

Grocery Product Arrangement Using Cluster Analysis

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Abstract—Literature on grocery layout improvements are limited. Grocery owners do not consider customer expectations in layout design. This study aims to determine products that must be grouped together in a grocery store based on customer's expected adjacency. The main method used is card sorting to identify customers' mental model on product arrangement. A representative grocery store was used to test the proposed method. There were 39 products used in the card sorting experiments based on the movable contents of the selected grocery store. Forty participants participated in an open card sorting to determine clustering of products. After groups had been determined, suitable names were identified for the groups. Pairwise Exchange Method (PEM) was then used within each group to determine how to arrange products within a certain area. Results of the study showed that customers expect products to be grouped according to use. Complementary and substitute products should also be placed close to each other.

Index Terms— grocery layout, card sorting, product adjacency, supermarket layout, pairwise exchange method

I. INTRODUCTION

In order to satisfy customers, retailers should be more mindful of their needs. Though price is one of the major determinants in a customer's buying decision, shopping experience also significantly affects the purchasing behavior of customers. In the context of grocery stores, customers consider geographic location, product portfolios, or best retail service (like fast movement in the queue, properly ventilated stores, and credit card acceptance for small purchases). For this reason, competition in retail is not just influenced by price but other dimensions such as convenience, product range / selection, quality, cleanliness of retail outlet, friendly staff, convenient operating hours, store design, and atmosphere [1]. Convenience was identified as one of the main drivers of customer loyalty in a grocery store which is related to its layout [2, 3]. Layout is an integral aspect of the design of the grocery store because it affects movement efficiency and the end goal of finding the items they want [4]. Consumers expect the store to have a more stable layout so that it is easier for them to find the items they look for especially if they are frequent shoppers [5]. The ability of the store to conform to consumer expectations is a determinant of shopping trip satisfaction

[6]. Consumers that are confused due to layout suffer inconvenience and withdraw their patronage [7]. It follows that when the design is not based on the expectation of the customer, it can result to lost revenues.

Grocery layouts vary depending on desired shopping behavior or clustering of products [8]. The consumption universe layout groups products according to relationships and therefore promotes conjoint buying. Reference [9] analyzed the relationship of products bought by grocery customers for a period of three years to determine which products are to be placed close together using multidimensional scaling. The results, however, generated product groupings that are not feasible due to adjacency constraints such as placing food and non-food items together. Moreover, not all products that are grouped based on buying associations are constantly being purchased by customers. If a customer wishes to purchase an item that is not within the group, it will take additional time in searching since he or she has no clue on which group was the item placed. This does not conform to the idea of a "one stop shopping" experience.

Reference [10] used an evolutionary algorithm to allocate length of shelves to particular products and also determines combinations of products to be placed adjacent to one another considering some constraints. The idea behind the evolutionary algorithm is given a population of individuals the environmental pressure causes natural selection (survival of the fittest) and this causes a rise in the fitness of the population [11]. One constraint considered by [10] is that products must be classified into groups where products of the same group must be placed together. Other constraints considered were product affinities, disparities, and grocery reference points. For example, bakery products must be placed near the oven and expensive products near the check out so that cashiers can keep an eye on them. However, these aforementioned constraints are too general and random. Employing them may still inconvenience customers because the customer's mental model was not taken into account in the arrangement. Also, the method proposed by [10] considered groceries with limited number of shelves.

Literature on grocery layout improvements are limited. Customer expectation was not considered in determining product adjacencies to increase customer satisfaction. Reference [9] proposed a grocery layout based on association of product categories through data mining. Product association, however, do not necessarily reflect expectations. These associations were derived from the group of products usually bought by consumers when they visit a store.

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This study aims to determine products that must be grouped together in a grocery store based on customer expectation. A method for determining product adjacencies was proposed. The outcome of the study can be used by grocery stores to provide a layout that will increase customer satisfaction and loyalty.

II. RESEARCH METHOD

A. Grocery selection

Prior to determining product adjacencies, a representative grocery store was chosen to try the method. The store fitted the criteria provided by the Philippine Amalgamated Supermarkets Association, Incorporated (PAGASA) in its definition of a grocery store which are: at least 3 checkout counters, it must be self-service, and the total land area must be at least 200-299 square meters.

B. Product identification

As an input to the experiment, current product adjacencies per shelf were noted in the grocery selected. There were five shelves containing different sets of products and a total of 50 products in the grocery. Although, there are 50 products, not all were considered since the owner only allowed certain product types to be moved based on the estimated amount of labor and time required. Therefore, 39 out of 50 products were subjected to re-arrangement. These 39 products are listed in Table 1.

