The Sales Impact of Using Handheld Scanners: Evidence from the Field

Abstract

Anecdotal evidence regarding whether handheld scanners, used in stores, increase or decrease consumer sales is mixed. This article reports on three field studies, supported by eye-tracking technology and matched sales receipts, as well as two laboratory studies that show that handheld scanner use (vs. not using it) increases sales—notably through unplanned, healthier, and impulsive purchases. The findings highlight these effects may be limited by factors such as not having a budget; for those without a budget, use of scanners can decrease sales. Building on embodied cognition and cognitive appraisal theories, the authors predict that scanners, as a bodily extension, influence sales through both cognitive (shelf attention, perceived control) and affective (number of products touched, shopping experience) mechanisms. The results offer implications for retailers considering whether to integrate scanners into their store environments.

Retail employees use handheld scanners to check prices, expiration dates, or inventory levels; more recent advances in scanner technology also allow them to complete a sale with customers anywhere in a store. Apple, Home Depot, and Nordstrom are among the pioneers that have sought to speed up the checkout process (Clay 2012). In a further step, some retailers put scanners into customers' hands. At Kroger, The Co-op, and Stop & Shop, handheld scanners or phone apps that serve similar purposes give customers the ability to scan products as they move through the store, then pay for the total basket before they leave (*Retail Business Review* 2018; Williams 2015). Industry analysts predict the persistence of this trend, and consumers may find handheld scanners at many retail locations in the future (Williams 2015). Web Appendix A illustrates some retailers that have experimented with handheld scanners and their implications, including benefits and concerns, for both consumers and the retailers.

Among the benefits of handheld scanners is the promise of saving people time at checkout, though consumers still expend effort to bag their groceries and may be required to undergo inspection checks, which could mitigate these time savings. Vuegen et al. (2019) find that time pressured shoppers use handheld scanners less than those without time constraints, suggesting the time benefits of usage are not perceived. Malone (2018) also notes that scanners introduce fun into shopping, yet their use transforms consumers into partial employees, which may imply less fun (Mills and Morris 1986). Another purported benefit stems from scanners' ability to keep a running tally of purchases, which may help consumers stay within their budgets (van Ittersum et al. 2013). Following her first use of a handheld scanner, a Kroger shopper noted her "careful and deliberate" mindset (Williams 2015, p. 2), such that she underspent her budget. This outcome is likely welcome news for shoppers but could be detrimental to retail sales; in conflicting evidence, Stop & Shop reported that its rollout of consumer handheld scanners

boosted sales by 10% (*Retail Customer Experience* 2009). To clarify such contrasting findings in real-world settings, we explicitly investigate the effect of consumer handheld scanners on sales (planned and unplanned purchases), as well as the mechanisms that might determine such sales differences. We also consider potential differences across consumers who follow financial budgets or not, to address the retail concern that handheld scanners might lead to underspending by budget-oriented shoppers.

In detailing the mechanisms that determine sales, we consider both cognitive and affective options. We study two cognitive factors: 1) attention to products/prices and 2) perceptions of control, as well as two affective factors: 1) tactile exploration and 2) shopping enjoyment. Perceptions of control (Langeard et al. 1981; van Ittersum et al. 2013; Web Appendix A) or attention to products and prices, might prompt sales lifts. Unlike other self-service technologies (e.g., stationary scanners, information kiosks), handheld scanners give consumers control, throughout the entire shopping experience, over their financial budgets, price checks, and purchase decisions. Being able to review prices and find discounted items may increase shoppers' purchase likelihood and result in increased overall sales. Smart shopping carts remain with customers during the shopping trip, and research cites the rational benefits of their use, including financial budgetary controls (van Ittersum et al. 2013). Handheld scanners are different than smart shopping carts however, in that, handheld scanners might be perceived as bodily extensions according to embodied cognition theory (Barsalou 1999, 2008; Niedenthal et al. 2005; Varela, Thompson, and Rosch 1991) and as such could have influences on cognitive experiences that go beyond smart shopping carts.

Affective factors might also be influenced by use of handheld scanners. Usage might encourage shoppers to pick up, touch, and closely examine products, and such affective, tactile

exploration encounters influence valuation and sales (Peck and Shu 2009). When consumers come in closer contact with products, their spending tends to increase. Perceptions of shopping enjoyment also could be pertinent if handheld scanners seem fun to use (Babin, Darden, and Griffin 1994; Holbrook and Hirschman 1982;). Such positive affective perceptions influence attitudes toward older self-service technologies, such as kiosks (Weijters et al. 2007). Notably though, these technologies are fixed in one location; they do not move with the shopper. If handheld scanners spread enjoyment throughout the shopping experience, it may increase the time shoppers spend looking at products, which should increase sales.

We develop hypotheses about main, mediation, and moderation effects of handheld scanner usage on sales. To test the predicted mechanisms, we gather more than 200 hours of eye-tracking data from two field studies, matched with sales data. The eye-tracking data reveal how handheld scanners influence shoppers' behaviors, thus allowing us to measure our process mechanisms (cognitive and affective experiences) behaviorally (Studies 1 & 2). To alleviate self-selection bias, we also conducted a field experiment (Study 3), matched with sales data. Then we gathered survey-based measures of the process mechanisms (attitudinally measured) and boundary conditions in two laboratory studies (Studies 4a & 4b). Figure 1 presents the conceptual model.

