illusion (SWI) that people perceived weight differently when the researcher changed the size while controlling shape and the mass (Charpentier, 1891). A most recent study shows that as human brains learn from daily statistical input, people assume smaller objects are denser (Peters, Balzer, & Shams, 2015). Material-weight illusion (MWI) also has been studied by a lot of researchers. It was first introduced by Seashore (1899), and his research shows that people assume weight differently

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when comparing material. Under the same weight, wood material is being assumed heavier than metal material (Wolfe, 1898). Harshfield and DeHardt (1970) supported Wolfe's idea and did experiments on more materials. When controlling the weight and size, polystyrene surface block was perceived heavier than wood surface block, and metal finish block had been assumed to have the lightest weight (Buckingham, Cant, & Goodale, 2009; Buckingham, Ranger, & Goodale, 2011). Research also show that the MWI is guaranteed to happen in the light weight object (58.5g) and less likely to happen on the heavy weight object (357 g) (Ellis & Lederman, 1999).

Self-checkout technology has been introduced to the public in recent years. Bi-optic and handheld scanners are the two type of scanning technology that is popular in most of the supermarkets in United States. Self-checkout became part of modern shopping experience. Despite the flaws of the system, retailers are pushing self-checkout technology all over the world, and they estimate they will install more than 300,000 unit of self-checkout station by 2019 worldwide (NCR, 2014).

When we consider the shopping procedure, we can clearly see the close relationship between package and checkout technology. It is possible both factors can affect the decision of the customers. However, most of the researchers are only focusing on the theory of how to implement the technology successfully (Bitner, Ostrom, & Meuter, 2002), customer preference and experience with the self-service system (Meyer & Schwager, 2007; Opara-Nadi, 2005), potential benefit of the self-serve checkout system (Smith, 2005). So far, only some of the research studies people's decisions on checkout method and the packaging characters.

In our study, we have considered the factors that may influence people's perception of weight. We categorized the grocery products we selected into two types of packaging, (1) rigid

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and non-rigid packaging (2) single-pack and multi-pack packaging. Despite the packaging of the products, it is believed that the perceived weight could be determined by the customers' physical condition. We considered the correlation between people's muscle strength and their perceived weight of packages.

Goals for our study were to validate (1) if people perceive rigid packaging to contain more product than non-rigid packaging; (2) if people perceive multi-pack packaging to contain more product than single-pack packaging; and (3) if people with lower overall muscle strength tend to estimate products heavier.

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CHAPTER 2: METHODS

2.1 Participants

We recruited 39 volunteers to participate in the study. There were 24 males and 15 females with an average age of 21.282 years old (SD= 3.734). The mean height of the participants was 1.773 meter (SD= 0.128). The data from four participants was excluded due to data loss during transfer and equipment failure.

2.2 Equipment

A five-level steel shelf was used in the experiment. It was 1.8288 meters high and 1.2192 meters wide, with a 0.4318 meters difference between each level (Figure 1).

Five 1.89 liter (1/2 gal) packages of milk and five 0.68 kg (24 oz) packages of tomato sauce were selected. We covered up all the labels on the packages with white paper and relabeled them using the word “Milk” or “Tomato Sauce” to avoid people select items due to graphic design (Garber, Hyatt, & Boya, 2008; Hurley, Galvarino, Thackston, Ouzts, & Pham, 2013). Each item had a different type of packaging: rigid/non-rigid and single-pack/multi-pack. The details of each package are listed in (Figure 2) (Table 1).

A standard-size shopping cart was used in the experiment for the participants to place the selected items in. (Figure 3)

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A hand dynamometer was used to estimate the overall muscle strength of the participants. Hand dynamometers have been proven as effective tools to estimate the overall muscle strength among young adults (Wind, Takken, Helders, Engelbert, 2010) (Figure 4).

2.3 Procedures

We contacted the participants to schedule the experiment. To prepare for the experiment, we randomly placed items in different shelf locations for each participant. Once the participants arrived, we measured their grip force with a hand dynamometer on both hands. Then we introduced the products the participants could pick from and asked them to pick one milk package and one tomato sauce package from the shelf and place them in the shopping cart.

As soon as the participants placed the items in the shopping cart, we asked them to estimate the net weight and overall weight of the selected items, the reason for item selection, and what self-checkout technology they would like to use. Then we asked the participants to take all the items off the shelf and guess the net weight and overall weight of each item.

After all the weight estimation, the participants were asked to fill in a questionnaire. We then debriefed the participants about the study and ended the experiment.

2.4 Data Analysis

The statistical software JMP Pro 13 were used to analysis the data. When analyzing the difference between categories, perceived weight of each product from each participant were collected, the researchers put these data into different categories: Rigid/Non-rigid, Single-

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pack/Multi-pack, Rigid Single-pack/Non-rigid Single-pack/Non-rigid Multi-pack, then the researchers calculate the mean of each categories and compare the perceived weight with the actual weight of the product and record the difference between two sets of data. Then calculate the mean of each categories, compare the difference between categories, and use t-test or paired t-test to valid the data. The researchers use linear regression function to find the correlation between grip force and perceived weight.

