The Effect of Product Placement on Shopping Behavior at the Point of Purchase: Evidence from a Randomized Experiment Using Video Tracking in a Physical Bookstore

Qiwei Han[1,2] Pedro Ferreira[1] João Paulo Costeira[2]
qiweih@cmu.edu; pedrof@cmu.edu jpc@isr.ist.utl.pt
Carnegie Mellon University[1] Instituto Superior Tecnico[2]

Abstract

Physical retailers are increasingly trying to understand in-store shopping behavior in order to increase sales. However, measuring and analyzing shopper behavior at the point of purchase in physical retailing remains challenging. In this paper, we implement an in-vivo randomized field experiment in a physical bookstore. We leverage video tracking technologies to monitor how shoppers respond to random book placement, which induces random search costs. More specifically, we randomize the position of newly released books on the top of a large table with several rows and columns such that each book's search cost becomes independent of the book's characteristics. We use advanced 3D cameras and vision-understanding algorithms that can track human motions in real-time to overcome the large costs associated to large-scale video data. This way we are able to significantly reduce the cost of encoding shopper activities by more than 80%. Our experimental results show that on an average day books placed at the edge of the table are both picked and taken more often by consumers than books placed in the center of the table. However, the likelihood of taking a book that was picked is on average similar for books placed at the edge and at the center of the table, that is, books at the edge of the table sell more only because they are, on average, picked more often. Armed with this knowledge, the bookstore manager may maximize profit by placing books with higher margins at the edge of the table.

1. Introduction

Physical retailers are increasingly trying to understand in-store shopping behavior in order to increase sales. For that purpose, they aim at identifying the causal drivers of shopper's decisions at different stages, such as search, consideration, valuation and choice (Shankar et al. 2011). In particular, understanding what happens at the point of purchase, termed as the "first moment of truth", is of major importance to design effective in-store marketing practices that convert product consideration into actual sales. (Hui et al. 2013).

Burke (2006) describes the evolution of marketing intelligence in past decades in waves, from widely used barcode scanners and customer loyalty cards to real-time tracking of consumers' actual shopping activities, using technologies such as RFID path tracking (e.g. Hui et al. 2009), eye-tracking (e.g. Chandon et al. 2009), wearable cameras (e.g. Hui et al. 2013) and surveillance video (Zhang et al. 2014). However, we know of no studies that perform field experiments while accurately recording shopping behavior inside a physical store (Shankar et al. 2011).

In this paper, we implement an in-vivo experiment in a physical bookstore and we leverage video tracking technologies to monitor how shoppers respond to random book placement, which induces random search costs. More specifically, we randomize the position of newly released books on the top of a large table across several rows and columns such that each book's search cost becomes independent of the book's characteristic, such as unobserved quality. To overcome the large costs associated to collecting and processing large-scale video data, we use advanced

3D cameras and vision-understanding algorithms that can track human motions in real-time. This allows us to significantly reduce the cost of encoding shopper activities.

2. Research Context and Experimental Design

We partner with an independent bookstore located in the center of a European capital city. The bookstore receives newly released books from all leading publishers and places them on the top of several large tables. In particular, all newly released books are first placed on the front most table. Later, when these books are replaced by the latest released books they are redistributed to other tables categorized by themes, such as literature, history, sports, etc. Once shoppers enter the store, they first visit the table that showcases the newly released books before they visit other tables.

Typically, the bookstore manager makes decision on book placement based on her own experience. For example, she may put selected popular books at more accessible positions because she believes that this will increase sales. As such, book placement may be correlated with unobserved factors such as book characteristics. In this paper, we devise a randomized field experiment that ensures random book placement. We use the table for newly released books to perform this experiment because unlike branded products, consumers may have limited prior knowledge about the new books and thus tend to rely on the information they gather in the bookstore to make purchase decisions. 30 books are placed on the top of the table across 5 rows and 6 columns. At the beginning of the experiment we randomly shuffled the books already on the top of the table. Right after we started the first cycle of our experiment. At the beginning of this cycle we randomly shuffled the integer numbers between 1 and 30, where 1 denotes the position in the front most row and left most column of the top of the table and 30 denotes the position in the back most row and right most column of the top of the table. Then, we placed incoming books in the slots identified by the ordered sequence of integer numbers obtained from the random shuffle. The first incoming book replaced the book on the top of the table in the position indicated by the first number in the shuffled sequence, the second incoming book replaced the book on the top of the table in the position indicated by the second number in the shuffled sequence and so on. The first experimental cycles ended when 30 new books were placed on the top of the table, therefore exhausting all available positions. Our experiment included two additional cycles similar to the first cycle. We recorded characteristics of every book used during our experiment, such as ISBN, title, rating at GoodReads.com, price, number of pages and lifetime (time that the book was on the top of the table). We also recorded the date when the book was placed on the top of the table. In order to ensure that all shoppers face a similar table top, bookstore staffers were instructed to keep each pile of books at the same height and to restore the table layout whenever it was changed due to the shopper's activity.