The combination of studies and methodologies enhances the external and internal validity of our findings, which produce several theoretical and managerial contributions. First, we apply embodied cognition theory (Barsalou 1999, 2008; Niedenthal et al. 2005) to a unique context, featuring handheld scanners used throughout the entire shopping experience, and demonstrate that their use increases sales. Second, we identify both cognitive and affective mechanisms of this effect in a serial mediation model. Cognitively, scanner users exhibit increased attention to

products through visual scanning and believe scanners grant them more control. Affectively, consumers touch more products and experience increased shopping enjoyment. These results are consistent with embodied cognition and cognitive appraisal theories, in that the scanner becomes a perceived extension of the shopper's body, following which the motor system influences cognitions, which then influence affective experiences and ultimately sales. Third, we show that handheld scanner use increases unplanned purchases but decreases planned purchases; it also encourages healthier and more impulsive purchases. Fourth, we identify a boundary condition: Retail sales tend to be enhanced (reduced) among consumers who follow a financial budget (are not on a budget).

From a managerial perspective, we give retailers recommendations for how to increase sales, especially unplanned purchases, simply by encouraging budget conscious consumers to use handheld scanners. It is not the handheld scanners per se that influence sales; rather, when consumers use scanners, they engage in more shelf attention and touch, report increased perceptions of control, and enjoy shopping. These behaviors result in increased sales. These processes might be especially impactful with experienced consumers as they have the cognitive resources to use scanners without getting distracted (Vuegen et al. 2019). From a public policy perspective, encouraging handheld scanner use also increases pricing accuracy, because consumers can verify shelf prices against what the scanner registers, which is more challenging for them to do with traditional checkout scanners (Goodstein 1994).

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Research Gaps

Self-service technologies (SST) "enable customers to produce a service independent of direct service employee involvement" (Meuter et al. 2000, p. 50). They can range from restaurant

ordering kiosks (Dabholker 1996), to ticketing kiosks (Reinders et al. 2008), to checkout scanners at grocery stores (Wang, Harris, and Patterson 2013). Table 1 summarizes research related to SSTs that support scanning tasks, including handheld scanners, smart shopping carts, and stationary check-out kiosks. Among these different technologies, handheld scanners are gaining popularity, though the precise effects of their introduction on sales and customer spending remain unclear (*Retail Customer Experience* 2009; Williams 2015).

Few prior studies investigate sales as a function of SST or scanner use. Rather, these studies tend to focus on consumers' intentions to use or factors that influence actual usage of the SST (Dominici et al. 2016; Wang, Harris, and Patterson 2013). In addition, most of the studied mechanisms are cognitive, reflecting functional aspects of the SST (e.g., perceived usefulness, ease of use), rather than the affective experience. In a notable exception, Weijters et al. (2007) cite fun as an aspect of SST, which influences intentions to use and attitudes. We seek to build on this literature stream by examining both cognitive and affective mechanisms that have effects on sales, using a serial mediation model that predicts that the bodily sensations of using scanners influence cognitions, which then influence affective experiences, and thus ultimately determine actual sales. For example, handheld scanners give consumers cognitive control (track financial budgets, look up prices, make purchase decisions) (Nixdorf 2017; Means 2018), which especially benefits those with low self-control (Montinari, Runnemark, and Wengstrom 2017), and this heightened control might increase their shopping enjoyment (Means 2018). By including behavioral measures, which have been largely overlooked in prior research (c.f. Vuegen et al. 2019) (see Table 1), we shed new light on how consumers use handheld scanners and the effects on sales. We consider two key behavioral measures: how much attention consumers devote to products/shelves and the number of products touched.

In addition to these novel behavioral measures, we investigate a potential boundary condition of the handheld scanner sales effect. Estimates for those having an implicit or explicit shopping budget range widely from approximately 30 (Stilley, Inman, and Wakefield 2010) to 90 percent (van Ittersum et al. 2010, Study 1), yet few studies consider the effects of budgets. In their study of smart shopping carts, van Ittersum et al. (2013) acknowledge the financial budgetary control issues that result from real-time feedback; it prompts shoppers with a specific budget in mind to increase their spending without going over their budgets, whereas nonbudget shoppers decrease their spending, because the smart carts make their total expenditures more salient. This informative study focuses on the type of products that enable consumers to meet their budgets (e.g., branded products) or cut back on spending (e.g., private-label products), without exploring affect in the shopping experience or how behaviors (touching, visually scanning products) might alter the outcomes.

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Theoretical Foundation and Hypotheses

We posit that scanner use leads to increased sales, notably for budget conscious consumers. Drawing on embodied cognition and cognitive appraisal theories, we detail mechanisms that likely influence these consumers who use handheld scanners to purchase more than those who do not.

Embodied Cognition: Handheld Scanner Use Influences Cognitive Processes

Embodied cognition theory highlights cognitions as embedded in a context that includes bodily movements and sensations (Barsalou 1999, 2008; Niedenthal et al. 2005; Varela, Thompson, and Rosch 1991). Existing models depict the mind as driving the body; action is the result of thoughts (e.g., Ajzen and Fishbein 1977). However, this one-sided view has been

challenged by new models in which bodily states also inform the mind (Barsalou 2008; Niedenthal et al. 2005). The brain is not solely responsible for cognitions, because sensorimotor aspects also influence them. This new theory emerged from research evidence showing that experiences are multimodal; memories are stored and retrieved as cognitive components but also with bodily states, sensory information, and situational factors (Eelen, Dewitte, and Warlop 2013). Consequently, motor systems can inform cognitions (Briñol and Petty 2008). For example, study participants holding a pencil differently exhibit varying levels of sentence comprehension, such that if they hold the pencil between their teeth, forcing the facial muscles into a smile, respondents are quicker to comprehend pleasant sentences (i.e., "You laugh as the merry-go-round picks up speed"; Glenberg et al. 2005, p. 122). When they hold the pencil between their nose and upper lip, forcing a frown, their comprehension is quicker for unpleasant sentences (i.e., "Your father collapses at the end of the annual road race"; Glenberg et al. 2005, p. 122). We similarly predict that handheld scanner use requires bodily movements, which then inform decision making.