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CHAPTER 3: RESULT

3.1 Rigid vs. Non-rigid

When comparing the mean perceived net weight of rigid and non-rigid tomato sauce packaging, we observed a mean difference of -0.0281 kg. The difference was not statistically significant. (Figure 5)

The difference between the mean perceived net weight of rigid and non-rigid milk packaging was 0.2231 kg. The difference was statistically significant (p=0.0375). (Figure 6)

3.2 Single-pack vs. Multi-pack

When comparing the mean perceived net weight of single-pack and multi-pack tomato sauce packaging, we observed a mean difference of -0.1132 kg. The difference was statistically significant (p=0.0256). (Figure 7)

The difference between the mean perceived net weight of single-pack and multi-pack milk packaging was -0.1223 kg. The difference was not statistically significant. (Figure 8)

3.3 Grip Force Effect

When trying to run the linear regression on the perceived overall product weight and grip force, two significant interceptions where shown but the slopes of the regression were not statistically significant. (Figure 10)

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3.4 Mixed Effect of Packaging Characteristic

When analyzing the data, we found some unexpected result concerning rigid/non-rigid or single/multi packaging characteristics, which led us to consider the mixed effect of these factors. We conducted paired t-test between all three types of the packing characteristics involved in the study: rigid – single-pack (RS), non-rigid – single-pack (NS), non-rigid – multi-pack (NM). We found that there were significant differences between these types of packaging, concerning both tomato sauce and milk. From the result of the paired t-test, we concluded that non-rigid multi-pack packaging was perceived to a have the same net weight as rigid single-pack packaging, and both of them were perceived to have a lower net weight than non-rigid single-pack packaging. (NM=RS>NS) (Figure 10, 11)

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CHAPTER 4: DISCUSSION

In our study, we examined the following hypotheses: (1) people perceive rigid packaging to contain more product than non-rigid packaging; (2) people perceive multi-pack packaging to contain more product than single-pack packaging; and (3) people with lower overall muscle strength tend to estimate products heavier. The first and the second hypothesis have been partially supported and the third hypothesis were being rejected, all the hypotheses are discussed below.

4.1 Hypothesis 1: People Perceive Rigid Packaging to Contain More Product than Non-Rigid Packaging Product.

Our results confirmed this hypothesis in the case of milk packaging. When comparing the perceived net weight difference between rigid and non-rigid packaging in our selected product, we observed that people perceived rigid milk containers to enclose more milk than non-rigid milk containers. This means rigid packaging milk may attract people who prefer to get a better value out of their purchase.

However, the hypothesis was rejected in the case of tomato sauce. People perceived rigid packaging does not contain more than non-rigid packaging. We associate this perception to the light weight of tomato sauce packaging (0.68 kg). This finding did not confirm to that of Ellis and Lederman (1999) who found that material weight illusion is guaranteed to happen on light weight objects and not likely to happen on heavy weight objects.

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4.2 Hypothesis 2: People Perceive Multi-Pack Packaging to Contain More Product than Single-Pack Packaging.

Our results supported this hypothesis in the case of tomato sauce packaging. When comparing the perceived net weight difference between single-pack and multi-pack packaging in our selected product, we observed that people perceived multi-pack packaged tomato sauce contain more than single-pack packaged tomato sauce. People with who prefer to purchase less tomato sauce may find single-pack package more desirable.

However, the hypothesis was not supported in the case of milk. People perceived net weight difference between multi-pack packaging and single-pack packaging.

4.3 Hypothesis 3: People with Less Muscle Strength Tend to Estimate Products to Be Heavier.

To validate this hypothesis, we plotted the perceived average overall weight and average grip force. People with less muscle strength did not tend to estimate products to be heavier, showing people's perception of the weight of products was not associated with their muscle strength.

4.4 Combination of Hypothesis 1 And Hypothesis 2:

When looking more deeply into the possible mixed effect of packaging characteristics, in the case of both tomato sauce and milk, non-rigid multi-pack packaging was perceived to contain

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similar net weight to rigid single-pack packaging. Both packaging characteristics were perceived to contain more than non-rigid single-pack packaging (NM=RS>NS).

Different packaging materials could be the cause of this result, since the net weight of our products was controlled. When people perceived the overall weight of the product to be higher, they also perceived the net weight of the product to be higher ($p<0.05$) (Figure 12).

4.5 Other Findings:

Additional results were found from the experiment. We observed that certain shelf locations and products were more popular than others. This could be associated with the short time span for product selection and the lack of brand and price information. Therefore people only picked the product based on packaging characteristic and convenience of the shelf location.

In addition, we found that some items were repeatedly chosen during the experiment. They were item 2 (glass jar) in tomato sauce and 7 (plastic jug) in milk. It can be argued that they are the most common packaging design for tomato sauce and milk in North America. We believe that the popularity was the result of shopping habits. This is in line with findings from previous studies about people's tendency to repeatedly purchase the same product (Bettman & Zins, 1977; Deighton, Henderson, & Neslin, 1994; Motes & Woodside, 2001; Taylor, 2001).

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CHAPTER 5: CONCLUSION

At this point we need to address the importance of our results. We can summarize it into three points: (1) Make the product more attractive to target audience, (2) Increase sales revenue, and (3) Decrease food waste and combat climate change.

5.1 Make the Product More Attractive to Target Audiences

Our research was concentrating on how packaging characteristics change people's perception of the product net weight.

Consumption rate of the product can be influenced by packaging characteristics (Raghubir & Krishna, 1999; Folkes, Martin, & Gupta, 1993; Wansink, 1996).

People have different lifestyles, which lead to differences in their perceptions of the products. Some people try to have a healthy lifestyle, they may prefer certain products that are perceived lighter (Deng & Kahn, 2009). Some people prefer to purchase products that are perceived heavier.

By implementing our results, we can change people's weight perception by manipulating packaging characteristics to make the product more desirable to intended customers.

5.2 Increase Sales Revenue

Due to the fluctuation of the market price for raw material and the emergence of competitors, manufacturers need to look into more options to increase profit, such as downsizing the product weight and packaging, increase sales revenue and increase purchasing frequency.

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5.2.1 Downsizing product

One way to increase the profit is to perform product downsizing, ie. to reduce the size of the product (Adams,Di Benedetto,& Chandran,1991). Downsizing can be performed on product weight or packaging, our result provides a general direction for the manufacturers to perform downsizing by manipulating packaging characteristics without potentially impact the sales revenue.