We aim at understanding shopper behavior along the path to purchase by capturing metrics that are indicative of the shopper's decision process. We use video tracking over other technologies to capture the shopper behavior in our experimental setting because the former is much less intrusive whereas either eye-tracking or wearable cameras may require the participants' attention. However, the costs from manually extracting information from video data are typically prohibitive (Hui et al. 2013, Zhang et al. 2014), especially considering that field experiments may need to run for several weeks or months at a time. In order to overcome the large costs associated to large-scale video data and detection reliability, we used Microsoft Kinect, an

advanced 3D camera and motion capture input device and implemented vision-understanding algorithms to lessen the effort of the video encoding process. Essentially, Microsoft Kinect provides an extra high-resolution depth 3D sensor that can complement regular video to address fundamental problems in tracking and recognition. We mounted the camera on the ceiling of the bookstore to monitor the area surrounding the table of new books. The camera was connected to the local server that enabled the real-time tracking of shopper activities. More specifically, we built a 3D representation of the space from the depth data and detected shoppers when they entered the scene using the vision-understanding algorithm detailed in Carvalho et al. (2016). We continuously tracked each shopper until she exits the scene, such that we recorded video only when she approached the table, picked or took books and moved away from the table"[1].

Finally, note that our randomized schedule ensures not only that books are placed in random positions on the top of the table but also that their lifetime (time on the top of the table) is also random. This eliminates any correlation between the book's lifetime and sales.

3. Data

We started our experiment on April 21st, 2016 and concluded 3 experimental cycles using a total of 90 books by May 24th, 2016. We collected about 91 hours of activity video, which represent about 20% of the working hours during 34 days (451 hours). In other words, our method helps us to eliminate over 80% of the encoding efforts. The lifetime of books on the table varies from 1 day to 26 days, with an average of about 12 days. An observation is added to our dataset when a shopper picks up a book and browses it for at least 10 seconds. This way we eliminate cases where there is no consideration process whatsoever. Once the shopper starts browsing a book, she may take the book away or put it back. Then she can sequentially pick up as many books as she wants. In total, 1,276 customers picked up 1,751 books during our experiment and took 122 books with them.

We denote the front most row and left/right most columns of the table as edge positions and the other ones as center positions. Thus, there are 14 edge positions and 16 center positions on the table. Figure 1 shows that there are no systematic differences in observed book characteristics between books placed at the edge of the table top and in the center of the table. This provides evidence of the good balance in observed covariates that our randomized schedule achieved.

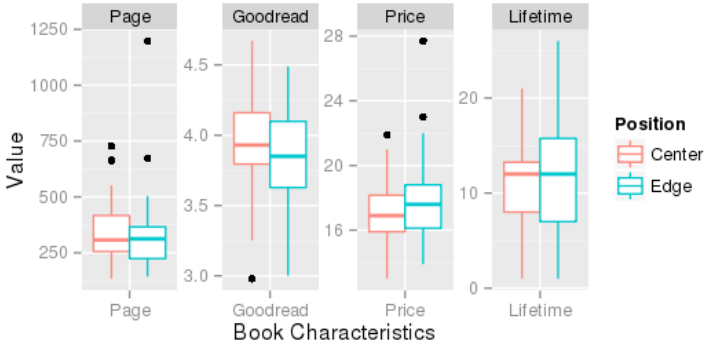

Figure 1: Comparing observed book characteristics between edge and center positions.

[1] The exact book that each customer picked or took during our experiment was confirmed manually and a-posteriori from the video data obtained to avoid measurement error.

4. Results

We evaluate the effect of book placement on shopper behavior by looking at how often shoppers pick and take each book, which are two key indicators of the shopper's consideration and intention to purchase processes. We normalize the number of times a book is picked and taken per day. Our variable of interest is whether the book is placed at the edge or center of the table. We also control for book characteristics, such as number of pages, price, and lifetime on the table. We use both negative binomial and zero-inflated Poisson models to control for excessive number of zeros in our dependent variables, in particular in the case of the number of times a book is taken. Table 1 shows our regression results using each book as an observation. We find that placing a book at the edge of the table positively affects both the shopper's search and consideration processes. In particular, on average, books placed at the edge of the table are picked 102% more often and taken 77% more often per day than those placed at the center of the table. Knowing this, the bookstore owner may maximize profit by placing books with higher margins in the edge of the table.

