Do Face Masks Really Meet Consumers' Expectations? Addressing Consumers' Post-Purchase Concerns and Criteria of Face Masks by Using Natural Language Processing

Sonia Bakhshian
Auburn University, USA

Keywords: Face-Mask, consumers' expectations, Natural Language Processing, COVID-19

Introduction and background. The ongoing novel COVID-19 virus has already infected millions of individuals worldwide. Since 2020, many countries have executed certain international and domestic restrictions (e.g., travel limitation, social distancing, closing non-essential businesses) to minimize person-to-person exposures and reduce infection rates among individuals. Align with restrictions, many countries required wearing face masks (e.g., disposable masks, cloth masks) in public. In addition to the governmental restrictions, many public health organizations worldwide have continuously encouraged individuals to wear face masks in public spaces to prevent spreading COVID-19. Even many countries have started vaccinating their citizens, individuals' may still need to continue wearing masks in public for a long term in the future. Thus, it is crucial to know notable barriers that reduce overall mask usage. To date, several experimental studies conducted on different types of respiratory masks (e.g., surgical, KN95) with the focus on comparing their protection level under the various conditions (e.g., Kim et al., 2020; Suen et al., 2020). However, no study was found to address the consumers' challenges, needs, and expectations of face masks that are currently available in the market. Thus, the purpose of this study was to explore consumers' criteria and challenges as well as the major defects of face masks at the post-purchase phase. In this study, we also attempted to introduce the application of natural language processing (NLP), as a time- and budget-saving data coding method, to the apparel and textile field.

Methods. Using secondary data, post-purchase review comments of five different brands of disposable masks were collected for this study. We selected the top five disposable mask brands with the highest review numbers in Amazon official website as the sample of this study. Amazon was selected as the data source for this study as it was reported as the most popular online website in 2020 by having a monthly traffic average of almost 3.68 billion visitors in 2020 (Statista, 2020). Data was extracted via the "Amazon Exporter Pro" application and it was saved in an Excel file. Data collection was done in February 2021. We extracted 7563 review comments from Amazon. The extracted data was verified purchased reviews in the US. This study was limited to English-language comments. Thus,

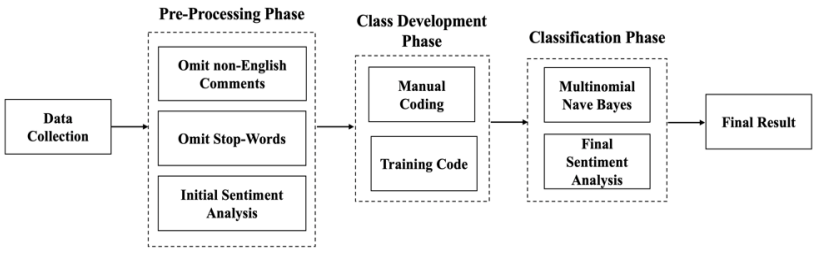

Figure 1. Method phases from data collection to the final

initial data cleaning was done to eliminate the non-English-language comments that resulted in eliminating 217 review comments. Instead of doing the traditional manual inductive coding and text classification for comments, we utilized natural language processing (NLP) toolbox and machine learning models in Python to speed up the coding process. Primary pre-processing data cleaning was done on the data to remove stop-words (e.g., "a", "and", "my", "our") and emojis throughout the dataset, using "SpaCy" library. Initial sentiment analysis was done on the data to find the most frequent words in comments and to obtain a general idea about the nature of the data. A coder manually coded 1250 review comments. The manual coding was done with the purpose of training and testing machine learning models. As the result of manual coding, three models of classification were defined for this study. The first model represents the "functionality" aspect of the mask, including three classes: comfortability, breathability, and protection. The second model indicates the "defects" aspect of the mask including three classes: quality, fit/size, and ears-loops/nose-wire. And finally, the third model, called "other features", consisting of two classes: price, and country of origin. Then, "multinomial nave Bayes" (MNB) was utilized as the machining learning classification model to classify this study text-based dataset including review comments and their titles (Domingos & Pazzani, 1997). Manually coded data were divided into test and training sets with 75% used to train the machine learning model and 25% of the manually coded data were used to test (evaluate) the performance of the model. We used "Precision", "Recall" and "F1-score", which ranged from 0 to 1, to measure the performance of our training and testing on the data. Precision is defined as the ratio of correctly predicted positive observations to the total predicted positive observations, while Recall is the ratio of correctly predicted positive observations to all observations in the actual class. And F1-score is the weighted average of both Recall and Precision. Finally, sentiment analysis was performed on each of the classes to find the direction of consumers' sentiments regarding them. The sentiment analysis results ranged from -1 to 1, where -1 indicates negative reviews, 1 represents positive views and zero indicates neutral reviews. Figure 1 illustrates all the stages of the method from primary data collection to obtaining the final results.

