Smart Mobile Advertising at the Point of Purchase: Digital Shopping Cart Displays Increase Sales

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Abstract: Digital innovations in retail environments can significantly influence product choices and consumer spending. This research examines the effects of mobile, location-based advertisements delivered via digital shopping cart screens in a real-world field quasi-experiment. Results reveal two key effects on purchasing (i.e., quantity, variety, and spending). First, location-based digital cart ads increase purchase quantity and spending on advertised products, consistent with enhanced awareness and consideration at the point of purchase. Second, these ads increase quantity, variety, and spending on non-advertised products within the advertised category, indicating spillover effects beyond the focal product. To investigate these effects, we tested two ad formats: centrally displayed ads and peripherally displayed ads aligned with product locations in the aisle. Both formats significantly increased purchasing relative to shopping carts without ad displays, but peripheral ads did not reliably outperform central ads. Exploratory analyses further show that the effect of cart ads remains robust across store zones and throughout the shopping journey. Together, these findings show that in-cart ads not only drive sales of promoted products but also increase overall purchasing within advertised categories, highlighting the profit potential of in-cart, location-based advertising.

Keywords: retail technology; smart shopping carts; mobile advertising; point-of-purchase advertising; digital displays

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Retailers often use in-store advertising to stimulate purchases (Bues et al., 2017; Sorensen, 2016; Woodside and Waddle, 1975), and consumers accept and appreciate this tactic (Kantar, 2024): Consumers ranked in-store ads as their top media channel for advertisements — above even cinema ads and sponsored events — citing them as particularly trustworthy and useful. During recent years, in-store advertising has evolved with advances in technologies (Grewal et al., 2020; Villanova et al., 2021). Specifically, mobile advertising has become a central tool in retailers' promotional strategies. A large body of research has examined out-of-store mobile ads, typically delivered via smartphones, documenting their effects on purchases (e.g., Danaher et al., 2015; Fong, Fang, and Luo, 2015). At the same time, other research has investigated in-store advertising, focusing primarily on stationary formats such as shelf signage, endcaps, and digital displays, and demonstrating that such ads can influence product awareness, search, and sales (e.g., Burke, 2009; Herhausen, de Jong, and Grewal, 2025; Roggeveen, Nordfält, and Grewal, 2016).

Despite these advances, research on mobile advertising within the store environment remains scarce. Existing studies on mobile in-store advertising have almost exclusively relied on smartphone-based push notifications, often examined in hypothetical scenarios or virtual shopping environments, and rarely in field settings measuring actual purchases (Bernritter, Ketelaar, and Sotgiu, 2021; Bues et al., 2017). Moreover, smartphone-based ads differ fundamentally from other forms of in-store media in how they reach and engage shoppers, raising questions about whether findings from in-app advertising generalize to other mobile in-store technologies. The present research addresses this gap by examining in-store mobile advertising delivered through a novel retail technology: digital ads displayed within the shopping cart. With digital screens integrated into the shopping cart — on or behind the handlebar, for example (see Figure 1) — such "smart carts" can deliver information directly and dynamically to shoppers as they navigate the store (Schultz and Zacheus, 2025; Shankar et al., 2021).

In addition to its managerial relevance, this research contributes to the literature on in-store advertising by addressing three important research gaps. First, the present study provides the first test of whether location-based ads (LBA) delivered via shopping carts affect purchasing. Research on digital signage has focused on stationary displays; research on mobile in-store advertising has focused on ads in smartphone apps. While both smartphone ads and digital cart ads can be tailored to the location of the shopper, they differ substantially in the way they address shoppers' attention. Mobile smartphone ads need to actively grab shoppers' attention, usually via push notifications signaled by acoustic signals or vibrations, thereby interrupting the shopping process. With digital cart ads, ad presentation is smoothly integrated in the shopping trip and the ads are nearly always in the center of the shopper's attention. Thus, digital cart ads may well affect shoppers in different ways. Second, previous research on in-store LBA has either used scenarios or VR-based shopping simulations, measuring either purchase intention or simulated purchases. Only one prior study has examined LBA in a field setting, comparing out-of-store and in-store ad delivery via mobile phones (Bernritter et al., 2021). The present research extends this work by examining LBA delivered via digital shopping cart displays, and by deploying such ads across store zones to examine how in-store advertising unfolds throughout the shopping journey. Specifically, we show that such zone-specific ads increase shoppers' overall purchase quantity, variety, and spending. Third, research on in-store LBA has focused on the effects on a single advertised brand and has not examined whether LBA influences sales at a broader level. We demonstrate spillover effects of digital cart ads: They increase sales not only for advertised products, but also for other, non-advertised products within the advertised category.

Figure 1. Smart shopping cart with a digital display.

Note. The screen on the handlebar (black area) presented mobile ads for promoted products, whereas the space at the front of the cart (blurred white area) presented a print ad for a local company unrelated to the retail environment. (Identifying information of the advertising agency, retail outlet, and advertised company have been redacted.)

Conceptual Background: Digital In-Store Advertising

There are many types of location-based advertising, varying in their medium, mobility, and proximity. Location-based advertising can be analog or digital, stationary or mobile, and out-of-store or in-store. For instance, a roadside billboard alerting consumers to a McDonalds at the next exit is analog, stationary, and out-of-store, whereas an ad delivered to a shopper's phone while in McDonalds is digital, mobile, and in-store. In this research, we specifically investigate *digital in-store advertising*. Digital and mobile out-of-store advertising, typically delivered via push notification on a mobile phone (e.g., Danaher et al., 2015; Fong et al., 2015), is beyond the scope of our research. In this section, we instead situate our research within the increasingly specific literatures on (i) digital in-store advertising, progressing from stationary digital signage to mobile in-app ads, and then (ii) digital in-cart advertising, as differentiated from in-app advertising.

Digital In-Store Advertising

Research on traditional (i.e., print) in-store ads has provided a rich foundation for understanding shopper behavior. For instance, traditional endcap signage helps shoppers visually

locate the advertised product on the shelf (Otterbring et al., 2014), whereas traditional ads on shelves (e.g., recommendation flags) can expand consumers' consideration sets but may also increase choice difficulty—especially in environments with large assortments, like supermarkets (Goodman et al., 2013). More recently, due to the widespread adoption of in-store technologies, digital in-store ads have also become common. These typically consist of stationary screens, such as endcap or above-aisle signage, that dynamically display promoted brands or products. Aside from their dynamic content, digital in-store ads are similar to traditional signage (Burke, 2009). Digital signage can increase sales, particularly when the advertised product is relevant to the shopper's current needs and goals (Burke, 2009). In the most powerful study to date on digital signage, with 30 million shoppers across 237 in-store advertising campaigns, Herhausen et al. (2025) found that digital signage increased sales of advertised products by an average of 8%.

The effectiveness of digital signage also varies by ad content. Roggeveen et al. (2016) found that digital signage only increased sales when the ad promoted a price discount. Herhausen et al. (2025) found no effect of a price discount, but did find that the effect was accentuated for low-price products. These findings suggest that simply increasing consumers' awareness of the product may be insufficient for in-store ads to be effective. Digital signage also appears most effective for ads introducing novel products (Burke, 2009; Herhausen et al., 2025), and for ads highlighting hedonic products (Burke, 2009; Herhausen et al., 2025).

The proximity of in-store signage to the advertised product is also crucial. Traditional print signage increases sales more when located near the advertised product (e.g., shelf displays) than when presented farther away (e.g., storefront displays; Han, Chandukala, and Li, 2022). The same also holds for digital signage: The digital ads in the study by Herhausen et al. (2025) appeared randomly across the store, without regard for the advertised product's location in-store. Yet, for every 10 meters closer that the digital ad was to the product's location on the shelf, sales of the advertised product increased by 2%. Essentially, the nearer the in-store ad is to the advertised product, the greater its effect on sales. The importance of proximity for in-store signage reveals a need for further research, especially regarding the effectiveness of in-store ads with newer technologies such as mobile devices. Indeed, a transition from stationary to mobile in-store displays has the potential to change not only *where* consumers encounter advertisements, but also *what* ads they encounter and *when* they encounter them.

The role of ad-product proximity highlights the importance of selectively targeting shoppers depending on their in-store location (see Table 1 for an overview). Previous research on this topic used mobile apps to distribute push notifications on shoppers' mobile phones. Bernritter et al. (2021), for instance, compared out-of-store messages (i.e., near the target store) to in-store messages. They found that the same mobile ad was more effective in-store than out-of-store, but only for consumers with low product category involvement. A few other studies focused specifically on in-store mobile ads, albeit only in hypothetical scenarios or virtual reality settings (see Table 1). A common finding among these prior studies is that the location matters critically: In-store mobile ads are more effective when the ad is presented near the product than when it is presented farther away (Bues et al., 2017; Ketelaar et al., 2017, 2018; Van't Riet et al., 2016). In the next section, we introduce a novel and more precise technology for in-store, location-specific advertising.

Table 1. Contribution table: research on in-store location-based advertising

Study	Main IV	Main DV	Product Category	Device for LBA	Setting	Selected Finding(s)
Bues et al. (2017)	• Location congruence (entrance vs. shelf) • Price discount (30% vs. none) • Personalization (personalized vs. general message)	• Purchase intention for advertised brand	Wine	Push Notifications on Smartphone App	Scenario	• Location congruence increases purchase intention • Location is the most important driver of purchase intention (compared to personalization and price discount)
Van't Riet et al. (2016)	• Location congruence (shelf with target product vs. shelf with unrelated product) • Goal Relevance (target product on shopping list vs. not)	• Simulated purchase of advertised brand • Attitude towards the ad • Mediator: Intrusiveness	Tomato soup	Push Notifications on Smartphone App	Virtual Reality Supermarket (CAVE)	• Positive effect of location congruence on purchase when goal relevance is high • No effect of location congruence on purchase when goal relevance is low • No effect of location on perceived intrusiveness • Negative effect of location congruence on attitude when goal relevance is low • No effect of location on attitude when goal relevance is high
Ketelaar et al. (2017)	• Location congruence (shelf with target product vs. unrelated shelf) • Medium type (mobile message vs. fixed signage)	• Simulated purchase of advertised brand • Ad attention	Chocolate sprinkles	Push Notifications on Smartphone App	Virtual Reality Supermarket (CAVE)	• Location-based ads are more effective • No effect of medium type when ad is location congruent • Mobile message more successful when ad is not location congruent
Ketelaar et al. (2018)	• Location congruence (shelf with target product vs. unrelated shelf) • Ad openness (open vs. closed)	• Simulated purchase of advertised brand • Attitude towards the ad • Mediator: Intrusiveness	• Wine	Push Notifications on Smartphone App	Virtual Reality Supermarket (CAVE)	• No effect of location congruency on intrusiveness • Conditional effect of ad openness on purchase (via lower intrusiveness and more positive attiude) stronger for location-congruent than incongruent ad

Bernritter et al. (2021)[1]	• Location (out-of store vs. in-store) • Product category involvement • Control condition in Study 2	• Choice of advertised product category (pilot study) • Simulated purchase of advertised brand (Studies 1 and 2)	• Fashion (Pilot Study) • Wine (Studies 1 and 2)	Push Notifications on Smartphone App	• Field (Exploratory Pilot Study) • Virtual Supermarket (Study 1) • Scenario (Study 2)	• In-store LBA is more effective than out-of-store, but only when product category involvement is low • Reactance mediates the effect
This study	• Location-based ads (absent vs. present) • Presentation (central vs. peripheral display)	• Actual purchases of advertised brands • Actual purchases of non-advertised brands	Groceries (many categories)	Display on Smart Cart	Field Quasi-Experiment in Supermarket	• In-cart ads increase real spendings on advertised and non-advertised products. • The spillovers occur within, not across, categories. • The increase for non-advertised products is relatively stronger than for advertised products. • Effects persist across store zones

Note. [1] Study 3 of this paper focused on out-of-store LBA only and thus is not listed in this table.

