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Validating Bluetooth logging as metric for shopper behaviour studies

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ABSTRACT

The ability to track shoppers as they move through retail environments using signals emitted by their communication devices kindles the interest of practitioners and researchers. This data collection method is cheap and has the ability to supply big data for shopper insights. However, this non-probabilistic sampling method can possibly under- or over-represent certain groups of the shopper population. This study assesses the validity of the data describing the length of shopping trips and representativeness of the sample of shoppers carrying Bluetooth-enabled devices. The authors track unique Bluetooth logs in-store and compare to simultaneously collected data from a manual, systematic sample of 324 shoppers observed and interviewed in the same supermarket. A comparison of the results obtained from the two samples (auto-logging and manual systematic) drawn from the same population indicates automated Bluetooth tracking produces very similar ($r = .92$, $p < .001$) trip lengths to that observed manually. Basket size, spend and occupation of Bluetooth trackable shoppers are similar to those with no Bluetooth-enabled devices. These findings present compelling evidence that the Bluetooth auto-logging method holds great potential for retail practice and research. An expected under-representation of the oldest demographic (66 y.o. and over) in the Bluetooth discoverable sample calls for complementary methods of data collection to minimise representation bias in real-time tracking technologies for shopper research. The benefits of using auto-logging data describing shopping trip length for retail practitioners and researchers are discussed.

1. Introduction

Understanding shopper behaviour metrics, such as shopping trip length, number of items purchased, or shoppers' navigation patterns is of great interest to the retail industry due to their direct influence on retailer performance indicators. A range of methods have been employed to obtain those insights: initially surveys, then researcher observation/shadowing and video surveillance (Scamell-Katz, 2012; Sorensen, 2009a; Millonig and Gartner, 2008; Underhill, 1999). More recently, radio frequency identification (RFID) or global positing system (GPS) tags (Utsch and Liebig, 2012; Hui et al., 2009) fitted to individual shoppers or shopping aids (carts, baskets) have provided insight to retailers and researchers. The increasing pervasiveness of smartphone ownership has given researchers the opportunity to track an individual's movements (Versichele et al., 2012; Stange et al., 2011; Utsch and Liebig, 2012; Abedi et al., 2013) and for store owners to track the wireless local area network (WLAN) and Bluetooth signals of their customers. In 2012, 76% of the Australian population owned a smartphone, and 40% of respondents who did not own a smartphone planned to purchase one in the next 12 months (Mackay, 2012) – in the US, 56% of adults own a smartphone, and 91% own a mobile phone of some kind (Smith, 2013). The majority of smartphones and portable electronic devices use a number of wireless protocols for communication, including Bluetooth (Abedi et al., 2013). These new technologies can be used for real-time auto-logging and are more effective than prior methods because they do not rely on shopper participation, associated observation bias, or shopper memory – the common pitfalls of traditional research methods. Yet, very few studies have examined the trustworthiness of data collected using such technologies. In this research, the authors address this gap by pursuing two objectives: (1) to test the validity of shopping trip length data obtained through Bluetooth logging; and (2) to assess the representativeness of the sample obtained using Bluetooth auto-logging technology in a supermarket research.

A Bluetooth-enabled and discoverable device is an electronic device that has Bluetooth turned on and is actively sending or receiving wireless information. Bluetooth is a technology that enables digital devices to connect to each other wirelessly. It is designed for low power consumption and it is based on low-cost transceiver microchips (Bekkelien, 2012). Each discoverable Bluetooth device transmits a unique identifier, known as a media access control (MAC) address. It can connect and communicate with other discoverable Bluetooth devices within a radius of

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1–10 m (O'Neill et al., 2006), which varies according to the power rating of the Bluetooth equipment in the devices (Haghani et al., 2010). Setting up a Bluetooth detector is fairly simple. Retailers can easily purchase a Bluetooth detecting device (beacon) available on the market to track Bluetooth activities indoors. Every time a Bluetooth device passes the detected radius of the sensor, its MAC, Bluetooth device name, and the timestamp of the detection will be recorded (Versichele et al., 2012). These sensors can generate pedestrian counts and time stamps for entry and exit. Traffic counts generated during different times or days, at different areas of a shopping mall can provide insights for shopper behaviour that retailers could not get from their sales or transaction logs. However, as this is a non-random sampling method, it may lead to biased and misleading results when used to estimate behaviours (Heckman, 1979). While there has been much discussion of Bluetooth technology as a metric for monitoring pedestrian mobility (Versichele et al., 2012; Kostakos and O'Neill, 2008; Millong et al., 2009; Haghani et al., 2010), there has been relatively limited attention paid to the representativeness of the samples obtained using such technology, and researchers have called for studies to address this lacuna (Versichele et al., 2012; Utsch and Liebig, 2012; Stange et al., 2011; Kostakos and O'Neill, 2008).