TABLE 1
 PRODUCT LIST

Alcohol	Coffee	Powdered Milk
Baby Diaper	Conditioner	Sanitary Napkin
Baby Powder	Cooking Oil	Sauce
Bath Soap	Cotton	Seasoning
Bath Tissue	Creamer	Shampoo
Biscuits	Fabric Softener	Snacks
Bleaching Liquid	Insecticides	Soda
Candies	Instant Noodles	Soup
Canned Fruits	Laundry Bars	Soy sauce
Canned Goods	Mayonnaise	Sports drink
Canned Milk	Pasta	Tea
Catsup	Powdered Detergents	Toothpaste
Chocolate Drinks	Powdered Juice	Water

C. Card Sorting

Card sorting was used to determine the mental model of grocery shoppers in terms of product adjacency. Forty participants for the card sorting were chosen using judgement sampling as proposed by [12]. Participants were limited to those who have experienced shopping in a grocery store. A questionnaire was used to uniformly screen potential participants in terms of economic class type, shopping experience, and frequency of shopping.

Product adjacencies based on customer expectations was incorporated by taking the tally of participants who placed two corresponding products adjacent to each other which is

called frequency between a product pair. Product type refers to grocery products such as milk, butter, cereal, etc.

Prior to experimentation each participant was given a questionnaire for screening and recording personal information. After the screening process, qualified participants were chosen for the open card sorting.

In the open card sorting, participants were allowed to create their own categories. They were given 39 cards with product type labels, pieces of small, white paper, and a pen. Each participant had to sort all 39 cards according to their expected grouping inside a grocery store. Aside from grouping the cards, the sorting also involved placing each product type adjacent to each other by stacking each product according to affinity. For example, if the participant decided to group milk, cereal, honey, and bread into one general category it means that milk should be beside cereal, cereal beside honey and honey beside bread.

After all the cards had been arranged, they were asked to write the name of the product category in one sheet of paper. Cards that were deemed not to belong to any group were set aside. To generate the dendogram, the results of the card sorting experiment were set in a card sorting software called CardSword 0.91 Beta.

After producing the dendogram, data were synthesized to tally the frequency of each product type pair placed adjacent to each other by the participants. For example, there were 6 participants who placed milk and cereal adjacent to each other. Thus, the frequency of the milk-cereal combination was 6. A frequency matrix was generated containing the total tallies of product adjacency for each pair. The resulting frequency matrix is expected to have an $n \times n$ dimension where n is the total products types. Therefore, the 39 products considered yielded a 39x39 matrix.

Since open card sorting was employed, there were no standard names for the general product categories generated by the card sorting software. The categorization done by the participants were processed to generate standard category names.

D. Layout Generation

Pairwise Exchange Method (PEM) was used to determine the arrangement of products within a category. This method is an improvement-type layout algorithm where locations of entities are exchanged in pairs until an optimal layout is generated based on a specific criterion [13].

There were two matrices used in the PEM: material flow matrix (MFM) and distance matrix (DM) based on existing layout. The MFM was taken from the result of the open card sorting experiment while the DM was based from the current product adjacency layout. The MFM shows the number of times a certain product was placed adjacent to another product by the participant. A dendogram was also generated through the card sorting experiment which shows how products should be grouped based on customer expectation. A sample matrix showing the distance and frequency (in parentheses) is shown in Table 2. The entry "2(5)" under juice means it is 2 units away from milk and there are 5 participants that placed them adjacent to each other. The formula for computing the cost of one layout is the summation of distance multiplied by frequency. The initial layout shown in Figure 1 was used as the basis of the

first iteration. If two items are not located on the same shelf, the distance is represented by M which is a very large number. For example, in the initial layout the distance between baby powder and baby diaper is represented as M because they are not in the same shelf. The distance between baby powder and laundry bars is 1 and baby powder and bath soap is 2.

All possible exchanges are evaluated and the one with the lowest cost is used to begin the second iteration. The final layout is the lowest cost in the previous iteration.

After generating the proposed layout, the result was validated using 20 mothers. The validation was done to determine if the same dendrogram will be generated using a different set of participants.