Variable	n_picked/day	n_picked/day	n_taken/day	n_taken/day
Model	NEG BIN	ZIP	NEG BIN	ZIP
Edge Dummy	0.705***	0.707***	0.572***	0.572***
	(0.164)	(0.167)	(0.265)	(0.265)
Book Characteristics	Yes	Yes	Yes	Yes
Observations	90	90	90	90
Log-likelihood	-151.10	-152.06	-33.36	-33.36

$p<0.001^{***}$, $p<0.01^{**}$, $p<0.05^{*}$

Table 1: Effect of edge vs. center on how many times a book is picked and taken from the table (each observation is a book used during the experiment).

We now study our dataset from the perspective of each shopper's visit to the table of new books at the bookstore. Each shopper's visit to this table mimics an "impression" in the online world, allowing the shopper to browse for books and make purchase decisions among the 30 books on the top of the table when she visits. We use a Linear Probability Model (LPM) to estimate the effect of the random book placement on the top of the table on the shopper's search and purchase process. This type of analysis allows us to characterize the shopper's path to purchase. The dependent variables are whether the shopper picks a book, takes a book and whether she takes a book conditional on picking up the book. We also include day fixed effects to control for systematic differences over time, e.g. during weekends and holidays consumers purchase more books. Table 2 shows the results obtained, which are in line with the ones reported above. In particular, books placed at the edge of the table are more likely to be both picked and taken. However, conditional on being picked, shoppers are equally likely to take books placed at the edge and at the center of the table. This finding suggests that book placement positively affects consumer choice mainly through its effect on the search process and not through its effect on the consideration process. This is aligned with the theoretical framework proposed by Branco et al. (2012) that consumers tend to gather information about products during the search process but then update their beliefs during the valuation process.

Variable	Pick (a)	Take (b)	Take conditional on pick (c)
Edge position	0.0386***	0.0019***	-0.0201
	[0.002]	[0.0004]	[0.0132]
Time FE	Yes	Yes	Yes
Observations	38,280	38,280	1,735
Adjusted R^2	0.0093	0.0011	0.0202

$p<0.001^{***}$, $p<0.01^{**}$, $p<0.05^{*}$

Table 2: Effect of edge vs. center on how many times a book is picked, taken and taken once picked from the table (each observation is a shopper's visit).

In essence, our research contributes to understanding what happens to consumers when sellers manipulate search costs. A number of recent studies along these lines discuss how recommender system over the Internet affect consumer and producer surplus (Belo et al., 2015). Our study shows that similar results arise in physical settings, calling once again for additional work to understand the welfare properties of recommender systems.

Acknowledgement

This work is partially supported by Portuguese Foundation for Science and Technology (FCT) under Grant [UID/EEA/50009/2013] and through Carnegie Mellon Portugal program under Grant [SFRH/BD/51153/2010]. We thank Mr. Jose Rodrigues and staff at Livraria Barata for their support with the experiment. We also thank Joao Carvalho for the technical support to build the 3D sensing infrastructure.

References

1. Belo, R., Ferreira, P., Matos, M. and Zhang, X. (2015), Recommender Systems and Consumer Welfare: Results from a Randomized Experiment in Video-on-Demand, *CODE@MIT*, October 16-17, 2015.
2. Burke, R. (2006). The Third Wave of Marketing Intelligence*, in Retailing in the 21st Century,* Manfred Krafft and Murali Mantrala (eds), Springer
3. Branco, F., Sun, M. and J. Miguel Villas-Boas (2012). Optimal Search for Product Information, *Management Science*, 58:11, pp. 2037-2056
4. Carvalho, J., Marques, M., Costeira, J.P., and Jorge, P.M. (2016). Detecting People in Large Crowded Spaces using 3D Data from Multiple Cameras, in *Proceedings of the 11th Joint International Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications*, pp. 218-225.
5. Chandon, P., Hutchinson, J.W., Bradlow, E.T. and Young, S.H. (2009). Does In-Store Marketing Work? Effects of the Number and Position of Shelf Facings on Brand Attention and Evaluation at the Point of Purchase, *Journal of Marketing*, 73 (November), 1-17.
6. Hui, S., Fader, P., and Bradlow, E. (2009b). The Traveling Salesman Goes Shopping: The Systematic Deviations of Grocery Paths from TSP-Optimality, *Marketing Science*, 28(3), 566-572.
7. Hui, S., Huang, Y., Suher, J., and Inman, J. (2013). Deconstructing the "First Moment of Truth": Understanding Unplanned Consideration and Purchase Conversion Using In-Store Video Tracking. *Journal of Marketing Research,* 50:4, pp. 445-462.
8. Shankar, V., Inman J., Mantrala, M., Kelley, E., and Rizley, R. (2011). Innovations in Shopper Marketing: Current Insights and Future Research Issues. *Journal of Retailing*, 87, pp. 29-42.
9. Zhang, X., Li, S., Burke, R., and A. Leykin (2014). An Examination of Social Influence on Shopper Behavior Using Video Tracking Data*, Journal of Marketing,* 78, pp. 24-41.