5.2.2 Make people believe product has superior value

Another way to boost profit is to make people believe product has superior value, it is known that certain types of people prefer to purchase high price–performance ratio products, under the same price, customers would choose the product they perceived heavier as they believe that such products have greater value (Raghubir & Krishna, 1999). If manufacturers follow the general direction of our result and keep their packaging to be perceived heavier when maintaining the price, it could potentially make their products standing out from their competitors.

5.2.3 Increase purchasing frequency

Increase purchasing frequency would also increase profit, study showed that when people perceive that they purchase large quantity of product, they tend to consume more (Raghubir & Krishna, 1999; Folkes, Martin, & Gupta, 1993; Wansink, 1996). The consumption rate could be raised by increasing the perceived weight of the product, which would increase the purchasing frequency that leads to increased sale revenue.

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5.3 Decrease Food Waste and Combat Climate Change

In United States and Europe, 15% to 30% of the food is being wasted after purchasing (Kantor and Lipton, 1997; Engström and Carlsson-Kanyama, 2004; Ventour, 2008; Quested and Johnson, 2009). Food manufacturing is a high energy-consuming process. Water, labor force, machine and energy are all needed for the growing, processing, maintaining, and distributing of food. 15% to 30% of the food purchased gets wasted, which means that 15% to 30% of the energy mentioned above gets wasted, and the decomposed food will be emitting methane and carbon dioxide into the atmosphere. Food waste could be one of the largest greenhouse gas emission resources we overlooked. In Williams, Wikström, Otterbring, Löfgren & Gustafsson (2012) study they found that food packaging makes up 20% to 25% of the reason that household food was wasted and in their conclusion, the number one reason of food waste resulted from packaging is "Difficult to Empty". If we increase the perceived product net weight which would in turn increase the food consumption and decrease the actual net weight of the product, we can potentially solve the "Difficult to Empty" issue, increase food usage efficiency, decrease food waste and greenhouse emission.

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CHAPTER 6: FUTURE WORK

6.1 Discover More Packaging Materials

Although we looked into people's perception of packaging characteristics, we only focused on two features, whether the material is rigid or non-rigid and if the package is single-pack or multi-pack.

We looked into four broad categories mentioned above in a large variety of packaging styles. For packaging materials, we can investigate a narrower category of materials such as plastic, metal, glass, cardboard etc. We can also explore different types of single-pack or multi-pack packaging, such as packaging transparency.

6.2 Find the Optimal Shelf Location to Increase Product Flow

Another aspect we can look into is the shelf location, although there are some researches that have already looked into finding the optimal shelf location for each product to increase sales (Curhan, 1972; Borin , Farris & Freeland, 1994; Murray, Talukdar & Gosavi, 2010), none of them included packaging characteristics nor customer feature into their calculation.

In the perspective of retailers, it would be ideal for them to find the optimal shelf location for each product, it would increase inventory turnover rate. As an alternative perspective, once the retailers find out the optimal shelf location for certain types of product, they can make the manufacturers to bid on slotting fee among competitors in the same category.

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More topics can be explored following our experiment, and our research provided a start for the much-needed future experiment in packaging design. Those future designs could not only be lucrative to the cooperation, but could also potentially decrease food waste and level of greenhouse gas emission.