This study aims to explore the validity of Bluetooth tracking data and the degree to which the samples obtained using automated Bluetooth tracking in shopper research represents the true shopper population in the following research questions:

- RQ1: What proportion of supermarket shoppers carry a Bluetooth *discoverable* device?
- RQ2: How *valid* is trip length data collected using Bluetooth?
- RQ3: How representative is the sample obtained using Bluetooth detection of supermarket shoppers in terms of *shopper behaviours* (shopping trip length, basket size and spend)?
- RQ4: How representative is the sample obtained using Bluetooth detection of supermarket shoppers in terms of *demographic characteristics*?

2. Literature review

2.1. Shopper research

Shopping trip length or time spent in-store has been coined as one of the three (along with money and angst) currencies shoppers bring to the store (Sorensen, 2009a, 2012a). Time affects decision-making through imposing (or not) restrictions on how many categories, brands and how much in-store communication the shopper is exposed to and information attended to (Park et al., 1989; Dhar and Nowlis, 1999). These, in turn, influence consideration set sizes, basket sizes and, eventually, the profitability of the store. Yet, the relationship between time and money is not straightforward. While some authors note (the expected) positive correlation – longer time in-store results in more money spent (Thomas and Garland, 1993) – others demonstrate that shoppers who find products quicker are more likely to buy additional items (McCann, 2012) and stores where time per item purchased is shorter tend to have higher revenues (Sorensen, 2009b). Furthermore, Sorensen uses the distribution of time in-store and the trip length congruity measure, to judge store efficiency. The above discussion indicates the importance of having robust measures of shopping trip length for retailing practitioners and researchers.

2.2. Bluetooth tracking

Bluetooth tracking is a versatile method, which has successfully been used to measure visit duration in a variety of settings. Over the past decade, researchers and practitioners have used Bluetooth technology in multiple applications to estimate human and vehicle traffic patterns. Researchers have matched MAC addresses detected from passing vehicles between successive points to provide a measurement of travelling time information for effective management of traffic conditions (Haghani et al., 2010); Versichele et al. (2012) and Stange et al. (2011) used Bluetooth to study pedestrian flow at outdoor public events and major festivals, such as Formula 1 races and the Ghent Festival in Belgium, which demonstrated the advantages of using Bluetooth to track mass event visitors and outlined its deficiencies. A joint Bluetooth/Wi-Fi scanning framework was introduced to assess the popularity of locations within a university campus and the average time spent 'on-campus' (Vu et al. 2010). Millonig and Gartner (2008) and Sorensen (2009b) have used novel technologies, including Bluetooth, to study patterns of shopper movement through a store, which has enabled the confirmation of assumptions (such as basic navigation patterns and time spent in store) made by practitioners and researchers.

Prior authors acknowledge the fact that Bluetooth tracking methods produce limited and potentially biased samples (Versichele et al., 2012; Kostakos and O'Neill, 2008), which raises concerns over the validity of such methods (Stange et al., 2011; Utsch and Liebig, 2012). This is because the tracking procedure and conditions are highly selective. To be tracked, a person must first: carry a Bluetooth-enabled device; second, Bluetooth on the device must be turned on (enabled); and third, the device must be sending or retrieving wireless information to be detected. A person's device must satisfy all of the above criteria when passing within the radius of a sensor in order to be detected (Versichele et al., 2012). This selection bias imposes key limitations on the representativeness of the sample, as certain segments of the population may be over- or under-represented (Rice and Katz, 2003). Many studies have revealed that the Bluetooth detection rate is low, as only between five and seven per cent of observed individuals are estimated to have a Bluetooth-enabled and discoverable device (Kostakos and O'Neill, 2008; Millong et al., 2009).

3. Method

3.1. Sample and procedure

This study was conducted in a typical suburban supermarket in a metropolitan city in Australia. The supermarket had a typical layout (approximately 1270 m^2) and was a part of a major retail chain. Researchers used three data collection methods in the same store, over the same period of time, to address the research questions. All three methods sample the same population. Methods one and two survey the *same* individuals, while method three anonymously samples the same population in terms of temporal and geographic space.

The *first method* was mall-intercept interviews ($n=324$) to determine the proportion of shopper population carrying a Bluetooth-enabled device (RQ1) and shopper demographic characteristics (RQ4). At the entrance[1] to the supermarket, every fifth shopper (as per systematic sampling (Zikmund et al., 2007)) was approached and invited to accept a sticker with an entry time stamp. The acceptance rate of this sticker was 78%. Shoppers were then required to return the sticker after they completed their shopping trip and participate in a five-minute interview. The compliance rate at the end of the shopping trip (number of interviews over the number of stickers accepted) was 74%. The

[1] Note that the supermarket has the same entry and exit point.