TABLE 2
 SAMPLE DISTANCE-FREQUENCY MATRIX

	milk	cereal	juice	cookies
milk(1)	-	1(10)	2 (5)	3 (2)
cereal(2)		-	1(3)	2 (6)
juice(3)			-	1 (5)
cookies(4)				-

III. RESULTS

A. Participants' profile

Participants came from all class types: 15% class A, 30% class B, 30% class C, 10% class D and 15% class E. About 65% of them are from the 30-49 age bracket while 15% came from 20-29 and 20% from 50-59. Majority of the participants (60%) shop either once a week or every other week. Only 20% shop once a month or twice a week.

B. Product groupings

From the card sorting experiment, the dendrogram shown in Figure 2 was derived. The final dendrogram was formed by using cluster analysis in the card sorting experiment. Cluster analysis aims to form groups that are distinct and homogenous [14]. Clustering is done well if homogeneity is maximized.

Seven clusters were formed from the dendrogram as shown in boxes. The clusters were named: beverages, condiments, canned goods and instant noodles, snacks, toiletries, baby products, and laundry needs. Most participants grouped the products according to their use. For instance, the laundry needs group included all products that are used for laundry. Baby products group consist of only two items that are used for baby care.

C. Layout Generation

The best arrangement of products within a cluster was determined using pairwise exchange method. For baby products, PEM was not done since there are only two products in the group. The products under beverages are too many so they were further divided into subgroups to reduce the length of the iteration process. From the card sorting results, products with high frequency values such as 10 and above were put in one group. To get the frequencies for the created sub groups, 20 participants were asked to arrange the sub groups in the exact order that they expect them to be inside the grocery. The purpose was to be able to execute the PEM and get the optimal adjacency for the sub groups.

The subgroups of beverages obtained are shown in Table 3.

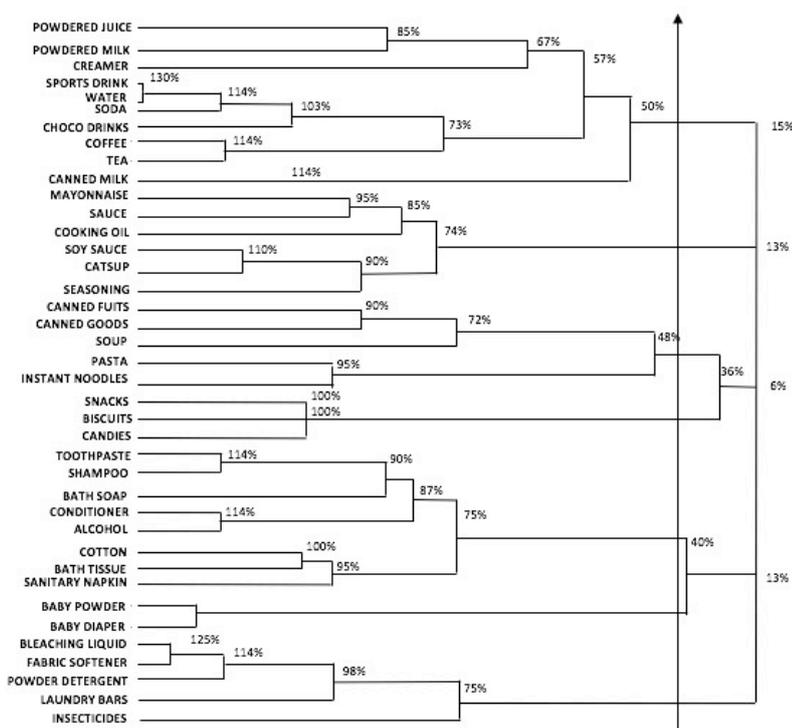


FIG. 2 DENDROGRAM FROM CARD SORTING

TABLE 3 SUBGROUP OF BEVERAGES

powdered juice, powdered milk creamer, coffee, choco drink tea, water canned milk sports drink, soda
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The use of PEM generated the proposed arrangement of products within clusters as shown in Table 4. For example, the condiments group should be arranged in the order: cooking oil-soy sauce-seasoning-catsup-sauce-mayonnaise. Such an arrangement is expected by the customers so if these items are arranged in this manner the total grocery shopping time is expected to be shorter. The time to look for the items will be minimized because customers will tend to look for the items in places they expected.