We explore two cognitive processes that likely reflect the influence of handheld scanner bodily movements: shelf attention and perceptions of control. First, shelf attention, or visual scanning of products and prices on shelves (Grewal et al. 2018), offers a behavioral measure of cognitive processes. Consumers might exhibit more shelf attention, as a result of their scanner usage, because they seek out products whose prices they can check. To use the scanner, consumers must slow down, approach the product and shelf, and scan the item, reducing the pace at which they move through the aisles. This slower pace enables them to scan more shelf information. Second, perceptions of control in SST settings involve mastery over both processes and outcomes (Langeard et al. 1981), and we predict that handheld scanner use increases this

attitudinal measure. By scanning product information, consumers gain feelings of mastery over their shopping experience, including feelings of control over what to buy, their ability to make good shopping decisions, and how much money to spend.

Appraisal Theories: Cognitive Processes Influence Affective Experiences

Appraisal theories support the link from cognitive processes to affective experiences (Ellsworth and Smith 1988; Smith and Ellsworth 1985), namely, consumers' moods, feelings, and emotional states (e.g., pleasure, arousal, dominance) (Mehrabian and Russell 1974). Smith and Ellsworth (1985) establish reliable location estimates of emotions along cognitive appraisal dimensions, suggesting a close link between cognitive appraisals and specific emotions. For example, appraisals of certainty with high attention co-locate with happiness, pride, and challenge emotions; whereas certainty with low attention co-locates with boredom, disgust and guilt. In our study context, shelf attention and perceptions of control are proxies for cognitive appraisals; as such, we predict that these cognitive processes influence shoppers' affective experiences, namely, their product touching and shopping enjoyment.

Product touching entails tactile experiences that tap into sensory elements (Spence et al. 2014). People touch products they like and avoid those they perceive as contaminated in some way (Argo, Dahl, and Morales, 2006), so the very act of touching is a behavioral indication of an affective state. Increased touching might stem from cognitive processes. For example, increased shelf attention increases consumers' focus on what they like, so using handheld scanners should encourage them to touch and examine products they believe they will enjoy.

Shopping enjoyment is a hedonic feature that includes pleasure and fun derived from the shopping experience (Dabholkar 1994). Shopping can be fun, playful, entertaining, fantastical, and escapist (Babin, Dardin, and Griffin 1994; Hirschman 1983; Holbrook and Hirschman

1982), and trials and uses of SSTs often evoke a sense of fun (Dabholkar 1994). As Weijters et al. (2007) show, when consumers perceive handheld scanners as entertaining and enjoyable, they are more likely to use them. We build on these findings and posit that scanners give consumers a sense of control, which makes shopping a more enjoyable endeavor.

Affective Experiences Influence Sales

Increased affective experiences (touching, shopping enjoyment) should lead to increased sales. The act of touching and holding products evokes ownership feelings (Peck and Shu 2009) and willingness to pay a higher price (Martin 2013; Peck and Shu 2009). Physical proximity research, mostly involving proximity among people, shows that greater proximity can increase feelings of attachment and positive evaluations (Esmark and Noble 2018). Hoch and Loewenstein (1991) support the applicability of proximity principles to consumer–brand relationships; closer proximity to a product influences desire for it and increases the likelihood that an item gets placed in the consumer's shopping cart. Similarly, if the use of scanner technology makes the shopping trip more enjoyable and fun, it should provoke usage, such that shoppers use the scanner more to interact with products. Both touching and shopping enjoyment thus should lead to increased sales. Formally:

H_1: Handheld scanner use leads to increased sales.

H_2: There is a serial mediation effect of handheld scanner use on sales such that the effect of handheld scanner use increases a) cognitive processes (shelf attention and perceptions of control) which in turn increases b) affective experiences (the propensity to touch and shopping enjoyment), and ultimately leads to c) increased sales.

Study 1: Eye-Tracking Field Study of Handheld Scanner Use

With Study 1 we seek to test the effect of handheld scanners on sales using a field setting to establish ecological validity. We measure various control variables, as well as multiple dependent variables, to minimize endogeneity in the hypothesized effects and test the robustness

of our findings, respectively. We assess the serial mediation effects behaviorally to specify how scanner usage influences bodily movements. The cognitive and affective versions of these bodily mechanisms are shelf attention and product touches, respectively.

Method

Design and participants. We use an eye-tracking data set, obtained from an independent industry research firm, collected in 2013 in collaboration with researchers who participated in the current study. With Tobii Glasses Pro eye-tracking devices, the data were aggregated by Tobii Studio Pro software. Participants were recruited in four stores, on various days of the week. Three stores belonged to the grocery chain ICA, and one represented the grocery chain Willys; they were all located in urban cities in Sweden. The stores ranged from larger supermarkets to hypermarkets. Scanners have been available for at least 10 years in both chains. The 393 participants were recruited by research assistants as they entered the store and asked to wear eye-tracking devices while shopping. They also had to complete surveys, both before they entered and after they exited the store, and the research assistants photographed their receipts and, if they used them, shopping lists. Due to technical issues with the eye-tracking devices and missing data from the surveys or receipts, 294 participants remained for the analysis. Their average age was 41.51 years (SD = 12.02), 60.5% were men, and the average participant had 1.26 (SD = 1.12) children living at home. Participants self-selected in the two conditions, however, there were no differences among consumers who used the scanner or not in terms of age ($t_{(292)} = 1.23$, $p = .22$), gender ($\chi^2_{(1)} = .90$, $p = .34$), or number of children living at home ($t_{(292)} = .40$, $p = .69$).