Digital In-Cart Advertising

Here we briefly introduce "smart" digital shopping carts, we summarize the very limited prior research on smart carts, and then we elaborate the physical and psychological differences between in-cart ads and in-app ads on mobile phones. Figure 1 shows a smart cart with a digital display. At its most basic, such a cart display can deliver location-general information, including ads that are not location-targeted. For instance, the cart could be programmed to display a series of ads in an endless loop, so that shoppers are exposed to the ads regardless of where they are in-store. When combined with Bluetooth technology, however, smart carts can also display location-targeted messages (Shankar et al., 2021): Retailers can place unobtrusive Bluetooth beacons at specific locations throughout the store, effectively creating invisible fences to define zones. As a digital cart approaches a beacon or crosses from one zone into another, targeted ads can be delivered to the in-cart display. For instance, retailers can automatically trigger a promotional video about wine on the cart's screen when a shopper enters the wine section of the shop, allowing retailers to deliver ads precisely when and where they might have the greatest impact.

In hypothetical shopping scenarios, consumers report a high willingness to use smart carts (Schultz and Zacheus, 2025), and presentation of nutritional information on an in-cart display can increase hypothetical choice of healthier foods (Eriksson et al., 2023). In the only in-store experiment to date with a smart cart, Van Ittersum et al. (2013) attached an iPad to a shopping cart, enabling shoppers to track their spending as they shopped. Van Ittersum et al. found that the smart carts affected spending, specifically increasing spending among budget shoppers and decreasing spending among non-budget shoppers. These prior studies suggest that consumers are willing to use smart carts, and that smart carts can affect consumers' product choices and spending. However, no prior research has examined the presentation of in-store ads on smart carts. The present research does so.

Note that ordinary push notifications delivered to mobile phones via cell towers lack the precision to target small areas, such as different zones of a shop. Technically though, such location-specific ads are possible on a mobile phone: If shoppers were to use the retailer's app on a Bluetooth-activated mobile phone in-store, their phone could similarly receive location-specific ads from in-store beacons. Although that is technically possible, we are not aware of any prior research that has examined such location-specific, in-app ads. The most relevant prior study was by Bernritter et al. (2021), who used Bluetooth-enabled in-store beacons to deliver in-app ads to shoppers' mobile phones. However, those ads were not location-specific, as the same ad was delivered regardless of the shopper's location in-store.

Moreover, mobile ads delivered via shopping cart display (*in-cart ads*) differ from those delivered via mobile phone (*in-app ads*) in several physical respects. (i) Reach: In order to receive location-specific in-app ads, the shopper must have downloaded the retailer's app, their phone's Bluetooth functionality must be switched on, and they must notice the promotional alert on their phone while shopping. In contrast, in-cart ads are displayed in plain sight to all cart shoppers. (ii) Persistence: In-cart ads are persistently available, with factors such as ad duration and frequency at the retailer's discretion, whereas in-app ads are accessible only at the shopper's discretion. (iii) Location-specificity: Shoppers receive in-app ads wherever they are when they choose to check their notifications, whereas they receive in-cart ads only at selected locations in-store, allowing retailers to deliver ads at the location of their choice. (iv) Manual constraint: In-app ads require the shopper to hold their phone, thereby occupying one hand. In-cart ads are hands-free, allowing shoppers to more easily pick up and inspect products. Collectively, the (i)

greater reach, (ii) greater persistence, (iii) more specific localization, and (iv) reduced manual constraint suggest that in-cart ads may be especially effective.

Those physical differences also suggest that in-cart ads and in-app ads may activate different psychological processes. (i) Awareness: Due to the greater reach and persistence of in-cart ads, they presumably increase awareness of the advertised product. (ii) Attention: In-app ads pull attention away from the retail environment, toward the phone. In-cart ads appear in a forward-central position. Thus, whereas in-app ads distract shoppers (Grewal et al., 2018), in-cart ads maintain shopper's attentional focus within the retail environment. (iii) Search demands: Due to the greater location-specificity of in-cart ads, they presumably reduce the search demands and increase the likelihood of successfully locating the advertised product. (iv) Reactance: Consumers often perceive in-app ads as intrusive (Ketelaar et al., 2018; Van't Riet et al., 2016), sometimes triggering reactance against the advertised product (Bernritter et al., 2021), whereas they tend to respond more positively to in-cart communications, particularly when these provide task-relevant information (Schultz and Zacheus, 2025). To be clear, our research was not designed to discriminate between these psychological processes. Nonetheless, to the extent that in-cart ads differ physically and may evoke different psychological processes from in-app ads, any findings from in-app ads may not generalize to in-cart ads. Thus, research directly investigating consumer responses to in-cart ads is needed. In the next section, we motivate our hypotheses about how in-cart ads affect shoppers' purchases.

Hypothesis Development

The present research adopted an empirics-first approach (Golder et al., 2023), aiming to identify and illuminate a novel, real-world marketing phenomenon (i.e., in-cart ads). So to be clear, this research was not designed to decisively test or discriminate among the various psychological processes that may underlie this presumed effect. Nonetheless, we do provide a few basic predictions grounded in current theory, and our results ultimately do provide more evidence for some psychological processes than for others, as is common among empirics-first research. In this section, we summarize some possible mechanisms by which in-cart ads may affect purchasing, and we present hypotheses that are motivated by that prior theorizing.

Advertised Products

A wealth of prior research on in-store advertising has revealed several psychological mechanisms underlying its effectiveness, including but not limited to those mentioned above. Most simply, (i) in-store ads raise *awareness* of the advertised product (Cobb and Hoyer, 1985), and when delivered near the product's location, (ii) in-store ads can help shoppers *locate* (or find) the advertised product (Inman, Winer, and Ferraro, 2009). Of course, in order to purchase a product, shoppers must be aware of it. And due to shoppers' limitations in attention (Kahneman, 1973) and memory (Miller, 1956), they tend to be consciously aware of only a small fraction of the available products at any given moment (Streicher, Estes, and Büttner, 2021). So by simply raising awareness of the advertised product, an in-cart ad may bring it into shoppers' consideration set (Zhang et al., 2009). But awareness, consideration, and even purchase intent are insufficient for purchasing; rather, to purchase the advertised product, shoppers must also locate it in-store. Indeed, shoppers spend a lot of time searching for products they want to purchase, and they very often fail to find them (Titus and Everett, 1996). By advertising products near their location in-store, however, in-cart ads could make product search more effective. For one thing, if shoppers know that an advertised product is nearby, they may be more motivated to search for it (Inman et al., 2009), knowing that they may find it with relatively little effort. Moreover,

seeing a product's branding or package in an ad can make it easier to visually locate and recognize that product on the shelf (i.e., *perceptual priming*; Otterbring et al., 2014). Thus, location-based cart ads likely facilitate both considering and locating the advertised product. And bringing in-store stimuli such as ads and products into visual attention, in turn, facilitates unplanned purchasing (Büttner, Florack, Leder, et al., 2014; Streicher et al., 2021). Consequently, location-based cart ads may trigger unplanned purchases, thereby increasing purchases of advertised products.

> **H_1**: Relative to shopping carts with no ad display, carts with location-based ad displays increase purchasing (i.e., quantity, variety, and spending) of advertised products.

To test **H_1**, we used two types of shopping carts: a standard cart with no digital display, and a cart with a display embedded in the handlebar (see Figure 2). We used three distinct but related measures of purchasing, using those reported in a similar in-store study by Estes and Streicher (2022): Purchase *quantity* is the total number of products purchased, purchase *variety* is the number of unique products purchased (i.e., not counting duplicates), and *spending* is the total amount spent on those purchases. To illustrate, a shopper who purchases two cans of Coca Cola and one can of Dr Pepper, each for €1, would have a total purchase quantity of 3, variety of 2, and spending of €3. If that shopper had been exposed to an ad for Coca Cola, they would have a quantity of 2, variety of 1, and spending of €2 on advertised products. To be clear, these three measures are correlated and non-independent (Estes and Streicher, 2022). Nevertheless, they capture distinct aspects of purchasing behavior and thus offer complementary insights. Purchase quantity reflects the overall volume of items acquired, whereas purchase variety captures assortment expansion across unique products, and spending reflects the aggregate financial impact of these choices. Moreover, differential changes across these variables can indicate specific shifts in purchasing patterns. For example, stockpiling would be reflected in unchanged variety alongside increases in purchase quantity and spending. A shift toward cheaper or more expensive products would be reflected in changes in spending, but not in purchase quantity or variety. Increases in all three variables, by contrast, would indicate a general increase in purchasing. Accordingly, we included all three to explore whether the presumed effect is robust across measures, or whether in-cart ads may differentially affect the measures. In the following, we use the term *purchasing* as an umbrella for these three measures, and we explicitly indicate when significant effects apply only to a subset of these outcomes.

Figure 2. Shopping carts with (left) and without (right) a digital display.

Note. Identifying information of the advertising agency, retail outlet, and advertised company have been redacted.