TABLE 4
 RESULTS OF PAIRWISE EXCHANGE

Cluster	Iter	Lowest Cost	Proposed Arrangement
Snacks	2	1st iteration = 40	Snacks-Candies-Biscuit
Canned Goods and Instant Noodles	3	2nd iteration = 60	Canned Fruits-Canned Goods-Soup-Instant Noodles-Pasta
Condiments	6	5th iteration = 125	Cooking Oil-Soy Sauce-Seasoning- Catsup-Sauce-Mayonnaise
Laundry needs	2	1st iteration = 112	Insecticides-Fabric Softener- Bleaching Liquid-Laundry Bars-Powdered Detergents
Toiletries	3	2nd iteration = 284	Alcohol-Bath Soap-Bath Tissue-Cotton-Sanitary Napkin- Conditioner-Shampoo-Toothpaste
Beverages	3	2nd iteration = 112	powdered milk – powdered juice – canned milk – chocolate drink – coffee – creamer – tea – water – soda – sports drinks

The proposal was validated by conducting another card sorting exercise. The second set of results showed almost the same dendogram as the initial card sorting experiment. The only difference is that the baby products, namely: baby diaper and baby powder, were grouped together with toiletries, namely alcohol, bath tissue, cotton, napkin, conditioner, shampoo, toothpaste, and bath soap. This proves that results from initial card sorting experiment are actually the same with the repeated card sorting experiment.

It can then be said that the expectations of the initial sample are actually almost the same with expectations of the mothers.

IV. CONCLUSION

Results obtained from the card sorting experiment proved that customers expect products to be grouped based on how they are used. Groupings include products that are used for drinking, products used for laundry, products that are ready to eat, products that serves as add-ons while cooking, etc. Complementary products and substitute products are expected to be adjacent to the other so they should be placed close to each other. The outcome of the study can be used to improve the layout of grocery stores offering the same sets of products.

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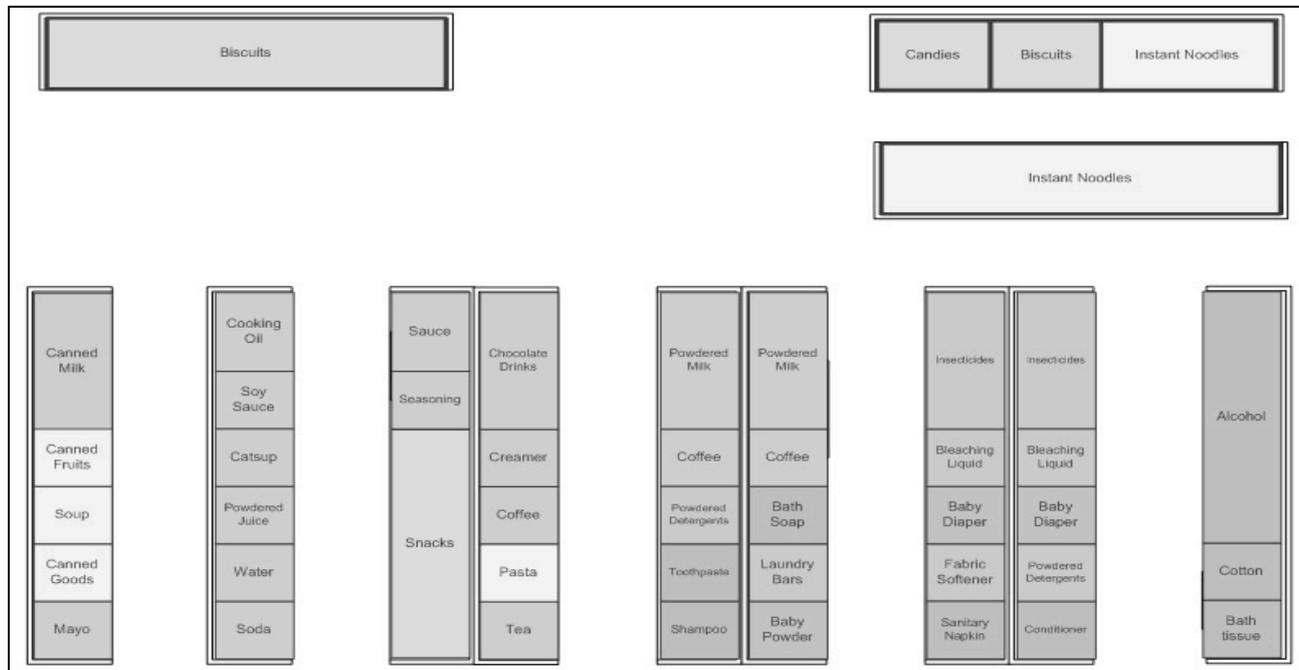


Fig. 1 Initial Grocery Layout