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APPENDIX A: LIST OF FIGURES

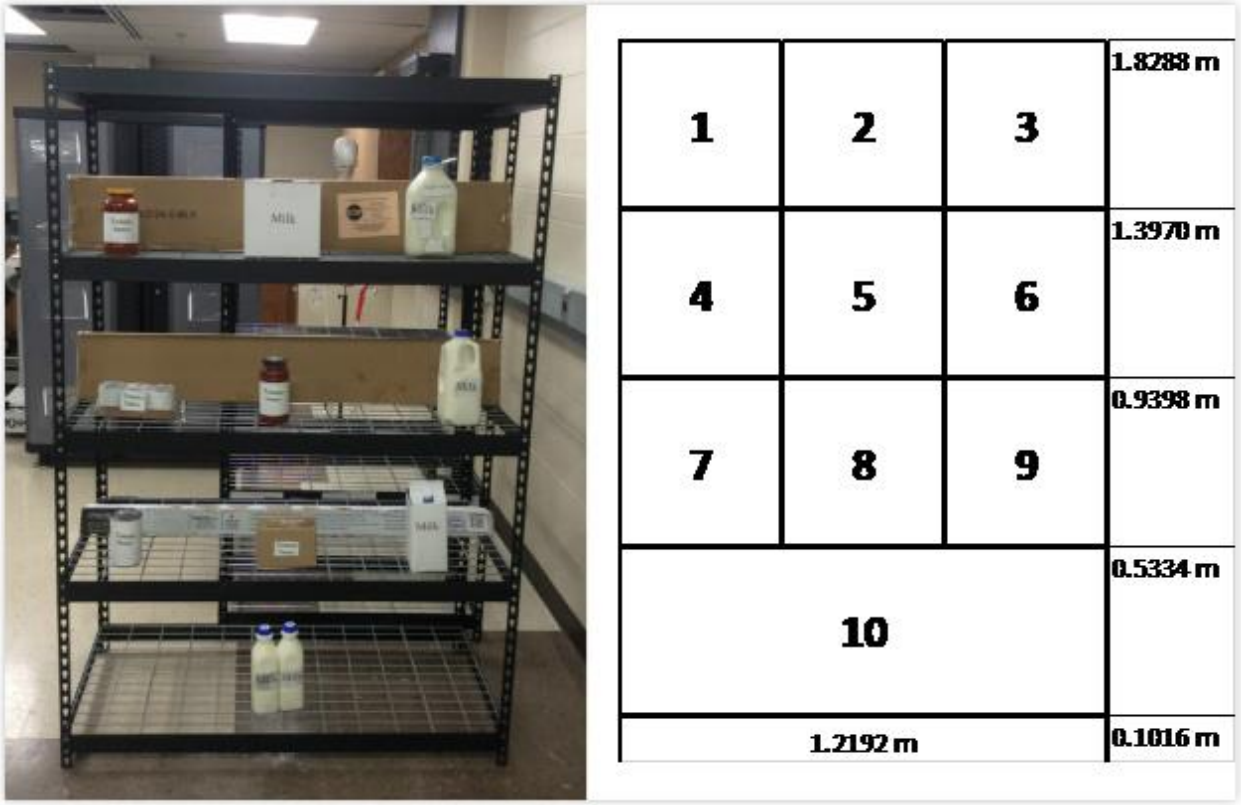

Figure 1: Picture and Diagram of the Shelf

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Item No.	Picture	Packaging Characteristics	Net Weight	Overall Weight	Length	Width	Height
Item 1		Non-rigid, Single-pack	0.680 kg	0.75 kg	0.08 m	0.08 m	0.165 m
Item 2		Rigid, Single-pack	0.680 kg	1.05 kg	0.09 m	0.09 m	0.165 m
Item 3		Rigid, Single-pack	0.680 kg	0.75 kg	0.085 m	0.085m	0.135 m

Figure 2: Detail of the Items

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Item 4		Non-rigid, Multi-pack	0.680 kg	0.85 kg	0.21m	0.07 m	0.08 m
Item 5		Non-rigid, Multi-pack	0.680 kg	0.9 kg	0.16 m	0.11 m	0.11 m
Item 6		Non-rigid, Multi-pack	1.952 kg	2.25 kg	0.19 m	0.12 m	0.19 m
Item 7		Non-rigid, Single-pack	1.952 kg	2 kg	0.105 m	0.105 m	0.25 m

Figure 2 Continued

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Item 8		Non-rigid, Multi-pack	1.952 kg	2.05 kg	0.075 m	0.15 m	0.25 m
Item 9		Rigid, Single-pack	1.952 kg	2.85 kg	0.12 m	0.095 m	0.255 m
Item 10		Non-rigid, Single-pack	1.952 kg	2.05 kg	0.095 m	0.095 m	0.24 m

Figure 2 continued

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Figure 3: Picture of Shopping Cart

Figure 4: Picture of Hand Dynamometer

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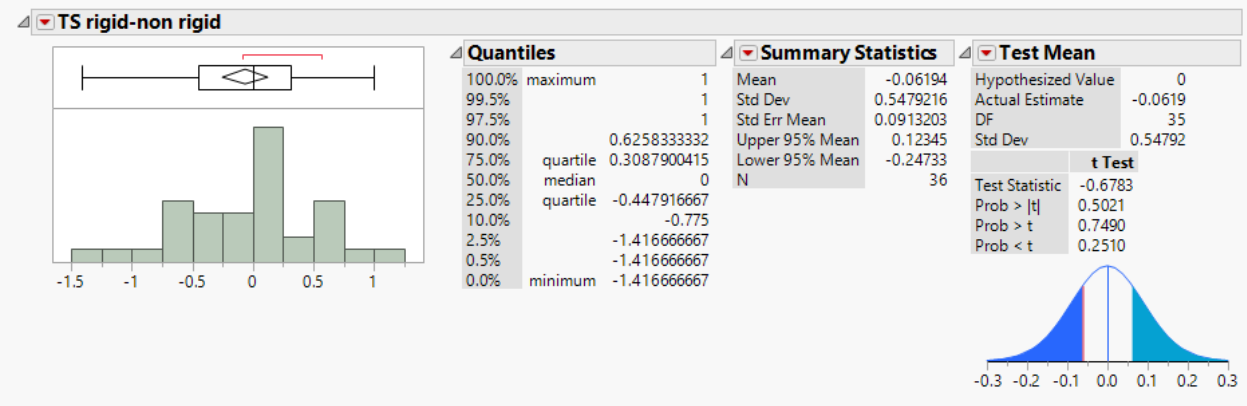

Figure 5: Result of Weight Difference in Rigid and Non-rigid Package Tomato Sauce