Non-Advertised Products

Beyond their effects on advertised products, in-cart ads may also increase purchasing of other, non-advertised products. Such a generalized effect could arise from attentional and/or memorial processes. In terms of attention, in-cart ads could stimulate purchasing of non-advertised products by exposing shoppers to other products located along the path to the advertised product, or on the shelf near the advertised product. Visual search consists of two broad modes: *goal-directed search*, which is driven by top-down factors such as current needs or wants, and *exploratory search*, which is predominantly influenced by bottom-up factors such as shelf displays (Janiszewski, 1998). Goal-directed search, in our context, would be specifically searching for the advertised product. Guiding shoppers toward specific shelf regions (e.g., an advertised product) may increase exposure to other products along that path (Abratt and Goodey, 1990; Russell and Kamakura, 1997), and on the shelf near the advertised product. Those

exposures may lead shoppers to consider the seen non-advertised products, thereby stimulating unplanned purchases (Chandon et al., 2009; Diehl, Van Herpen, and Lamberton, 2015). Exploratory search may be even more general, with shoppers intentionally exploring the assortment for interesting products. In-cart ads could encourage shoppers to engage in such active visual exploration. Indeed, stimulating visual exploration via front-of-store digital signage (e.g., product promotions) can activate an exploratory mindset characterized by more dispersed viewing patterns (i.e., looking around more) and greater physical exploration (i.e., walking farther in-store), thereby increasing product exposures and unplanned purchases (Streicher et al., 2021). Thus, by increasing the product array that shoppers see and consider, both goal-directed and exploratory visual search could trigger unplanned purchases across various product categories, not only of the advertised products.

In terms of memory, in-cart ads could stimulate purchasing of non-advertised products by reminding shoppers of other brands within the advertised category, or even other brands that may complement the advertised product. Memory is well known to involve a process of spreading activation, whereby activating one concept (e.g., via exposure) automatically activates other, associated concepts (Anderson, 1983; Collins and Loftus, 1975). This spreading activation produces a cognitive phenomenon called *semantic priming*. As described above, Otterbring et al. (2014) showed that in-store ads facilitate visual recognition of the advertised product, via a process of perceptual priming. Likewise, semantic priming occurs when exposure to one concept brings to mind another, categorically-related concept (Neely, 2012). For instance, seeing an ad for Budweiser might remind shoppers of Stella Artois (Lee and Labroo, 2004). In a set of studies with a restaurant-search website, for example, an ad for a particular restaurant (e.g., Pizza Hut) increased sales likelihood for competitors from the same category (e.g., Domino's; Sahni, 2016). Activating a concept can also bring to mind other, thematically-related concepts from different categories that in some way complement that concept (Estes, Golonka, and Jones, 2011). For example, a Budweiser ad might additionally remind shoppers of pizza (Estes et al., 2012), or an ad for wine might activate a desire for cheese. And crucially, activating or bringing to mind a particular brand or product increases its likelihood of entering the shopper's consideration set (Sahni, 2016), and may also increase its processing fluency (Berger and Fitzsimons, 2008; Mohsenin and Munz, 2025), thereby increasing its likelihood of being chosen or purchased. Thus, due to spreading activation and semantic priming, in-cart ads may increase purchasing beyond the advertised products.

In-cart ads might trigger yet another potential psychological process that includes elements of both attention and memory: distraction from shopping routines. Recent studies showed that shopping-unrelated use of mobile phones in-store disrupts shoppers' normal routine, leading them instead to spend more time in-store viewing more products (Grewal et al., 2018) and making more unplanned purchases (Sciandra, Inman, and Stephen, 2019). In-cart ads differ importantly, in that they are shopping-relevant. Nevertheless, by diverting shoppers' attention from their normal shopping routine, in-cart ads might similarly lead shoppers to view and purchase more products unplanned. Taken together, then, various attentional and memorial processes suggest that in-cart ads may increase purchasing of non-advertised products.

H_2: Relative to shopping carts with no ad display, carts with location-based ad displays increase purchasing (i.e., quantity, variety, and spending) of non-advertised products.

Although we had no specific hypothesis about it, we also explore whether this presumed effect on non-advertised products might occur within the advertised category (i.e., *within-category spillover*), or across product categories (i.e., *cross-category spillover*). To illustrate, an in-cart ad for Coca Cola might increase purchasing of Dr Pepper (within-category) and/or pizza (cross-category). This difference is both managerially relevant and theoretically informative. It is managerially relevant because within-category spillover would indicate that advertising a target brand boosts purchasing of its competitors, akin to competitive interference in advertising, whereby an ad for one brand hinders memory for another brand's ad (Burke and Srull, 1988). Such a competitor boost could be positive for retailers, but may be undesirable for the advertised brand. Cross-category spillover would also be positive for the retailer, to the extent that it increases purchasing. Regarding theoretical insights, any of the attentional and memorial processes described above would predict within-category spillover. However, the occurrence or absence of cross-category spillover could constrain theoretical explanation. Specifically, exploratory visual search, thematic priming, and distraction would all predict cross-category spillover: Visual exploration entails viewing objects across category boundaries (Streicher et al., 2021), thematic priming entails consideration of products outside the advertised category that may complement the advertised product (Estes et al., 2011), and distraction activates broad exploration of the assortment (Grewal et al., 2018). Thus, a lack of cross-category spillover would suggest that neither visual exploration, thematic priming, nor distraction underlies the presumed effect of in-cart ads on purchasing of non-advertised products.

Spatial Attention

As described above, one possible psychological mechanism through which in-cart ads may affect purchasing is in locating the product: By displaying the advertised product near its location on the shelf, in-cart ads may help shoppers find the product. To further examine this possible mechanism, we used two variants of digital cart ads, shown in Figure 3: (a) *centrally-displayed ads*, which appear in the center of the screen and (b) *peripherally-displayed ads*, which appear on the left or right side of the screen and include a stylized arrow indicating whether the advertised product is located on the left or right side of the shopping zone. The peripheral ads were intended to spatially orient shoppers' visual attention to the product's location, thereby further increasing purchases of advertised products. Indeed, orientation cues can influence where and how consumers allocate attention (Goodman et al., 2013; Titus and Everett, 1995). Specifically, arrows are well-established orientation cues (Posner, 2016; Tipples, 2002) that reliably direct visual attention toward the indicated location (Chacón-Candia et al., 2023). So to the extent that in-cart ads work by helping shoppers find the advertised product, peripheral ads should increase purchasing of advertised products more than central ads do.

Figure 3. Examples of mobile ads in the 'central display' (top), 'peripheral-left' (middle), and 'peripheral-right' (bottom) conditions.

Beyond orienting shoppers' attention toward the area where the advertised product is located, peripheral ads might also increase purchasing of non-advertised products, by activating exploratory search (see Janiszewski, 1998; Titus and Everett, 1995). Streicher, Estes, and Büttner (2021) presented promotional products on a screen to shoppers, but critically, those promoted products all appeared either in the center of the display, or at various locations on the periphery of the display. They found that the peripheral display led shoppers to explore the store assortment more, and ultimately to purchase more products unplanned. In the present study, our peripheral in-cart ads alternated between one advertised product on the left side of the display (with left-pointing arrow), and another advertised product on the right (with right-pointing arrow). We reasoned that these peripheral in-cart ads thus might similarly activate exploratory search, further increasing purchasing not only of advertised products, but also of non-advertised products.

> **H_3**: Relative to centrally displayed in-cart ads, peripherally displayed in-cart ads increase purchasing (i.e., quantity, variety, and spending) of (**A**) advertised products and (**B**) non-advertised products.

We tested these hypotheses in a field quasi-experiment with over 1200 real shoppers spending their own money in a grocery store. We installed Bluetooth beacons at strategic locations across the shop, demarcating different zones of the store. As shoppers entered the store, we provided them with either a standard shopping cart with no display, or a smart cart with a Bluetooth-enabled digital display on the handlebar (Figure 2). As the shoppers with the smart carts entered different store zones, their carts received digital ads that promoted products available in that zone. Because in-store ads are more effective when including price discounts (Roggeveen et al., 2016), all in-cart ads included price discounts. The in-cart ads appeared centrally for some shoppers, or peripherally for other shoppers (Figure 3).

Methods

Setting. The study was conducted across eight days, from approximately 9am to 5pm, in a mid-sized grocery store (approx. 1200 m^2) in a mid-sized European city.

Participants. 1236 shoppers were pseudo-randomly distributed among the 'no display' (n = 454), 'central display' (n = 369), and 'peripheral display' (n = 413) groups. The study had a quasi-experimental design because we were unable to fully randomize assignment of shoppers to shopping carts, as explained below. Participants were not informed that they were part of a study.

Ad displays. The study included different shopping carts (Figure 2) differing only in their digital ad displays (Figure 3). The 'no display' group shopped with a standard cart without a digital display. The 'central display' group used a cart that included a digital display located centrally on the cart handlebar, with advertisements shown centrally on the display. The 'peripheral display' group used the same shopping cart, except that the advertisements were instead shown on the left or the right half of the display (within-participants). The digital displays in the carts used by the central and peripheral groups were Bluetooth-enabled, allowing us to present mobile ads specific to the shopper's location.

Location-tracking. The store layout partially constrained shoppers' journeys, guiding shoppers through a typical path. In consultation with shop managers, we segmented the shop into seven distinct shopping zones along that path (see Figure 4). We then created a series of invisible fences demarcating each zone by placing Bluetooth low energy beacons along the boundaries of each zone. The beacons were suspended from the ceiling, well above the shopping area, where

shoppers were unlikely to notice them. This allowed us to deliver location-specific ads across the shopping journey.

Figure 4. Floor plan (blurred) illustrating product displays, typical shopping journey (red arrows and brown hashed area), and shop zones (demarcated in red).

Mobile ads. As shoppers in the central and peripheral display groups entered each zone, the cart display received a signal from the beacons demarcating that zone, triggering two advertisements on their cart displays. The two ads within each zone were shown twice each, in alternating order: Each ad appeared initially for two seconds to capture attention, and then for three seconds to allow for more detailed processing. Directionally from the entrance of each zone, one advertised product was located to the left, and one was located to the right. The seven

zones each triggering two ads resulted in a maximum of fourteen product ads throughout the shopping journey, though shoppers who did not enter all zones of the shop saw correspondingly fewer ads.[1] (Note that our analyses assume equal numbers of zones entered and hence ads shown across groups.) Each ad included an image of a branded product and its discounted price.