Measures. We calculated total sales per shopper from the photos of the actual receipts. The total amount determined the total amount spent variable, or *sales in SEK* (Swedish krona), which we log transformed with a base of 10. With the eye-tracking data, we examine actual

behavior during the shopping trip. *Shelf attention* reflects the number of eye fixations on products and price tags; we combined both types of fixations to increase the reliability of the measurement, because fixations on price tags and products are often difficult to distinguish in eye-tracking research (Grewal et al. 2018). To measure *product touch*, we used the number of times shoppers touched a product, as recorded by the eye-tracking videos. Each touch (picked up or not) prompted a record, even if the same product were touched several times. This method meant that the sales data could indicate different values than the number of touches recorded (e.g., a shopper touched several cans of Coca-Cola, but the total sales number is 1).

We also measured control variables to assess the robustness of the hypothesized effect and minimize endogeneity. These variables included whether shoppers used a shopping list or not (dummy coded), if they were shopping on a weekday or weekend day (Friday–Sunday; dummy coded), their self-reported price consciousness, reported trip satisfaction[1] (please see Appendix A for wording of items) age, gender, and number of children living at home. Appendix B contains the correlations among all key variables.

Results

Main effects. Among the usable sample of 294 shoppers, 97 participants (33.0%) used handheld scanners. For robustness, we controlled for all the relevant covariates measured in this study.[2] We first ran a regular ordinary least squares (OLS) regression with log-transformed sales (in SEK) as the dependent variable and the covariates as independent variables, while excluding the handheld scanner as a variable. Among the control variables, only shopping lists, age, and number of children had a significant impact on sales. When we add the handheld scanner

[1]Satisfaction is used as a control variable as past satisfaction influences future purchases (Gustafsson, Johnson, and Roos (2005).

[2] Even without covariates, we find a significant difference between people who use the handheld scanners or not, in terms of total log-transformed sales ($M_{scanner} = 2.48$, $M_{noscanner} = 2.27$; $t_{(292)} = 4.15$, $p < .001$), in support of H_1.

predictor to the model, while controlling for the other variables, we find a significant impact of the use of handheld scanners on sales (b = .14, antilog$_{10}$(b) = 1.39, $p < .01$)[3] (after controls), in support of H_1. The full models and statistics are in Table 2, Panel A; means for sales across the two groups with the covariates are $M_{noscanner} = 2.29$, $M_{scanner} = 2.43$ (Appendix C).

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Serial mediation. We use PROCESS[4] model 6 (Hayes, 2018) to test the indirect effects predicted in H_2: handheld scanner → shelf attention → touch → log$_{10}$(sales). We include the control variables in all stages of our serial mediation model and obtain a significant indirect effect (.07, 95% CI [.03, .11]).[5] The remaining direct effect of handheld scanner is insignificant (b = .02, $p = .54$). The indirect effect through shelf attention also is significant (handheld scanner → shelf attention → log$_{10}$(sales): .03, 95% CI [.00, .06]), but that through touch is not (handheld scanner → touch → log$_{10}$(sales): .02, 95% CI [-.01, .06]). These results support our serial mediation prediction in H_2. The complete coefficient details are available in Web Appendix C.

Additional analyses. In addition to total sales, we examined two alternative outcome measures to check the robustness of our results: number of categories visited and time in grocery aisles. The number of categories visited relies on one of the participating retailers' category classification, which divides each store into 50 categories (e.g., diapers, fruit & vegetables, dental). If a shopper visits a particular category, we code it as 1. The time spent in grocery aisles (in seconds) provides a time-related variable. Main effects, including all the relevant covariates,

[3] We use a conversion rate of 1 USD = 8 SEK throughout the manuscript. To reverse the transformation of the dependent variable, log$_{10}$(y_i) that was done to achieve a properly normally distributed error terms, we also calculate the antilog$_{10}$($b_{scanner}$), which provides an easier interpretation of the effect of handheld scanners ($b_{scanner}$) on actual sales (Y), throughout the manuscript where appropriate.
[4] All mediation models in this manuscript use 10,000 bootstrap samples to derive the confidence intervals.
[5] The serial indirect effect of handheld scanner on log$_{10}$(sales) through shelf attention and touch also is significant without the control variables (.09, 95% CI [.04, .15]), See Web Appendix D. For a test of parallel mediation, and reverse causality, see Web Appendix E.

show that consumers who use handheld scanners (versus those who do not) visit more categories ($M_{noscanner}$ = 7.14, $M_{scanner}$ = 9.71; $F_{(1, 285)}$ = 20.68, $p < .001$) and spend more time in the aisle ($M_{noscanner}$ = 308.94, $M_{scanner}$ = 474.56; $F_{(1, 285)}$ = 17.33, $p < .001$) (see Web Appendix B).

The serial indirect effects using numbers of categories visited as the dependent variable (handheld scanner → shelf attention → touch → categories) are significant both with and without the covariates (without covariates .81, 95% CI [.39, 1.33]; with covariates: .59, 95% CI [.26, .99]). When we use time in the grocery aisles as the dependent variable (handheld scanner → shelf attention → touch → time in grocery aisles), the serial indirect effects again are significant in both cases (without covariates 50.34, 95% CI [22.55, 85.22]; with covariates 37.05, 95% CI [15.01, 65.71]).