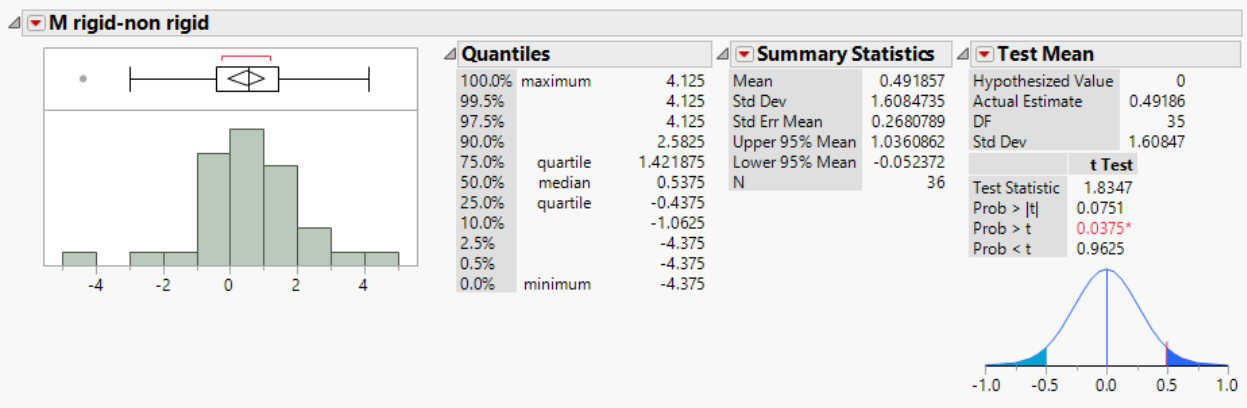

Figure 6: Result of Weight Difference in Rigid and Non-Rigid Package Milk

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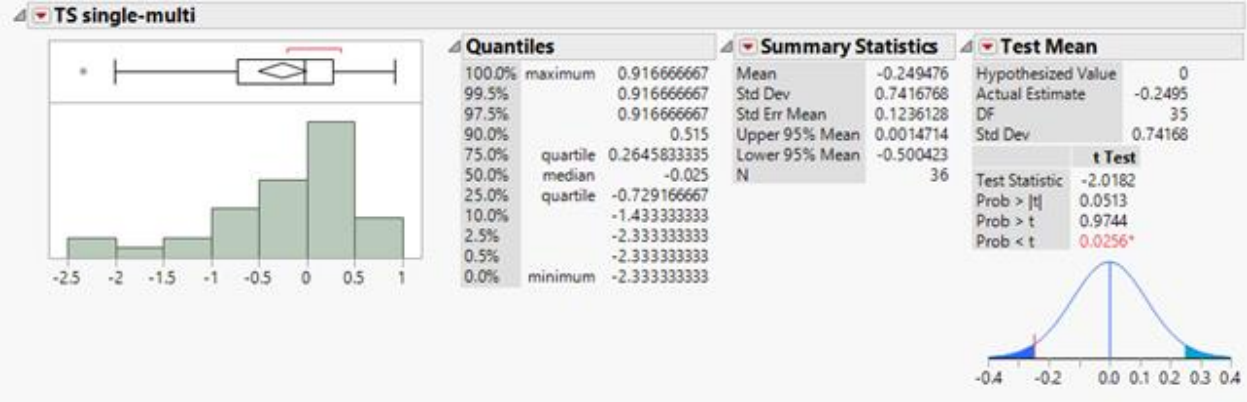

Figure 7: Result of Weight Difference in Single-Pack and Multi-Pack Tomato Sauce

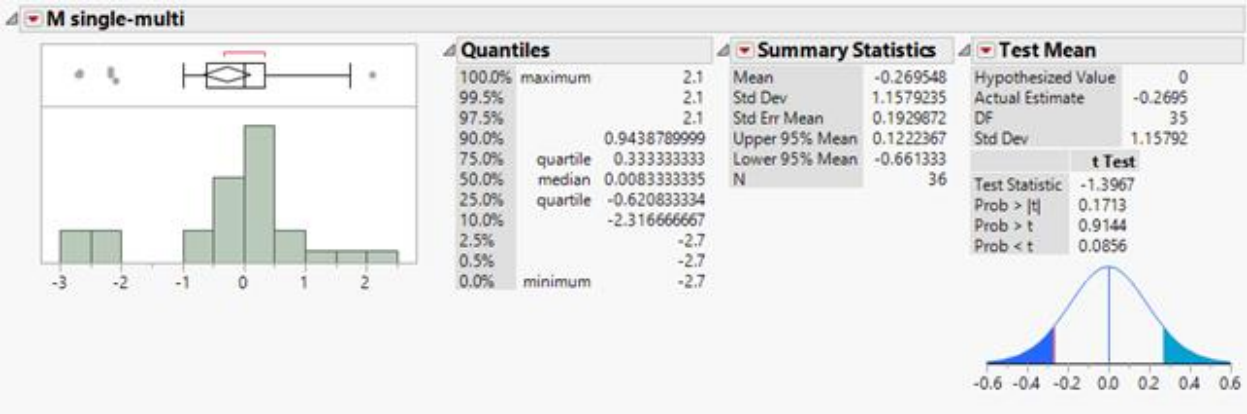

Figure 8: Result of Weight Difference in Single-Pack and Multi-Pack Milk

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Figure 9: Correlation Between Grip Strength and Perceived Overall Weight

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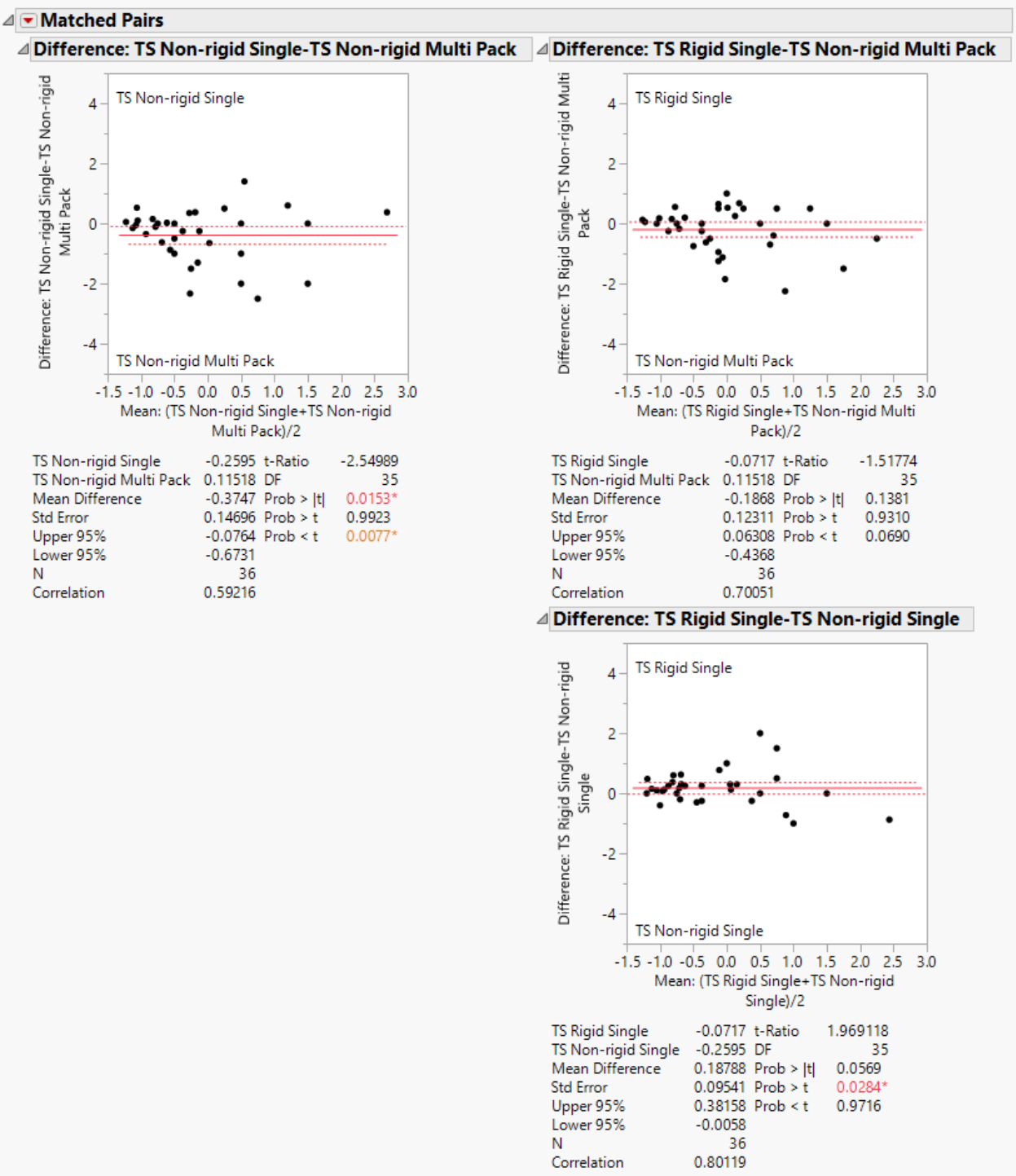