For shoppers in the central display group, the ads always appeared in the center of the display, and the ads did not indicate on which side of the zone each product was located (Figure 3, top). Thus, the display contained no spatial information. Shoppers in the peripheral display group saw ads for the same products (with minor adjustments for the reduced display size), but each ad appeared on either the left or the right of the display. In this group, each ad was additionally accompanied by an arrow that cued shoppers to the location of the advertised product (Figure 3): Products were always shown on the side of the display that corresponded to the product's location relative to the zone entrance (and presumably to the shopper), and the arrow also always pointed toward the product's location (i.e., left or right). After both ads in the given zone were displayed twice each (in alternating order), the display remained blank until the shopper's cart reached another zone.

Procedure. The study included 15 standard 'no display' shopping carts, 15 'central display' carts, and 15 'peripheral display' carts. The shopping carts were stationed in a designated area at the store entrance. During the period of study, we placed a research assistant (*RA*) at the cart area. As shoppers entered the cart area, the RA pseudo-randomly distributed the three cart-types among shoppers.[2] The standard cart was visibly discernible from the display carts by the handlebar (Figure 2). We visually differentiated the central and peripheral display carts by colored tape placed on the far side of the cart and out of view of the shopper: Central displays were marked with a small red tape, whereas peripheral carts had a small blue tape. Another RA (or two RAs during peak times) was stationed inconspicuously after the checkout area. As each shopper checked out, the cashier printed an extra receipt. When the shopper exited the checkout area, the RA retrieved this duplicate receipt from the cashier, and marked the receipt with a red or blue marker to indicate a central or peripheral display, respectively. Receipts from the no-display group were left unmarked. Because the receipt was printed and handed directly from the cashier to the RA, data collection did not require any action from shoppers (e.g., active compliance). This procedure ensured that purchase data were collected unobtrusively for all shoppers using the study carts.

Data. Our data consist of print copies of shoppers' receipts; we have no shopper data (e.g., gender, age, retailer loyalty). For each receipt, we manually coded each purchase as either an advertised product or a non-advertised product, and we recorded purchase quantity (i.e., the number of units purchased), purchase variety (i.e., the number of unique units purchased), and spending (i.e., amount spent). For instance, a purchase of two cans of Coca Cola at €1 each would be coded as quantity of 2, variety of 1, and spending of €2. Thus, we had nine primary

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[1] Note that the majority of people were exposed to at least 5 out of 7 zones due to the physically constrained pathway through the shop. The 14 advertised products were as follows. Zone 1: strawberries, poppy seed rolls; Zone 2: sparkling wine, grilled sausages; Zone 3: milk, mozzarella cheese; Zone 4: canned tuna, pesto sauce; Zone 5: fruit juice, beer; Zone 6: frozen pollock, frozen breaded fish; Zone 7: potato chips, chocolate. Each ad promoted a specific branded product. Several ads promoted the store's own brand, so for confidentiality, we do not identify the specific brands promoted in the ads.

[2] Because the RA was unable to keep a precisely accurate mental count of each cart-type distributed throughout each day, and because during peak times some shoppers grabbed a shopping cart of their own volition before the RA could provide one, shoppers were not perfectly distributed among the three cart-type groups.

measures: quantity, variety, and spending on advertised products, on non-advertised products, and on total products (i.e., sum of advertised and non-advertised products).

Analyses. The various measures had differing characteristics that required varying analyses. For advertised products, purchase quantity and variety were mildly overdispersed, so we used Poisson regression with a log link function. And given the preponderance of zeros in these measures (i.e., 87.9% of shoppers bought none of the advertised products), we compared an ordinary Poisson to a zero-inflated Poisson (ZIP). Because the model fit was substantially better with ZIP than with ordinary Poisson for both quantity and variety, we report the ZIP results below. For non-advertised products, purchase quantity and variety were highly overdispersed, so we used negative binomial (NB) regression with a log link function and an estimated dispersion parameter, and we tested it against zero-inflated negative binomial (ZINB). Because the model fit was better with ordinary NB than with ZINB for both quantity and variety, we report the NB results below. Total quantity and variety were also highly overdispersed, but contained no zeros (i.e., all shoppers purchased at least one product), so we also used ordinary NB regression (rather than ZINB) for those analyses. Finally, raw spending variables (i.e., on advertised, non-advertised, and total products purchased) were substantially skewed, so we log-transformed them to reduce skew, and then we analyzed them via OLS regression or ANOVA as appropriate. Note that all tables and figures show raw spending amounts, whereas analyses use log-transformed spending. The data and analysis code are available at the Open Science Framework.[3]

Results

As detailed below, carts with a display (either central or peripheral) increased purchase quantity and spending on the advertised products, and quantity, variety, and spending on non-advertised products within the advertised category. Relative to the central display, however, the peripheral display did not further increase any of the three purchase outcomes (i.e., quantity, variety, or spending). Thus, digital cart ads generally increased purchasing of both advertised and non-advertised products, and this effect appeared generally robust across the shopping journey.

Relationship between advertised and non-advertised purchasing. Intercorrelations among measures are reported in Table 2, and several findings emerged. First, purchase quantity, variety, and spending were highly correlated among advertised products (all $r \geq .73$), and also among non-advertised products (all $r \geq .72$). Second, purchase quantities and varieties of advertised products weakly but significantly correlated with purchase quantities and varieties of non-advertised products (all $.08 \leq r \leq .10$), indicating that shoppers who bought more advertised products also tended to buy slightly more non-advertised products. That is, some shoppers simply bought more products than other shoppers, regardless of the in-cart ads. Third, purchase quantity and variety of advertised products did not predict spending on non-advertised products (both $r \leq .02$), nor did purchase quantity or variety of non-advertised products predict spending on advertised products (both $r \leq .02$). Finally, spending on advertised and non-advertised products correlated negatively ($r = -.11$). That is, shoppers who spent more on advertised products tended to spend slightly less on non-advertised products. This likely reflects an individual difference in sensitivity to price discounts (e.g., Ortmeyer, Lattin, and Montgomery, 1991), with some shoppers focusing their spending on advertised (and therefore discounted) products.

[3] https://osf.io/ga83s/?view_only=71bfd3564ea14befba054b97e60b4de4

Table 2. Intercorrelations among measures. "Advertised" and "Non-Advertised" indicate advertised and non-advertised products, respectively. ** $p < .01$; *** $p < .001$.

	1.	2.	3.	4.	5.	6.
1. Advertised Quantity	—					
2. Advertised Variety	.93***	—				
3. Advertised Spend	.73***	.73***	—			
4. Non-Advertised Quantity	.08**	.10***	.02	—		
5. Non-Advertised Variety	.08**	.09**	.01	.92***	—	
6. Non-Advertised Spend	.00	.02	-.11***	.76***	.72***	—

Table 3. Purchase quantity, variety, and spending on advertised products, non-advertised products, and total purchases as a function of display-type in the shopping cart.

		Advertised Products		Non-Advertised Products		Total	
Display	Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
None	Quantity	0.18	0.77	17.18	12.47	17.36	12.56
	Variety	0.12	0.51	12.13	8.73	12.25	8.76
	Spend (€)	0.92	4.92	45.24	37.94	46.15	38.25
Central	Quantity	0.35	1.47	18.91	13.38	19.26	13.65
	Variety	0.21	0.86	13.75	9.93	13.96	10.11
	Spend (€)	1.78	7.45	48.42	35.92	50.20	36.95
Peripheral	Quantity	0.39	1.48	19.39	15.13	19.78	15.26
	Variety	0.22	0.72	13.92	10.67	14.13	10.72
	Spend (€)	2.08	8.21	53.33	44.66	55.41	45.35

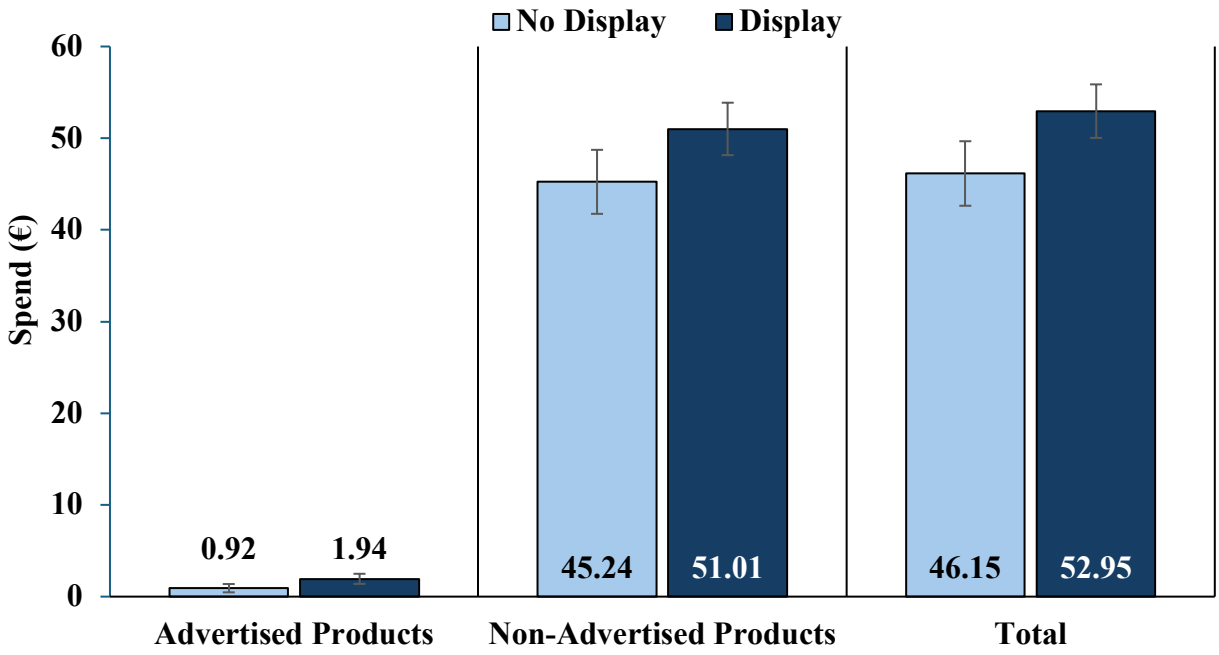
Effects of the cart display-type (i.e., none, central, peripheral) on purchase quantities, varieties, and spending are summarized in Table 3. Below we report results of display-type separately for advertised products, non-advertised products, and total purchasing, before proceeding to test the effect across the shopping journey and across different category-types. We illustrate all effects using our bottom-line measure of spending, which directly captures the economic impact of in-cart ads, as it incorporates both the quantity of products purchased and their price, thereby providing a parsimonious summary of the underlying effect across measures. However, because advertised products were promoted with price discounts, spending effects should be interpreted alongside the other purchase measures (quantity and variety), which provide a more precise indication of purchasing effects. We therefore report full results of all three purchasing measures in the Web Appendix, where we also illustrate the key effects with purchase quantity and purchase variety (whereas spending is shown here in the main document).