Discussion

Using eye-tracking data matched with actual sales, we show that consumers who use handheld scanners spend more, as well as spend more time in grocery aisles and visit more categories. A post hoc analysis shows the use of the scanner appears to result not in larger ticket items but rather more products purchased as the average prices of products do not differ across conditions ($\log_{10}(avgprice)_{scanner}$ = 1.29; $\log_{10}(avgprice)_{noscanner}$ = 1.31, p = .42).[6] Furthermore, our results specify *how* handheld scanner use leads to increased sales; it increases shelf attention (cognitive process), which increases product touching (affective experience) and sales. Despite this evidence of a positive influence of handheld scanners on sales, through the behavioral mediators, relatively few consumers actually used the handheld scanners in this study. Therefore, Study 2 includes a larger sample, from whom we collected information about the items they planned to purchase.

[6] To determine the average price per item, we use the "averages of ratios" per participant, rather than the ratio of average total sales and items purchased, to allow for the statistical tests we apply.

Study 2: Second Eye-Tracking Field Study

Method

Design and participants. The same private research institute that aided with Study 1 conducted Study 2 in 2017, in collaboration with the authors. Four stores, different than those in Study 1, provided the settings, and they all belonged to the grocery chain ICA. This exploratory study includes a larger sample, with data collected using more sophisticated hardware (Tobii Glasses Pro 2). Snapshots from the eye-tracking recordings are available in Figure 2. The shoppers were not primed or put into any experimental conditions but rather were randomly approached as they entered the store and asked if they would be willing to participate in a shopping behavior study (in Study 3 we randomly assign consumers to handheld scanner use conditions to address self-selection concerns). As an incentive, they received 100 SEK (~$12) gift cards, presented when they completed the study. A pre-shopping questionnaire asked them how much money and time they planned to spend in the store and if they had any shopping lists with them. If they had a shopping list, it was photographed. If they did not, research assistants asked what they were planning to buy and noted it. After completing their shopping trip, shoppers completed a second questionnaire that measured their attitudes toward the store, satisfaction with the trip, and demographics. In total, 654 participants completed the study, but 53 participants forgot to keep their receipts and 4 only returned products, so our final sample consists of 597 shoppers. Their average age was 41.87 years (SD = 13.88), 63.8% were women, and their average household size was 3.06 people (SD = 1.40). There were no differences in age ($t_{(595)} = 1.35$, $p = .18$), gender ($\chi^2_{(1)} = .56$, $p = .45$), or household size ($t_{(595)} = .06$, $p = .95$) between scanner users and nonusers.

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Measures. We measured sales with the method applied in Study 1, according to the total amount on each receipt (log transformed with a base of 10), and the control variables: shopping list usage, price consciousness, trip satisfaction, age, gender, and household size (instead of number of children living at home). We also measured household income (dollars per year) and planned spending. For planned spending, we asked, "How much money do you think you will spend?" and the response could be any positive number. The behavioral variables came from the eye-tracking videos, as in Study 1. The touch variable was coded, in addition to the initial coding, by an independent coder who was unaware of the study purpose. Products that had been touched were coded as such if they were picked up or grasped. The correlations among all key variables are in Appendix B and can be directly compared to Study 1.

Results

Main effects. The percentage of participants who used handheld scanners (34.3%) was similar to that in Study 1 (205 out of 597). To assess the robustness of this status for predicting sales, we ran OLS regressions and controlled for the relevant control variables, including planned spending. The regression with $\log_{10}$(sales) as the dependent variable, the covariates as independent variables, and no handheld scanner variable indicated that the planned spending, shopping lists, price consciousness, age, and household income control variables had significant impacts on sales. Adding the handheld scanner variable to the model with control variables reveals a significant impact of the handheld scanners on $\log_{10}$(sales) (b = .11, antilog$_{10}$(b) = 1.29, $p < .001$), in support of H_1. The full models and statistics are in Table 2 (Panel B), and the means and estimated marginal means when controlling for covariates are in Appendix C and Web Appendix B.

Serial mediation. As in Study 1, we relied on the rich eye-tracking data to investigate differences across usage groups in the serial mediated model. In PROCESS Model 6, handheld scanner is a dummy-coded independent variable, shelf attention is the first-stage mediator, product touches are the second-stage mediator, and sales is the dependent variable. The serial mediation model includes covariates (planned spending, shopping list usage, satisfaction, weekend, price consciousness, age, gender, household income, and household size). The covariates appear in all three regression models that PROCESS uses to calculate the bootstrapped indirect effects. The serial mediation pathway (handheld scanner → shelf attention → touch → $\log_{10}$[sales]) is significant (indirect effect: .01, 95% CI [.00, .03]),[7] whereas those through shelf attention and touch are insignificant (handheld scanner → shelf attention → $\log_{10}$(sales): .00, 95% CI [-.00, .01]; scanner usage → touch → $\log_{10}$(sales): .02, 95% CI [-.01, .04]). The direct effect of handheld scanner is significant (b = .08, $p < .01$). These results support $H_{2a–c}$ and replicate the serial mediation results of Study 1. Web Appendix C contains details.

Additional analyses. We again calculated serial mediation models with time spent in grocery aisles (minutes) and numbers of categories visited. Both models showed significant serial mediation, whether we controlled for covariates or not, consistent with Study 1 (see Web Appendix E).

Exploratory Analyses

The measure of planned spending that we included in Study 2 refers to a purchase for which shoppers have identified a need (mentally or on a shopping list), prior to entering a store. Unplanned spending instead refers to a purchase not anticipated prior to entering the store (Park,

[7] As in Study 1, the serial indirect effect for Study 2 through the proposed model (handheld scanner usage → shelf attention → touch → $\log_{10}$[sales]) was significant without covariates (.09, 95% CI [.06, .13]; Web Appendix D). For a test of parallel mediation, and reverse causality, see Web Appendix E.