Results. Table 1 depicts the performance of the MNB machine learning models on data and the frequency of sentiment analysis. As shown in Table 1, three of the models can predict their classes with high accuracy. According to the model 2 result, low quality of materials, size and fitness issues, easily-to-separate ear-loops/straps, and unfitted nose-wires were mentioned as the main barriers of using face masks at the post-purchase phase. Model 1 result demonstrates comfortability, breathability, and protection as the three main criteria for a functional face masks from consumers' point of view. The model 3 result illustrates the

Table 1. Final results of the models' performances and sentiment analysis.

Model	Class	Precision	Recall	F1	Negative	Neutral	Positive
Model 1. Functionality	Comfortability	.69	1.00	.82	33	33	395
	Breathability				21	20	46
	Protection				51	64	101
Model 2. Defects	Quality				129	36	116
	Size/Fit	.81	.63	.71	64	3	31
	Ear-loops/ Nose-Wire				323	104	272
Model 3. Other Features	Price	.77	.81	.77	33	46	400
	Country of Origin				43	25	16

importance of price and country of origin of face masks. After reviewing the negative sentiment regarding country of origin, consumers expressed that they are more willing to purchase and use "made in America" face masks rather than using "made in China" masks.

Conclusion. This study highlights the consumers' needs, expectations as well as major defects that are currently available in the facemasks. The findings of this can be a valuable guide map for industry professionals (e.g., designers, product developers) to help them develop better designs, materials, and technologies that are more acceptable to wearers. This study is an initial step towards using automated and fast methods that can be integrated into current methods for human-coding for classification tasks in qualitative studies. This machine learning method can be used for speeding up the rate of qualitative analysis with a big dataset. This study can be valuable for academia by suggesting a fast, inexpensive, and accurate method of data analysis. This study opens up room for future researchers by encouraging them to apply this machine learning method in various contexts. Future researchers are encouraged to apply this method for other trendy types of respiratory masks (e.g., KN95, N95) to explore their defects and reflect consumers' main needs of using them.

References

Domingos, P., & Pazzani, M. (1997). On the optimality of the simple Bayesian classifier under zero-one loss. *Machine Learning*, *29*(2), 103-130.

Kim, M. C., Bae, S., Kim, J. Y., Park, S. Y., Lim, J. S., Sung, M., & Kim, S. H. (2020). Effectiveness of surgical, KF94, and N95 respirator masks in blocking SARS-CoV-2: a controlled comparison in 7 patients. *Infectious Diseases*, *52*(12), 908-912. https://doi.org/10.1080/23744235.2020.1810858

Statista. (2020, December). *Most popular online retail websites worldwide in 2020, by average monthly traffic.* https://www.statista.com/statistics/274708/online-retail-and-auction-ranked-by-worldwide-audiences/

Suen, L. K. P., Guo, Y. P., Ho, S. S. K., Au-Yeung, C. H., & Lam, S. C. (2020). Comparing mask fit and usability of traditional and nanofiber N95 filtering facepiece respirators before and after nursing procedures. *Journal of Hospital Infection*, *104*(3), 336-343. https://doi.org/10.1016/j.jhin.2019.09.014