Figure 10: Result of Mixed Effect of Tomato Sauce

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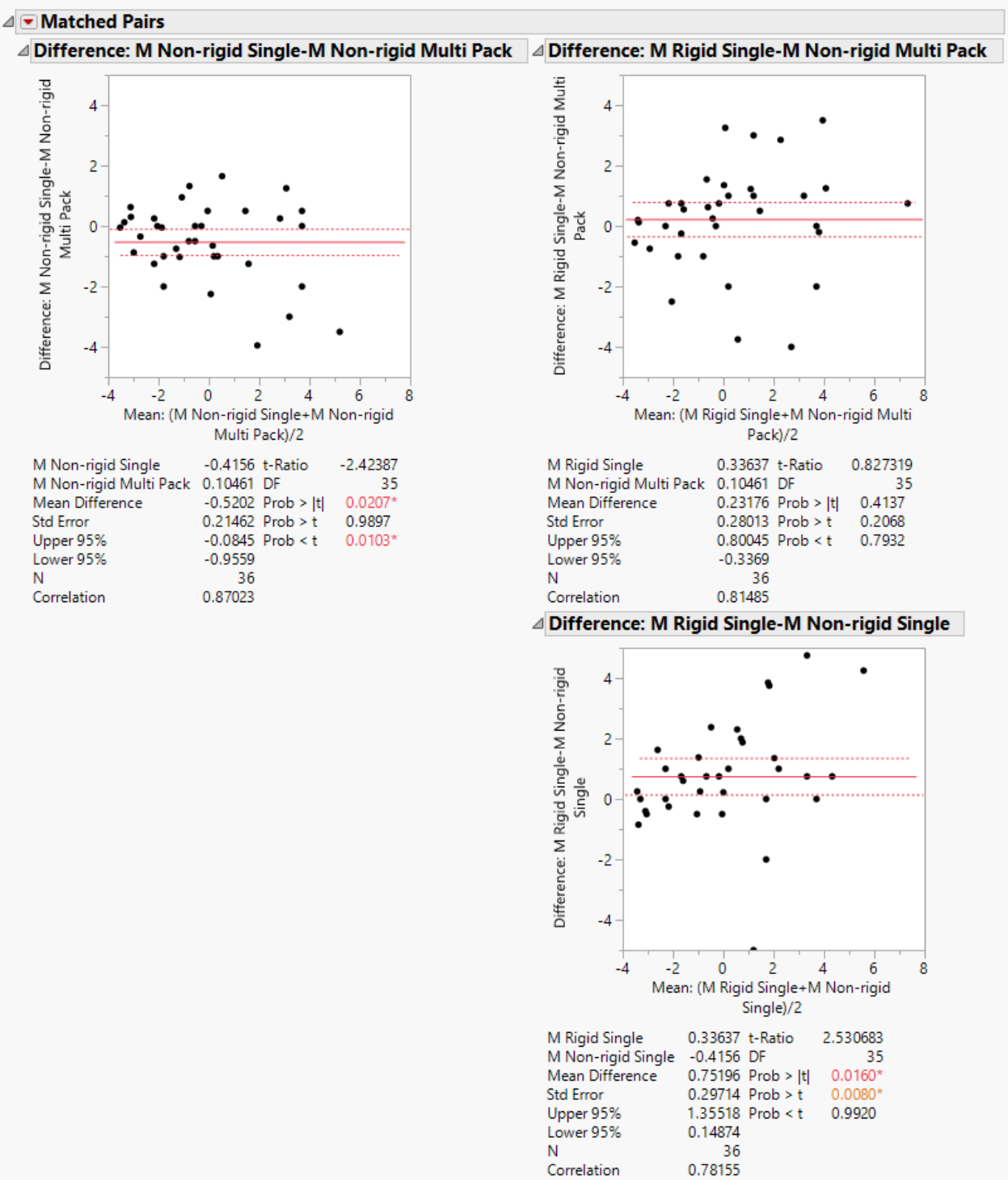