Iyer, and Smith 1989). If consumers engage in more shelf scanning and touch and explore more products due to their scanner use, they might undertake more unplanned purchases but also reduce their planned spending. That is, they focus more closely on their mental budgets through their scanner use (Heath and Soll 1996; Heilman, Nakamoto, and Rao 2002; Stilley et al. 2010), but they need to decrease their planned purchases if they spend more on unplanned purchases.

Moreover, scanners arguably affect not just the degree of planned purchases but also what kind of products are purchased. In an exploratory fashion, we thus test whether shopping baskets differ, in terms of how healthy, impulsive, hedonic, and stockpilable the products within them are, according to category values established by Ailawadi, Ma, and Grewal (2018).

Planned, unplanned, and partially planned purchases. We asked an independent coder, unaware of the study objectives, to code all receipt items as planned, partially planned, or unplanned purchases, according to the information the shopper provided prior to entering the store. Planned items correlated directly with the items the shopper told the research assistant that he or she intended to buy. Partially planned items reflected more vague categorizations, such as vegetables or meat. Items not listed were coded as unplanned purchases. To highlight relative differences, we calculated these receipt variables as a fraction of the total number of items or total amount spent.[8] Finally, we coded the receipts for the number of discounted items purchased and if each product was a private-label item (using the filter word "ICA"), to address whether consumers might purchase more deals or lower priced private-label items due to their scanner use. We again used relative values for the number of private-label and discounted items. Poor quality photos led us to exclude 4 participants from the receipt analyses.

[8] We excluded purchases of plastic bags from this analysis; in Sweden, shoppers must pay (~3 SEK) for bags for their groceries.

According to the coded receipts, shoppers using the handheld scanners bought relatively fewer planned items ($M_{scanner}$ = 39%, $M_{noscanner}$ = 47%; $t_{(591)} = 2.70$, $p < .01$) but relatively more unplanned items ($M_{scanner}$ = 57%, $M_{noscanner}$ = 50%; $t_{(591)} = 2.37$, $p < .05$). We find no significant differences in the number of partially planned ($M_{scanner}$ = 4%, $M_{noscanner}$ = 3%; $t_{(591)} = .76$, $p = .44$) purchases across scanner use groups. We also find no differences between groups in the number of items that shoppers had planned to buy but forgot or chose not to buy ($M_{scanner}$ = 16%, $M_{noscanner}$ = 15%; $t_{(550)} = .40$, $p = .69$). Thus, using scanners does not change what people buy; rather, the use prompts them to buy additional items. We do not find any significant differences in the fraction of items bought on a discount ($M_{scanner}$ = 10%, $M_{noscanner}$ = 10%; $t_{(591)} = .45$, $p = .66$) or fraction of private-label items ($M_{scanner}$ = 4%, $M_{noscanner}$ = 3%; $t_{(591)} = 1.35$, $p = .18$) either.

Types of food-related items purchased. Although we relied on the categorization recommended by Ailawadi, Ma, and Grewal (2018) to classify the products in each shopper's shopping basket as healthy, impulsive, hedonic, and stockability, we also augmented their list with entries from several categories they did not collect (e.g., fruit), by gathering information from a separate sample of 499 MTurk participants. We used this information to calculate values for the overall basket. We multiplied each food item purchased with the rating (for each of the four dimensions) for that category, then summed all item ratings and divided them by the total number of food items purchased. Thus, we derive values for each shopping basket pertaining to each of the four dimensions. Of the 597 participants, the same 4 participants with poor quality receipt photos as in the planned/unplanned analysis were omitted from the analysis, as well as 15 participants who only bought non-food items.

Shoppers who use handheld scanners buy relatively more healthy ($M_{scanner}$ = 4.43, $M_{noscanner}$ = 4.25; $t_{(576)} = 2.24$, $p < .05$) and impulsive ($M_{scanner}$ = 3.72, $M_{noscanner}$ = 3.64, $t_{(576)}$ =

2.27, $p < .05$) products. We find smaller, marginally significant differences for hedonicity and stockpilability, in that handheld scanner use led to purchases of fewer hedonic ($M_{scanner} = 4.06$, $M_{noscanner} = 4.13$; $t_{(576)} = 1.70$, $p < .09$) and stockpilable ($M_{scanner} = 4.34$, $M_{noscanner} = 4.41$; $t_{(576)} = 1.83$, $p < .07$) products. An overview of these exploratory analyses is in Table 3, and a few examples of categories that were assessed highly on the different dimensions are in Web Appendix F.[9]

---------INSERT TABLE 3 HERE--------

Discussion

With a larger sample and different stores, Study 2 replicates and generalizes the results from Study 1. Consumers who use handheld scanners spend more and buy more items, even after accounting for their planning and price consciousness. The results reconfirm our serial mediation predictions: Scanner use increases attention to shelf information, product touches, and then sales, consistent with our theorizing that bodily states inform the mind (Barsalou 2008; Niedenthal et al. 2005), which influences affective experiences (Ellsworth and Smith 1988; Smith and Ellsworth 1985) and sales. Consumers are more prone to buy unplanned items, likely because they spend time scanning shelves and touching and exploring products that they otherwise might not have considered. Healthier and more impulsive products enter more shopping baskets too, perhaps because holding and exploring products, as a result of scanner usage, (1) makes fresher products (e.g., produce) more appealing, (2) encourages consumers to consider the ingredients of products they hold, or (3) makes it harder for consumers to overcome impulsive tendencies once products are in their hands. Finally, we find no evidence that consumers using scanners find or

[9] We check for any differences in basket characteristics for planned versus unplanned purchases, but scanner use leads to healthier purchases of both planned and unplanned items. People using handheld scanners bought more impulsive items among their unplanned purchases.

purchase more items on sale, which should be welcome news for retailers looking to ensure the returns on their investments in handheld scanners.