Advertised products. As expected, cart displays increased purchasing of the advertised products. Compared to no display, carts with a display (either central or peripheral) increased purchase quantity and spending on advertised products. ZIP regression on purchase quantity revealed that carts with a display significantly increased the likelihood of purchasing (zero model: B = -.44, SE = .21, z = -2.11, p = .035), and also increased the quantity of purchases (count model: B = .34, SE = .16, z = 2.18, p = .029). The effect on purchase variety was nonsignificant (see Web Appendix, Table A1), but this null effect should be interpreted with caution, as the limited number of advertised products limits variation in this measure, thereby reducing the likelihood of detecting changes in variety. Nonetheless, carts with a display significantly increased spending, B = .14, SE = .05, β = .09, $t(1235)$ = 3.16, p = .002. These effects on purchase quantity and spending support $\mathbf{H_1}$. The effect of cart displays on our bottom-line measure of spending is shown in the left panel of Figure 5. For analogous effects on purchase quantity and purchase variety, see Figures A1 and A2 in the Web Appendix. Relative to the central display, however, the peripheral display did not further increase purchase quantity, purchase variety, or spending (see Web Appendix, Table A2). This result did not support $\mathbf{H_{3A}}$.

Non-advertised products. Cart displays also significantly affected purchasing of non-advertised products. Compared to no display, carts with a display (either central or peripheral) significantly increased purchase quantity (B_{exp} = 1.12, χ^2 = 6.82, p = .009), purchase variety (B_{exp} = 1.14, χ^2 = 9.56, p = .002), and spending (B = .10, SE = .05, β = .06, $t(1235)$ = 2.15, p = .032) on non-advertised products (Web Appendix, Table A3). These results support $\mathbf{H_2}$, and the effect on spending is shown in the central panel of Figure 5. (See Web Appendix, Figures A1 and A2 for effects on purchase quantity and variety, respectively.) Relative to the central display, however, the peripheral display did not further increase purchase quantity, purchase variety, or spending (see Web Appendix, Table A4). This result did not support $\mathbf{H_{3B}}$.

Total purchasing. Cart displays also significantly affected total purchasing. Specifically, compared to no display, carts with a display (either central or peripheral) significantly increased total purchase quantity (B_{exp} = 1.13, χ^2 = 8.33, p = .004), total purchase variety (B_{exp} = 1.15, χ^2 = 10.65, p < .001), and total spending (B = .13, SE = .05, β = .08, $t(1235)$ = 2.80, p = .005). The effect on total spending is shown in the right panel of Figure 5. The effects on purchase quantity and variety are shown respectively in Figures A1 and A2 of the Web Appendix (see also Web Appendix, Table A5). Relative to the central display, however, the peripheral display did not further increase total purchase quantity, total purchase variety, or total spending (see Web Appendix, Table A6).

Figure 5. Spending on advertised products, spending on non-advertised products, and total spending. Error bars indicate 95% confidence intervals.



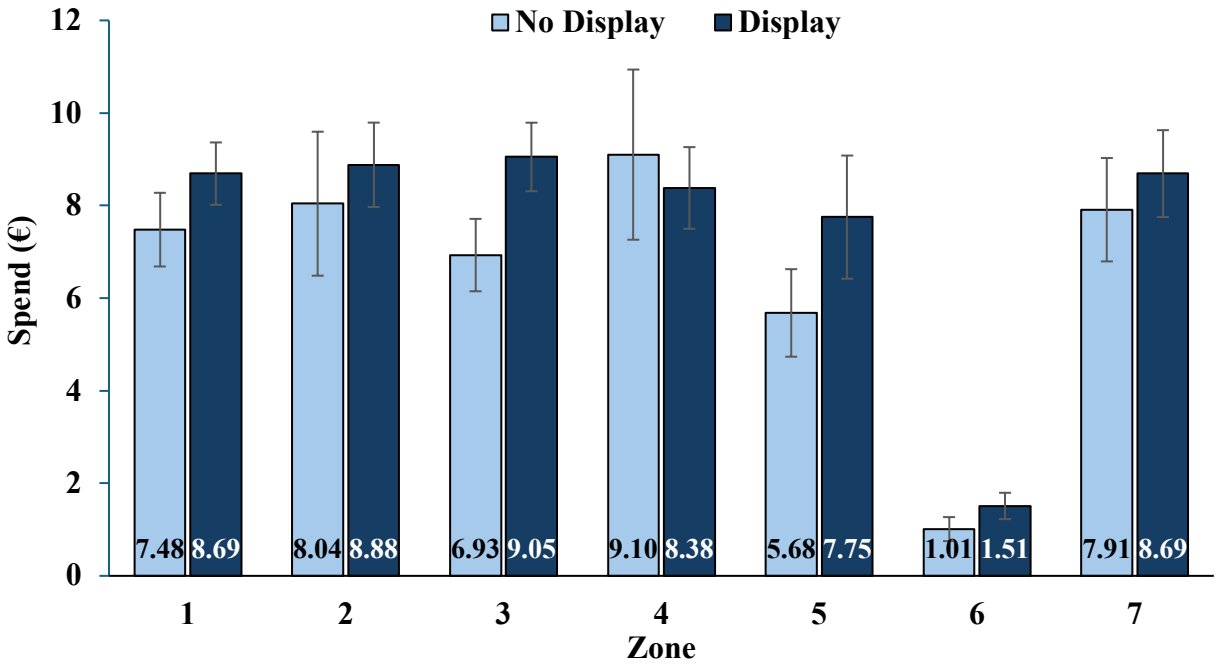
Prior research has established the effect of in-store digital signage on sales of advertised products (Herhausen et al., 2025). The present research reveals that in-cart ads can increase spending not only on advertised products, but also on other, non-advertised products. Although the *absolute* increase in spending was much larger for non-advertised products (€5.77) than for advertised products (€1.02; Figure 5), this difference should be interpreted cautiously, because it appears to simply reflect the fact that non-advertised products constitute a much larger share of shoppers' total basket than advertised products. In fact, the *relative* increase in spending was much larger for advertised products (111%) than for non-advertised products (13%).

In the remaining analyses reported below, we simplified the analyses based on our main results reported above: Given that the absence or presence of in-cart ads (whether central or peripheral) reliably affected purchasing, whereas the nested variable of display-type (central vs peripheral) did not affect purchasing, the following analyses focused only on the absence or presence of in-cart ads.

Robustness check. To test the robustness of our effect of a cart display (either central or peripheral) on total purchasing, we added as control variables the day of the week and the time of the day (both dummy coded) that the shopper checked out. Purchase quantity, purchase variety, and spending varied significantly across the day of the week and the time of the day (for detail see Web Appendix, Table A7). Most importantly, after accounting for day of week and time of day, the effect of a display (either central or peripheral) remained significant in purchase quantity ($B = 0.10$, $SE = 0.04$, $\chi^2 = 5.47$, $p = .019$), purchase variety ($B = 0.11$, $SE = 0.04$, $\chi^2 = 7.03$, $p = .008$), and spending ($B = .12$, $SE = .05$, $t(1235) = 2.55$, $p = .011$). Thus, the effect of digital cart ads on purchasing remained robust when controlling for the day of the week and the time of the day.

Purchasing across the shopping journey. The store layout (see Figure 4) constrained the shopping path. All shoppers entered at Zone 1 and proceeded through Zones 2, 3, and 4, as there was no other entry or exit point throughout those zones. Although there was a discreet shortcut after Zone 4 that led directly to the checkout, it was narrow, and informal observation indicated that few cart shoppers took that shortcut (it was used primarily by basket shoppers). Rather, the vast majority of cart shoppers continued sequentially through Zones 5, 6, and 7 to the checkout. Thus, the sequentially numbered zones provide a proxy measure of distance (and time) travelled through the shop. Figure 6 shows spending across the seven zones of the shop, comparing shoppers without a cart display to shoppers with a display (either central or peripheral). Carts with a display increased spending in most but not all zones of the shop. See Figures A3 and A4 in the Web Appendix, respectively, for purchase quantity and variety across store zones.

Figure 6. Spending across the shopping journey. Zones are shown in Figure 4. Error bars indicate 95% confidence intervals.