Figure 11: Result of Mixed Effect of Milk

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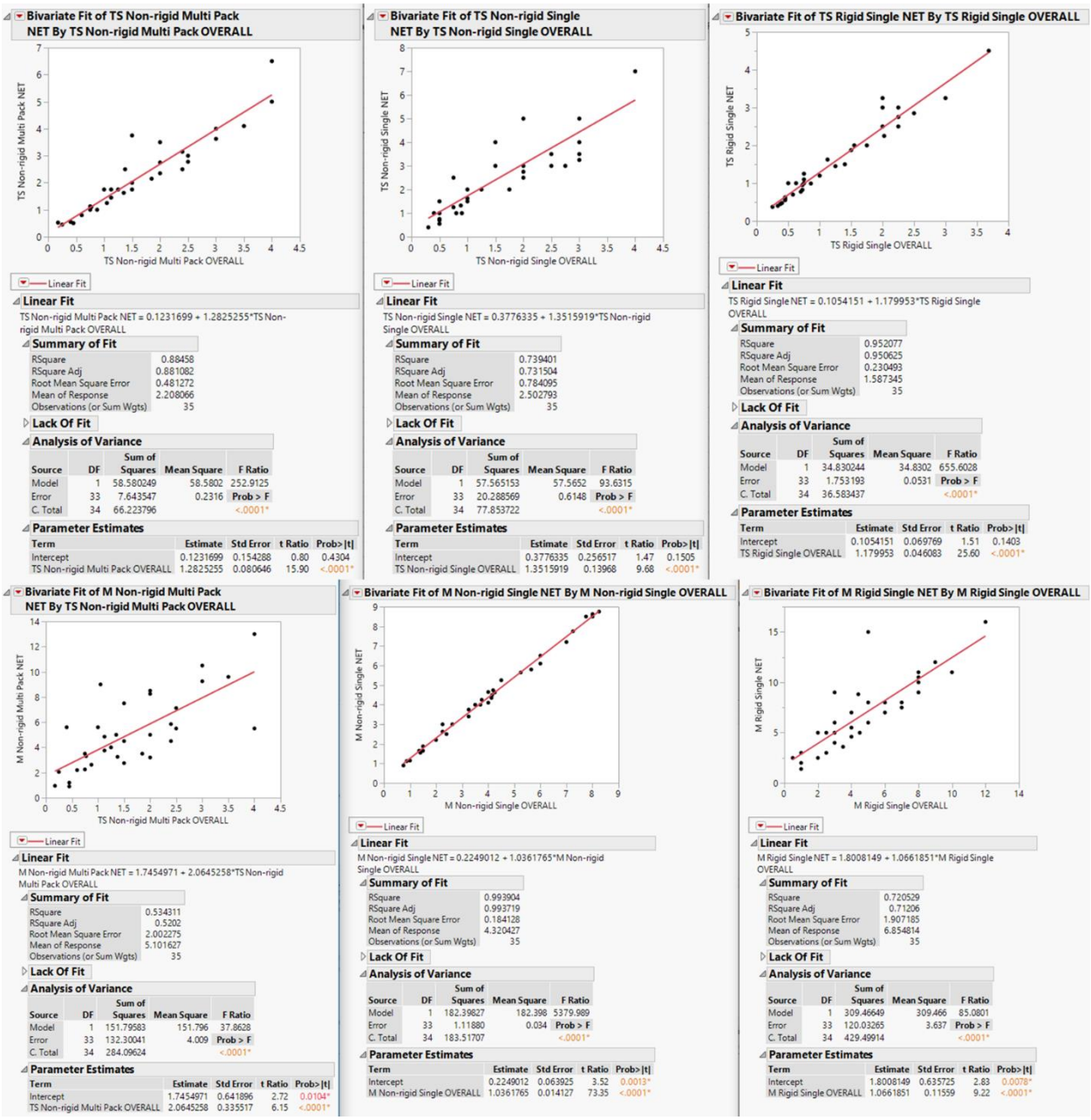

Figure 12: Net Weight vs. Overall Weight

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APPENDIX B: ATTACHMENTS
Experiment Document: IRB Approval

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
2420 Lincoln Way, Suite 202
Ames, Iowa 50014
515 294-4566

Date: 1/31/2017

To: Ahmad Mumani
4325 Todd Drive Unit 207
Ames, IA 50014

CC: Dr. Richard T Stone
3004 Black Engineering

From: Office for Responsible Research

Title: Packaging Characteristics as determinants for the perceived heaviness, and their role in supermarket self-checkout

IRB ID: 16-499

Approval Date:	1/30/2017	**Date for Continuing Review:**	1/29/2019
Submission Type:	New	**Review Type:**	Expedited

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- **Use only the approved study materials** in your research, **including the recruitment materials and informed consent documents that have the IRB approval stamp.**
- **Retain signed informed consent documents for 3 years after the close of the study**, when documented consent is required.
- **Obtain IRB approval prior to implementing any changes** to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.
- **Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences** involving risks to subjects or others; **and (2) any other unanticipated problems involving risks** to subjects or others.
- **Stop all research activity if IRB approval lapses**, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.
- **Complete a new continuing review form** at least three to four weeks prior to the **date for continuing review** as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. **Approval from other entities may also be needed.** For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **IRB approval in no way implies or guarantees that permission from these other entities will be granted.**

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 202 Kingland, to officially close the project.

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.