Study 3: Field Experiment

Respondents in Studies 1 and 2 were not randomly assigned to the scanner use conditions, which may create concerns that self-selection issues drive the field study results. Therefore, for the field experiment in Study 3, we randomly assigned consumers to the scanner use conditions.

Method

Design and participants. Trained research assistants randomly approached shoppers in an ICA grocery store that offers handheld scanners. This store was not part of either Studies 1 or 2. The research assistants asked the shoppers if they would be willing to participate in a research study in return for a scratch-off ticket. Shoppers who agreed indicated whether they had used the handheld scanners at that particular store in the past, as a screening question. Only those who had a scanning account set up with the store were allowed to participate, then randomly assigned to an experimental condition that asked them either to use the handheld scanner for their shopping trip or to shop without it. Each shopper received a unique identification number (to enable us to match them with their assigned condition) and were asked to check in with the research assistant after they finished shopping. At that point, they completed a short questionnaire while the research assistant took a photo of their receipt.

As control variables, we used age, gender, household size, and how much time the shopper planned to spend in the store. Eighty-one shoppers provided receipts or total amounts after they had completed their shopping trip, which served as the units of analysis. We log transformed the sales data with a base of 10. The average age of all participants was 53.56 years

(SD = 15.32), 54.3% were women, and the average household size was 2.37 people (SD = 1.24). We find no differences in age ($t_{(79)} = .27$, $p = .79$), gender ($\chi^2_{(1)} = .00$, $p = .96$), or household size ($t_{(79)} = .48$, $p = .63$) across scanner users versus nonusers.

Results

Main effects. Using log-transformed sales as the dependent variable and the treatment as the independent variable, we find a main effect, such that handheld scanner users had higher sales than non-scanner users ($M_{scanner} = 2.60$, $M_{noscanner} = 2.43$; $t_{(79)} = 2.16$, $p < .05$).[10] In the regression without the treatment variable (handheld scanner usage), planned time and household size indicate positive coefficients, and gender and age are insignificant predictors. Adding the handheld scanner variable to the model (and keeping all covariates) reveals a significant effect on $\log_{10}$(sales) (b = .13, antilog$_{10}$(b) = 1.35, $p < .05$), such that using the handheld scanner led shoppers to spending more than if they did not use them. The full model is in Table 2, Panel C.

Discussion

We replicate the effect of using handheld scanning devices on sales, as found in Studies 1–2, while also alleviating concerns about a self-selection bias. Study 3 provides a more controlled test of the hypotheses in a field setting, which indicates consistency across settings and methodologies.

Study 4: Understanding Attitudinal Process Mechanisms and a Boundary Condition

Studies 1-3 suggest benefits of handheld scanners for retailers, due to their effects on sales and consumers' behavioral patterns, but they do not identify any attitudinal mechanisms or boundary conditions. In Study 4a we aim to replicate the results from these studies in a more controlled setting, such that we assign consumers randomly to scanner usage groups and measure

[10] Controlling for the same variables as used in the regression evokes similar estimated marginal means ($M_{scanner} = 2.58$, $M_{noscanner} = 2.45$; $F_{(1, 75)} = 4.20$, $p < .05$)

the attitudinal mediators of perceptions of control (mastery over processes and outcomes) and shopping enjoyment (hedonic, fun aspects). The boundary condition of financial budget is explored in Study 4b.

Study 4a: Method

Design and participants. For this online experiment, we created a virtual store and assigned participants to one of two scenarios, with or without scanning devices. All participants read, "You are at the grocery store shopping for items that you need in your everyday life. Your shopping budget is, at most, 80 dollars,[11] as that is all the money you have brought to the store." Those assigned to the scanning condition also read, "This particular retailer offers shoppers the use of portable self-scanning devices to scan products as they shop inside the store. Self-scanning means that you scan your items as you put items into your bag, and you check out in express lanes, without the need to wait in checkout lines. You are using the self-scanning device for your shopping today." Participants watched a short 20-second video of a shopping cart being pushed to help participants visualize the shopping situation; in the scanning condition, it also featured views of a hand using the handheld scanner in a realistic shopping situation to again help visualize the situation.

Next, participants visited the simulated shopping store, which stocked 16 products in five categories: (1) fruits & vegetables, (2) meat, seafood, & vegetarian, (3) dairy, deli, & cheese (4) pantry items, and (5) snacks & beverages. The grocery store departments were depicted in the same order used by most of the actual stores in which we conducted Studies 1–3, and the onscreen displays showcased the products and their prices. Participants could buy any amount,

[11] Research shows that the average multi-person household grocery household shops 1.5 times a week and spends $118 weekly ($78.66 per trip; source: FMI 2015; Lake 2019). Similarly, the average household spend on food consumed at home per week is a reported $85.85 (US Bureau of Labor Statistics 2019). While the exact fraction per shopping trip fluctuates each year, and between demographic groups, we rounded this to an even $80 in our study.

from none to all of the displayed products, in all five categories. Participants in the scanning condition saw a scanner instead of a regular cursor that tilted and "bleeped" when they moved or clicked their mouse. A tally on the right side of the screen also updated dynamically as they scanned each item, keeping track of which items had been scanned and the total time spent (Figure 3; please see the video below the Figure to help visualize the scanner manipulation). Shoppers in the control condition had to keep track of their purchases themselves.

---------INSERT FIGURE 3 HERE--------

After the experimental shopping trip, participants completed a short survey with measures of their shopping enjoyment ($\alpha = .94$) and perceptions of control ($\alpha = .85$) on multi-item Likert scales (1 = "completely disagree," 7 = "completely agree"). We also assessed perceived shopping efficiency (Cronbach's $\alpha = .93$), as a potential alternative explanatory variable, because scanner use also may help consumers achieve greater time efficiency in stores. Finally, we gathered demographic information. The scales and items are all in Appendix A.