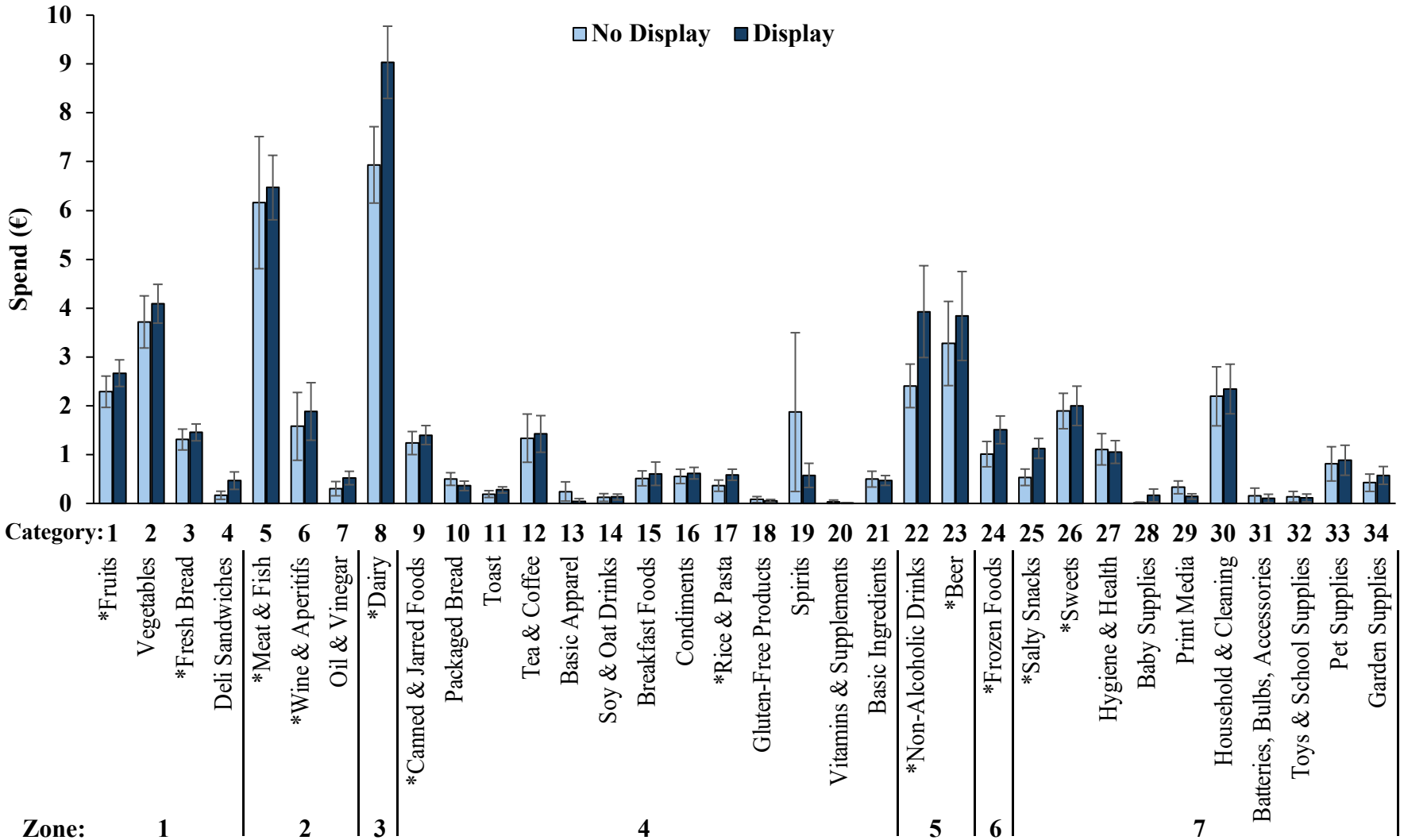


To test the effect of the cart display across zones, we conducted 2 (display: absent, present; between-participants) × 7 (zone: 1-7; within-participants) mixed ANOVAs on the three purchase outcomes. As reported above, the main effect of display was significant on purchase quantity, $F(1, 1234) = 7.13$, $p = .008$, purchase variety, $F(1, 1234) = 9.59$, $p = .002$, and spending, $F(1, 1234) = 6.51$, $p = .011$. The main effect of zone was also significant on purchase quantity, $F(6, 7404) = 231.38$, $p < .001$, purchase variety, $F(6, 7404) = 338.09$, $p < .001$, and spending, $F(6, 7404) = 216.53$, $p < .001$. This simply indicates that purchasing was higher in some zones than in others. In particular, purchasing was markedly lower in Zone 6 (frozen foods) than in all other zones (see Figure 6). Although the display × zone interaction was not significant in spending, $F(6, 7404) = 1.03$, $p = .403$, it was significant in both purchase quantity, $F(6, 7404) = 2.73$, $p = .012$, and purchase variety, $F(6, 7404) = 2.69$, $p = .013$. Full results are reported in Table A8 of the Web Appendix. Most importantly, there was little evidence that the display

decreased in effectiveness across the shopping journey. We further explore the reliability of the spending effect across specific product categories in the next section.

Purchasing across advertised and non-advertised categories. Based on the retailer's shelf and zone category organization (i.e., the planogram-level merchandising structure), we divided all products into 34 distinct categories. As shown in Figure 7, cart displays increased spending in most but not all product categories: Spending was numerically higher with a cart display than without it in 24 of the 34 categories (i.e., 71%). The effect was most pronounced among dairy (Category 8) and non-alcoholic drinks (Category 22), and it was most strongly reversed in spirits (Category 19). This latter, reversed effect on spirits appears to drive the overall null effect in Zone 4 more generally (see Figure 6).

Figure 7. Spending across product categories. Asterisks indicate categories in which a product was advertised in-cart. Error bars indicate 95% confidence intervals.



The effect of cart displays on spending on non-advertised products (see Figure 5) could be due to increased sales within the advertised category (i.e., *within-category spillover*), and/or beyond the advertised category (i.e., *cross-category spillover*). For instance, one of the ads promoted Lindt chocolates (see Figure 3), which was in Category 26 (i.e., sweets). That ad increased sales of Lindt chocolates; this is the effect of the cart display on sales of *advertised products*, shown in the left panel of Figure 5. But that same Lindt ad also increased sales of other products; this is the effect on sales of *non-advertised products*, shown in the central panel of Figure 5. A further question, however, is more precisely which types of non-advertised products were purchased: within-category, or cross-category. Did the Lindt ad, for instance, increase sales only of other sweets, or did it increase sales more broadly, even beyond the advertised category?

To test whether the in-cart ads induced within-category and/or cross-category spillover, we grouped all categories for which a product was advertised on the cart display (e.g., sweets); these *advertised categories* are denoted by an asterisk in Figure 7. We then also grouped all remaining categories for which no ad appeared on the cart display (i.e., *non-advertised categories*), and compared them via 2 (display: absent, present; between-participants) × 2 (category-type: advertised, non-advertised; within-participants) mixed ANOVAs on purchase quantity, purchase variety, and spending (see Web Table A9 for full results). Category-type significantly moderated the effect of the cart display (i.e., display × category interaction) on purchase quantity, $F(1, 1234) = 16.44$, $p < .001$, purchase variety, $F(1, 1234) = 16.11$, $p < .001$, and spending, $F(1, 1234) = 5.61$, $p = .018$). The interaction in spending is illustrated in Figure 8. (See also Web Figures A5 and A6 for the interaction in purchase quantity and purchase variety, respectively.) Planned contrasts indicated that, within the advertised categories, cart displays significantly increased purchase quantity, $F(1, 1234) = 12.88$, $p < .001$, purchase variety, $F(1, 1234) = 14.73$, $p < .001$, and spending, $F(1, 1234) = 15.05$, $p < .001$. Within the non-advertised categories, however, cart displays had no effect on any of the three purchasing outcomes (see Web Table A10). Thus, in-cart ads elicited within-category spillover, but not cross-category spillover. For example, the Lindt ad increased sales not only of Lindt chocolate, but also of other sweets (e.g., M&Ms). It did not increase sales beyond its own category, however.

Purchasing across food and non-food categories. We also explored the effect across alternative classifications of product categories. A common distinction among product categories in grocery retailing is that between food and non-food categories. *Food categories* included all foods and drinks (i.e., categories 1-12 and 14-26). *Non-food* categories included all remaining products (e.g., basic apparel, print media, garden supplies; categories 13 and 27-34). Separate 2 (display: absent, present; between-participants) × 2 (category-type: food, non-food; within-participants) mixed ANOVAs revealed significant moderation (i.e., display × category interaction) on purchase quantity, $F(1, 1234) = 9.15$, $p = .003$, purchase variety, $F(1, 1234) = 13.36$, $p < .001$, and spending, $F(1, 1234) = 7.30$, $p = .007$. Full results are reported in Table A11 of the Web Appendix. The interaction on spending is illustrated in Figure 9. (See also Web Figures A7 and A8 for the interaction in purchase quantity and purchase variety, respectively.) Planned contrasts revealed that, within food categories, cart displays significantly increased purchase quantity, $F(1, 1234) = 8.43$, $p = .004$, purchase variety, $F(1, 1234) = 11.98$, $p < .001$, and spending, $F(1, 1234) = 14.36$, $p < .001$. Within the non-food categories, however, cart displays had no effect on any of the three purchasing outcomes (see Web Table A12). We refrain from speculating about the cause of this moderation, though, and we caution that the finding is exploratory. In particular, we note that all in-cart ads featured food products; non-food products

did not appear in any of the in-cart ads. Thus, it is unclear whether the apparent moderation by category-type may be due instead to food products being featured in the in-cart ads.

Figure 8. Spending on advertised and non-advertised categories. Error bars indicate 95% confidence intervals.

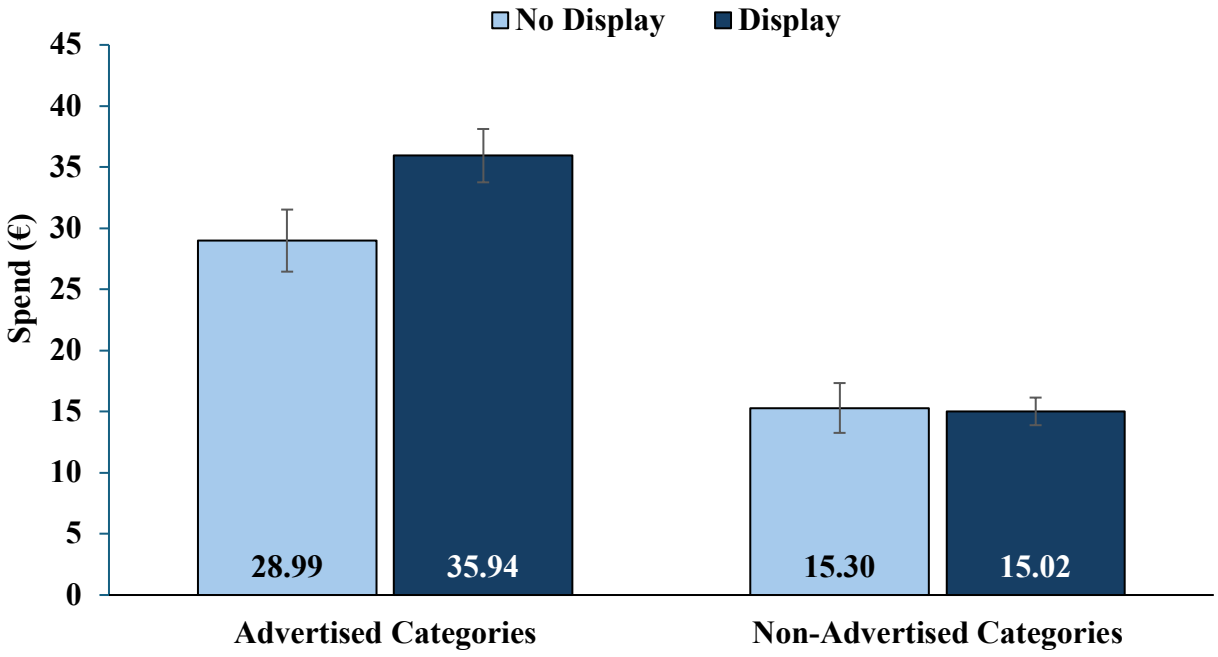
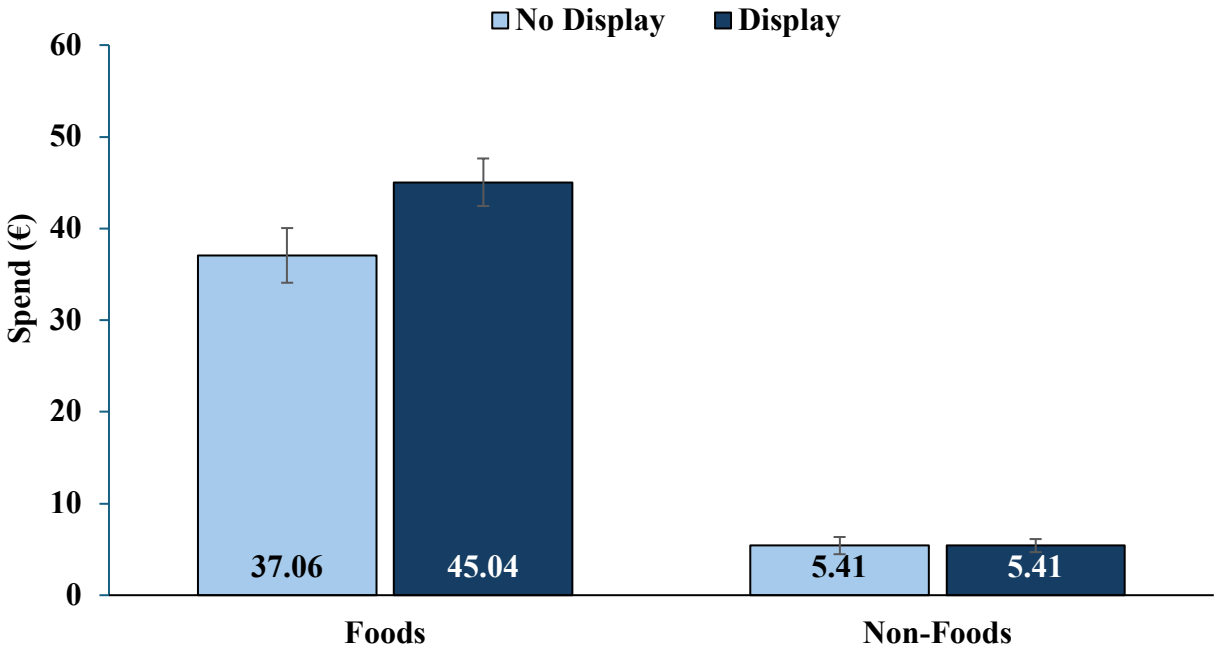