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Experiment Document: Consent Document

ISU IRB # 1 16-499
Approved Date: 30 January 2017
Expiration Date: 29 January 2019

Attachment 4-Consent Form

Consent Form for

Packaging characteristics as determinants for the perceived heaviness, and their role in supermarket self-checkout

You are invited to participate in a research study about the effect of packaging characteristics on the perceived heaviness, and their role in supermarket self-checkout. You were selected as a participant, because we are seeking for people who are above 18 years old from both genders, and frequently visit shopping district. You should not participate in this study if you have osteoarthritis or rheumatoid arthritis affecting your hands, or any walking difficulties and/or are not familiar with self-checking-out stations. Also, you should not have previous experience in cashiers or supermarkets related works. The purpose of this study is to investigate the effect of packaging characteristics on the perceived heaviness, and how the consumer characteristics affect his/her perception of items' weight. Also, it will study how consumers' and packaging characteristics, and the perceived and actual weight affect the consumer preferences toward different self-checking technologies. We ask you to read this form and ask any questions you may have before agreeing to participate in the study. Please discuss any questions you have about the study or about this form with the principal or co-principal investigators before deciding to participate.

This study is being conducted by Ahmad Mumani, a graduate student at Iowa State University (ISU) in the college of engineering, department of Industrial and Manufacturing Systems Engineering (IMSE).

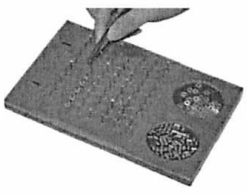
Procedures:

If you agree to participate, we will measure your pinch and grip strength, dexterity level, and height. Then you will be provided with a shopping list containing different items which are placed on shelves. Read the list and from the items on the shelves, select the items which you would like to simulate buying. After then, place the selected items in the shopping cart and estimate the items' weight while they are in the cart; Thereafter, you should select the preferred method to self-checkout each item and all the items in the cart. After the experiment, you will be asked to fill a short survey. The entire study will last for 40-90 minutes and you will be video recorded only during the shopping/checking out tasks, and the recordings will be only used for ergonomic assessments.

Devices that will be used

Hand dynamometer: used for testing hand grip strength.

Pinch gauge: measure the force applied between the thumb and the individual fingers on the hand.



Michigan dexterity test: used to assess for any form of work that requires the manual manipulation

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ISU IRB # 1 16-499
Approved Date: 30 January 2017
Expiration Date: 29 January 2019

Attachment 4-Consent Form

Risks or Discomfort:
No significant risk is expected in this study beyond what experienced in the normal shopping environment.

Confidentiality:
In any document we may publish, we will not include any information that may identify you as a participant. Video recordings will not be published or shared when results are disseminated. Research records, including video recordings, will be stored securely using Cybox, ISU's secure cloud storage system. Only the research team will have access to all research records. After the study is complete and the related research article(s) approved, all video recordings will be securely deleted.

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy study records for quality assurance and data analysis. These records may contain private information.

Voluntary Nature of the Study:

Your participation is completely voluntary. If you decide to participate, you are free to stop at any time without any responsibilities or penalties. Your preferences and some general information will be obtained from you after the experiment, this is by using surveys' and interview questions. You may choose not to answer any of the questions. If you are a student in any of Dr. Stone's classes, your choice to participate will not affect your grades or relationship with Dr. Stone in anyway. If you have any concern, you can skip any part of the study.

Costs and Compensation:

You will not have any costs from participating in the study.

If you are a student in one of Dr. Stone's classes and participated in this study, you will receive up to 5 extra credit points for participating in this study. If you only participate in a portion of the study, you will be given full credit as long as you signed the consent form. You may alternatively, choose to complete an auxiliary homework based extra assignment worth the same amount of points.

If you are not a student in any of Dr. Stone's classes, no compensation will be offered.

Contacts and Questions:

The principal investigator of this study is Ahmad Mumani. You are encouraged to ask questions at any time during this study. For further information or any questions later, you are encouraged to contact him at Iowa State University, Industrial and Manufacturing System Engineering

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ISU IRB # 1 16-499
Approved Date: 30 January 2017
Expiration Date: 29 January 2019

Attachment 4-Consent Form

department, aamumani@iastate.edu. If you have any questions or concerns regarding this study and would like to talk to someone other than the principal investigator, you are encouraged to contact Dr. Richard Stone at Iowa State University, Industrial and Manufacturing System Engineering department, 3027 Black Engineering, rstone@iastate.edu.

If you have any questions *about the rights of research subjects or research-related injury*, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, Iowa State University, Ames, Iowa 50011.

Statement of Consent:

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant's Name (printed) _____

_____ _____

Participant's Signature Date

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Experiment Document: Shopping List

Attachment: 6: Shopping list

Suppose that you want to buy the following items from the shelves in front of you, pick the items that you would like to buy. Put these items in the cart and fill columns 1-3

Item	Item name	1. Check the items selected	2. Estimated Net Weight	3. Estimated Overall Weight	4. Preferred self-checkout method
1	Milk				
2	Tomato Sauce				

*Scanning technologies

Bi-optic scanner

handheld scanner

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Experiment Document: Survey

Attachment 7: Survey
Select the choice that best represents your response

l. What is your gender?

Male Female

2. How old are you?…….Years

3. How tall are you?…….Feet.….Inch

4. Are you right-handed or left-handed?

Right handed Left- handed

5. On average, how many times do you visit the shopping districts each week?

I -3 times 4-6 times 7-9 times 9+ times

6. Before visiting shop districts, usually

I prepare a list of items needed I don't prepare a list of items needed

7. Who is the primary shopper in your family?

I my dad my mother other members

8. When deciding on the items to be bought, what factors affecting your purchase decision. Choose all that apply

a. Brand Name b. Weight of the package

c. Price d. Size of the package

e. The amount contained in the package exterior packaging (appearance) f. Ease of handling the package

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Attachment 7: Survey

9. As for the items you selected in the experiment how frequently you buy them every week.

Item	Item name	Frequency of purchase #
1	Milk	
2	Tomato Sauce	

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