Figure 9. Spending on food and non-food categories. Error bars indicate 95% confidence intervals.



Discussion

Location-based digital cart ads provide a new way, based on recently emergent technology, to distribute in-store ads to shoppers in the moment when they are close to the advertised products. These results underscore the importance of mobile, location-sensitive ads as a future direction in in-store marketing. They provide a conceptual basis for exploring how digital cart ads can redefine in-store ad effectiveness.

Digital cart ads increased sales of both advertised and non-advertised products. The effect was robust across multiple purchase outcomes (i.e., quantity, variety, and spending), with particularly consistent effects for purchase quantity and spending. It remained consistent across the shopping journey (i.e., zones of the store), and was robust to separate controls for shopping times (i.e., day of week and time of day). The in-cart ads increased purchasing of non-advertised products within the advertised categories (i.e., within-category spillover), but not in non-advertised categories (i.e., no cross-category spillover). For instance, an ad for strawberries increased spending on other fruits, but not on vegetables. Such spillover effects are consistent with prior work showing that advertising can increase demand for other products within the same category (Gijsenberg et al., 2025; Lancaster, 1984; Schultz and Wittink, 1976). We tested two versions of in-cart ads: centrally-displayed ads and peripherally-displayed ads, which were placed on the left or right side of the screen, depending on the location of the advertised product. Both the centrally and the peripherally displayed ads increased purchasing. Compared to centrally-displayed ads, however, peripherally-displayed ads did not further increase purchasing of either advertised or non-advertised products.

Theoretical Contributions

Prior research has established that the physical attributes of shopping carts can influence both product selection (Van den Bergh et al., 2011) and spending (Estes and Streicher, 2022; Streicher and Estes, 2016). Furthermore, studies on smart shopping carts have shown that providing shopping-related information during the shopping journey can encourage healthier product choices (Eriksson et al., 2023) and help consumers use their limited budgets (Van Ittersum et al., 2013). Building on these previous findings, the present study is the first to demonstrate that location-based mobile advertisements delivered via digital shopping cart screens can significantly impact shoppers' purchase quantity, variety, and spending.

Together, these results demonstrate that (i) mobile ads in smart shopping carts can increase sales, (ii) the effect spills over to non-advertised products, and (iii) the spillover is constrained within the categories to which advertised products belonged. This extends research on smart shopping carts (Eriksson et al., 2023; Van Ittersum et al., 2013) by demonstrating that mobile, location-specific cart ads can impact purchasing through different mechanisms that may operate in parallel (as explained below). The findings also extend the literature on in-store digital signage, which has until now focused exclusively on the effectiveness of stationary displays (e.g., Burke, 2009; Han et al., 2022; Herhausen et al., 2025; Roggeveen et al., 2016). It also extends research on location-based in-store ads (e.g., Bernritter et al., 2021), which used mobile in-app ads that differ substantially from digital cart ads, and which were not location-specific. At a more general level, the present research contributes to the literature on in-store technologies based on the "internet of things" (Shankar et al., 2021).

Digital cart ads increased purchasing of advertised products, replicating prior studies of digital in-store signage (e.g., Herhausen et al., 2025) and mobile in-app ads (Bernritter et al., 2021). A plausible explanation is that in-store ads increase awareness of the advertised product, and by bringing it into shoppers' consideration set (Zhang et al., 2009), the ad increases sales of

that product. Our quasi-experiment with digital cart ads allowed us to test an additional mechanism that may contribute to the effect: Digital in-cart ads could also help shoppers locate the advertised product, by presenting the ad when the shopper is near the advertised product. However, the spatially-directive cart ads that pointed shoppers toward the location of the advertised product (i.e., peripheral ads) did not appear to help consumers find these products any more than a general, non-directive ad presented within the relevant shopping area (i.e., central ads). Thus, if digital cart ads do help consumers find the advertised products, they appear to do so at the general level of the shopping zone rather than at a more specific left/right direction. This finding contributes to the literature on attention-based consideration and its role in driving product purchases (Chandon et al., 2009; Diehl et al., 2015; Zhang et al., 2009).

Perhaps the most important contribution of our research concerns the spillover effect on non-advertised products. Neither research on digital signage (e.g., Herhausen et al., 2025) nor on mobile in-app ads (e.g., Bernritter et al., 2021) has addressed potential effects on non-advertised products. Our results demonstrate that in-cart ads increase purchasing of non-advertised products. In absolute terms, the increase in spending was larger for non-advertised products (€5.77) than for advertised products (€1.02). This difference partly reflects the fact that non-advertised products make up a much larger share of shoppers' total baskets. Indeed, the relative increase in spending was smaller for non-advertised products (+13%) than for advertised products (+111%).

As an empirics-first (Golder et al., 2023) paper, our study was not explicitly designed to reveal the psychological processes underlying this spillover effect. Nonetheless, our pattern of results supports certain accounts over others. Our finding of within-category spillover, but not cross-category spillover, is consistent with two explanations. First, an attention-based explanation suggests that goal-directed search for advertised products leads to incidental exposure and, consequently, unplanned purchases of products that are located physically close to the advertised products (Abratt and Goodey, 1990; Chandon et al., 2009; Diehl et al., 2015; Russell and Kamakura, 1997). A second, memory-based explanation from spreading activation (Anderson, 1983; Collins and Loftus, 1975) suggests that seeing the ad reminds shoppers of products from the same category, via semantic priming (Estes et al., 2011; Neely, 2012; Sahni, 2016). Thus, goal-directed search and/or semantic priming may explain the spillover effects observed in our study.

However, our findings are inconsistent with three alternative explanations that imply both within-category and cross-category spillover: unplanned purchasing due to distraction from the shopping plan (Grewal et al., 2018), exploring the assortment more generally (Streicher et al., 2021), or thematic priming of complementary products outside the advertised category (Estes et al., 2011). In addition, peripheral ads did not increase sales of non-advertised products more than central ads. The peripheral ads, with their visual guidance alternating between left and right directions, should be more likely than central ads to distract shoppers and/or to activate an exploratory mindset. Yet, the peripheral and central ads affected purchasing about equally, thereby providing further evidence against distraction or store exploration as underlying mechanisms. In sum, the present research contributes to the literature on location-based in-store ads by identifying two mechanisms by which digital cart ads may increase sales of non-advertised products: (i) incidental visual exposure and/or (ii) semantic priming. While we cannot

unambiguously attribute the spillover effect to either of the two mechanisms, we can rule out distraction, exploratory search, and thematic priming as alternative accounts.

Practical Implications

The present study provides clear and important implications for retailers: Location-sensitive in-cart ads can increase sales. As such, they provide a meaningful addition to retailers' arsenal of technology-based in-store instruments (Grewal et al., 2023). For retailers, the dual benefit of driving both direct sales of advertised products and indirect sales of non-advertised products (i.e., within-category spillover) supports the use of location-sensitive cart ads to increase overall revenue (Gilbride et al., 2015): In our study, shoppers without cart ads spent an average of €46.15, whereas shoppers with in-cart ads spent an average of €52.95. This gross difference of €6.80 amounts to a whopping 14.7% increase in total spending. Indeed, this effect size compares favorably to the 8.1% increase from stationary in-store digital signage (Herhausen et al., 2025). Hence, even when considering the investment required to implement a digital cart ad system, this investment is likely to pay off rather quickly.

The implications for brand managers are more ambiguous. On one hand, in-cart ads increased sales of advertised products, indicating a direct benefit for the promoted brand. Thus, if brands pay retailers for such in-cart ads, that investment will likely pay off. On the other hand, in-cart ads also increased sales of non-advertised products within the same category. This highlights the risk that competitors may benefit from the advertising brand's in-cart ad. Similar patterns have been observed in other contexts (Sahni, 2016). Brand managers may take this into account when negotiating retail media fees for in-cart ads. However, within-category spillover does not necessarily represent an inefficiency from the perspective of large suppliers. In many retail contexts, major manufacturers act as *category captains*, collaborating with retailers in managing assortments and developing strategies to grow the overall product category (e.g., Kurtuluş and Toktay, 2005). From this perspective, advertising that increases sales across the entire category—even when competitors also benefit—may still be strategically valuable for the focal brand if it contributes to overall category growth and strengthens the supplier's role as a category development partner for the retailer.

This pattern of increased sales of not only the advertised product, but also of other products in the advertised category, raises the prospect of cannibalization, substitution, complementor, and competitor effects. Our results provide no evidence of cannibalization from the in-cart ads, such as if an ad for strawberries reduced the sales of apples. On the contrary, we found within-category spillover, whereby the in-cart ads instead increased sales of other products in that advertised category. Nor do our results provide evidence of a more general substitution effect, such as if an ad for strawberries reduced the sales of potatoes. On the contrary, we found no cross-category spillover from advertised products onto non-advertised categories. This lack of cross-category spillover also excludes a complementor effect, such as if an ad for strawberries increased sales of cream. That is, buying more advertised products (e.g., strawberries), and buying even more other products within the advertised category (e.g., apples), had no observable effect on purchases of other products (e.g., potatoes, cream). However, our results provide strong evidence of a competitor effect: For instance, an in-cart ad for strawberries increased sales of apples, and an in-cart ad for Lindt chocolate increased sales of Snickers. As explained above, for retailers, this may represent a double-win, in that the in-cart ads increase sales of both advertised and non-advertised products. For brand managers, however, this represents a small win for the brand that comes at the expense of a larger win for collective competitors. Whether that

competitive tradeoff is worthwhile may depend on brand factors (e.g., familiarity), brand goals (e.g., increasing brand awareness), and the broader market context (e.g., category profitability).

The present research also has important implications for consumer welfare. In fact, we must emphasize the ironic nature of these effects: All digital cart ads in our experiment presented products with promotional, discount prices, yet the ads increased overall spending. Upon initial consideration, one might reasonably assume that overall spending was higher because the digital cart displays led consumers to purchase relatively more of the advertised products. If so, that could benefit consumers by providing them with higher value-for-money in terms of greater quantity of the advertised products at lower cost. And indeed, we observed such an effect. However, that effect was quite small in absolute terms.

Much larger in absolute terms was the effect on non-advertised products (see Figure 5). Thus, the higher total spending with digital cart ads was due mostly to purchases of non-advertised products, which presumably did not entail price discounts. Effectively, seeing price discounts on a small number of products increased consumers' spending far more broadly. This ironic effect is important because consumers are likely aware that in-store ads are designed to persuade them to purchase the advertised products (Friestad and Wright, 1995), but critically, they may not be aware that such ads can have a more subtle influence on their purchasing more broadly. This may not only have unwanted effects on consumers, in particular vulnerable groups such as children or compulsive shoppers (Büttner, Florack, and Serfas, 2014; Horváth et al., 2015); it may also undermine trust in the retailer if shoppers feel manipulated (Edwards, Li, and Lee, 2002). This has two implications: (a) consumer policy should educate consumers about the effects of digital cart ads (and other new technologies) on their behavior, and (b) retailers should not force consumers to use carts with digital ads, for instance, by allowing consumers to switch off the display when shopping. This may become even more important when digital cart ads are not only location-sensitive, but also exploit personal data such as from loyalty cards, or include surreptitious techniques such as face-reading (Garaus et al., 2021) that may undermine consumers' privacy and autonomy.

An Agenda for Future Research

The goal of the present research was less to provide comprehensive answers, and more to provide first insights into a novel retailing phenomenon that is both managerially relevant and theoretically interesting. Of course, this empirics-first approach leaves many questions unanswered. In the following, we outline various avenues for future research, which are informed partly by the present study on digital cart ads and partly by expected future developments within the domain of smart carts.

Limitations and Further Research on Digital Cart Ads. An important limitation concerns the quasi-experimental nature of our design. Although shopping carts were pseudo-randomly distributed to shoppers at the store entrance, assignment was not fully randomized. Consequently, we cannot rule out the possibility that some shoppers may have self-selected into conditions—for instance, by preferring or avoiding carts with digital displays. While the naturalistic field setting provides high ecological validity, future research could strengthen causal inference by implementing stricter random assignment procedures or by combining field experiments with controlled laboratory or virtual-store studies.

The present study provides preliminary evidence that attentional processes (i.e., incidental exposure during goal-directed search; Abratt and Goodey, 1990; Russell and Kamakura, 1997) and/or memory-based processes (i.e., semantic priming; Neely, 2012; Sahni, 2016) contribute to the effects of digital cart ads on purchases of advertised and non-advertised

products. However, our study was primarily designed to examine the effectiveness of digital cart ads, and not explicitly to disentangle these different processes. The latter will require combining field studies with more controlled lab experiments. In particular, eye-tracking in stores (Streicher et al., 2021) or in VR settings (Meißner et al., 2019) can directly examine how digital cart ads guide attention. Attention accounts and memory accounts could be tested against each other by comparing spillover effects to non-advertised products as a function of semantic relation versus spatial proximity. This could, for instance, be achieved by manipulating whether semantically-related products (i.e., memory mechanism) are placed far from or near to (i.e., attentional mechanism) the advertised products.

The study was conducted in a store where shoppers were previously not exposed to smart carts or digital cart ads. Hence, further research should examine the long-term effects of digital cart ads on shopper behavior both in-store and out-of-store, such as revisits and store switching (e.g., Leszczyc and Timmermans, 1997). More generally, future research should systematically examine ad content and exposure parameters to optimize the effectiveness of digital cart ads. Prior work on location-based advertising shows that less intrusive ads tend to be more effective (e.g., Ketelaar et al., 2018). Accordingly, future studies should test digital cart ad designs that mitigate reactance (cf. Bernritter et al., 2021). Exposure duration and ad refresh rate warrant similar attention. Effectiveness likely follows an inverted-U: If frequency is too low, sales potential is underrealized; if too high, ads distract shoppers from the store environment and undermine ad effectiveness because of shoppers' limited attentional capacity (Grewal et al., 2018), or by inducing ad fatigue (Guo and Jiang, 2024). In terms of ad exposure, the layout of the store in which we conducted our study strongly constrained cart-shoppers' path, as the only shortcut out of the typical path was at the fifth of seven zones. Thus, essentially all shoppers with in-cart displays were exposed to ads in Zones 1-5, but a small minority of cart shoppers may have skipped Zones 6 and 7. Ideally, future research on in-cart ads would control ad exposure more tightly, though that may decrease ecological validity, as few shops fully constrain the shopping path without any path deviations.

With digital in-store ads, exposure has not only a temporal but also a physical dimension. The effect of in-cart ads on product choice could be moderated by the physical proximity of the displayed product to the shopper's hands. Advertisements presented closer to the hands (e.g., on the handlebar, as in the present study) could elicit stronger purchase responses than ads presented farther away (e.g., at the front of the cart), because near-hand presentation may activate grasping affordances (Tucker and Ellis, 1998) and embodied action tendencies (Shen, Zhang, and Krishna, 2016). Prior work demonstrates the potential of considering research on embodiment when designing shopping carts (Estes and Streicher, 2022).

Furthermore, our results are based on findings in a mid-sized supermarket. In addition, data collection was restricted to the time window between 9 a.m. and 5 p.m., raising the question of whether the observed effects generalize to shoppers visiting the store at other times of the day. Although our data collection did not span the entire day, we conducted robustness checks including day of week and time of day as controls, and the pattern of significant results was unaffected by the inclusion of these variables. Nonetheless, future studies could extend this work by examining digital cart ads across a broader range of shopping times to assess whether effectiveness varies for different shopper populations or shopping missions. In terms of store size, prior research on stationary digital signage found that effectiveness varies with store size (Roggeveen et al., 2016). Hence, future work should systematically examine how context factors such as store size, retail format (e.g., discounter, hypermarket, convenience store), and shopper

characteristics (e.g., motivational orientation; Büttner, Florack, and Göritz, 2014) influence the effectiveness of digital cart ads. For example, larger stores may increase exposure opportunities but also introduce longer routes and more attentional competition; discounters' streamlined assortments may reduce opportunities for within-category spillover; and task-focused shoppers may be more sensitive to perceived ad intrusiveness than experiential shoppers. Due to the unobtrusive approach of our study, we have no data on shopper characteristics, and thus we cannot reveal under what circumstances consumers are more or less susceptible to the effects of digital cart ads. Previous research suggests, for instance, that shoppers with high buying impulsiveness are particularly prone to effects on attention and in-store exploration (Büttner, Florack, Leder, et al., 2014; Streicher et al., 2021).

Outlook: Future Developments in Smart Carts. Presenting ads for promoted products is an important and innovative aspect of smart shopping carts, but it does not fully realize the technology's potential. We expect that smart carts will integrate more functionality in the future, such as in-cart guidance to promoted shelf locations via shelf-based beacons, barcode readers for self-scanning items, managing customers' shopping lists, or providing additional information about products (Eriksson et al., 2023; Schultz and Zacheus, 2025; Van Ittersum et al., 2013). This would require further research that examines how digital cart ads interact with these different functionalities. For instance, providing functions that support keeping track of one's purchases might increase shopper satisfaction, but may also interfere with the effectiveness of ads intended to stimulate additional purchases. Furthermore, scanning products could also be used to make promotions more effective and present recommendations for products based on recent purchases—a personalization technique that is very common in online retailing, but not yet in brick-and-mortar retail (Scholdra, Wichmann, and Reinartz, 2023).

Smart carts also provide the opportunity to synchronize with the shopper's profile and to tailor ads and product recommendations to the purchase history across multiple shopping trips. This can be achieved when consumers activate the smart cart with their loyalty cards or via face recognition (Schultz and Zacheus, 2025). In order to motivate shoppers to use their profile, retailers could offer added-value functions to logged-in shoppers, such as personalized promotions or real-time spending tracking with budget alarms (Van Ittersum et al., 2013). However, such approaches raise privacy and security concerns that warrant careful governance and further research (Pauwels and Fagbola, 2025).

Finally, smart carts and digital ads could be situated within the broader concept of media retail (Pauwels and Fagbola, 2025). The displays on smart carts can be used not only to promote products from a retailer's assortment, but also as a digital advertising channel that retailers can sell to brands for targeting shoppers. For instance, a luxury car brand might advertise in-cart at a high-end grocery store. In this way, brands can target shoppers with a wide range of advertising formats, including display, video, and streaming-style content, while shoppers are in a purchase-oriented mindset. As smart carts become more prevalent and more deeply integrated with data-driven targeting technologies, their influence is likely to extend beyond immediate purchasing to shape competitive dynamics, consumer trust, and the overall shopping experience. Understanding when and how such in-cart media creates value for retailers, brands, and consumers alike will be critical as physical retail environments continue to converge with digital advertising infrastructures.

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