In return for minimal monetary compensation, 299 participants completed the survey through Amazon Mechanical Turk (MTurk), but 27 participants (9.0%) failed to respond correctly to the manipulation check (i.e., if they had been "asked to shop for maximum 20 dollars," for which the correct answer was "no"). Among the 272 remaining participants, the average age was 37.7 years (SD = 11.96), and 46.3% were women. We find no significant differences across groups in age ($t_{(270)} = .33$, $p = .74$) or gender ($\chi^2_{(1)} = 1.14$, $p = .29$), so the randomization worked adequately.

Study 4a: Results

Main effects. We find significant main effects of using the scanner on total sales ($M_{scanner} = \$67.42$, $M_{noscanner} = \$61.79$; $t_{(270)} = 2.44$, $p < .05$), in support of H_1.

Serial mediation. Using PROCESS Model 6, we investigate if use of the scanner influences sales, through perceptions of control as a first-stage mediator and shopping enjoyment as a second-stage mediator. The full serial indirect effect is significant (.72; 95% confidence interval [CI] [.16, 1.61]; see Web Appendix G for the full serial mediation model).

Alternative mechanisms. We checked if the effect of scanner use on sales was mediated by perceptions of shopping efficiency. The results show no significant indirect effect (1.47; 95% CI [-.78, 3.81]). For a test of parallel mediation, and reverse causality, see Web Appendix H. Of particularly note in Web Appendix H are the significant results for scanner use → shopping enjoyment → sales. These results are consistent with past research that has shown elements of fun in SSTs (Weijters et al. 2007) and suggest that handheld scanners might influence affective experiences, even in the absence of cognitions.

Study 4a: Discussion

This test of our predictions in a controlled setting supports our predictions: Compared with nonusers, shoppers who use scanners perceive more control, which enhances their sense of enjoyment. These feelings lead to higher sales. The results thus are consistent with embodied cognition (Barsalou 1999, 2008; Niedenthal et al. 2005) and cognitive appraisal (Ellsworth and Smith 1988; Smith and Ellsworth 1985) theories, which predict that bodily movements influence cognitive processes (perceptions of control), which in turn influence affective experiences (shopping enjoyment).

Study 4b: Method

Handheld scanners can display a running total of purchases for consumers, which could help them stay within budget. Van Ittersum et al. (2013) find that handheld scanner use increases purchases among shoppers with a financial budget but decreases them for people without a

budget. However, Montinari, Runnemark, and Wengström (2017) indicate a negative, nonsignificant overall influence of scanners, which conflicts with our finding of increased purchases among consumers who use scanners. Perhaps financial budget issues explain these distinctions. That is, in Study 4a, consumers had an explicit budget. In Studies 1 and 2, respondents self-selected into handheld scanner conditions, and plausibly, people on a budget might prefer to use handheld scanners to help maximize their purchases without going over budget. When we account for planned spending in Study 2, we still find a positive overall impact of handheld scanners though.

Therefore, in Study 4b, we explicitly focus on the influence of having a budget on handheld scanner usage. In line with van Ittersum et al. (2013), we expect that handheld scanner users (vs. non-users) who are budget conscious maximize their spending, without going over their budget, by using the scanners to tally their purchases accurately and easily. Those without a budget might decrease their spending when they use a handheld scanner though, because the running tally highlights previously ignored budgetary issues. In other words, the lack of a formal financial budget might attenuate the effects of handheld scanner usage and possibly even reverse them (van Ittersum et al. 2013).

Design and participants. Study 4b uses the same setup as Study 4a, except that it features a 2 (scanning/no scanning) × 2 (no budget/80-dollar budget) design, resulting in four manipulations. Half of the participants did not receive any budget constraint. We obtained responses from 979 MTurk participants, but 105 (10.7%) failed to respond correctly to the manipulation check and thus were dropped, leaving 874 responses. Their average age was 37.92 years (SD = 13.16), and 61.8% were women. We find no significant differences across groups in terms of age ($F_{(3, 870)} = 1.42$, $p = .24$) or gender ($\chi^2_{(3)} = 3.39$, $p = .33$).

Measures. The shopping simulation is the same as in Study 4a, including the interactive scanning cursor and graphical display in Figure 3, as well as the same 20-second video. Shoppers chose items freely from the five product categories and responded to the same questions.

Study 4b: Results

A two-way analysis of variance (scanner/no scanner × budget/no budget) reveals a significant negative effect of the presence of a financial budget ($F_{(1, 870)} = 30.83$; $p < .001$) and a negative marginal main effect of handheld scanner use ($F_{(1, 870)} = 3.51$; $p < .07$). We also find a significant interaction between them ($F_{(1, 870)} = 20.76$; $p < .001$). In planned contrast analyses, participants constrained by a budget buy more if they used a handheld scanner ($M_{scanner} = \$68.13$, $M_{noscanner} = \$62.12$; $F_{(1, 870)} = 3.72$; $p < .06$), whereas participants without a budget constraint buy more in the no-scanner condition ($M_{scanner} = \$70.37$, $M_{noscanner} = \$84.78$; $F_{(1, 870)} = 20.02$; $p < .001$). As a replication check, we test the serial mediation mechanisms we found in Study 4a; the results are consistent and appear in Web Appendix G. For a test of parallel mediation, and reverse causality, see Web Appendix H.

Study 4b: Discussion

Study 4b helps clarify our previous findings. We find a marginal negative effect of the use of handheld scanners, suggesting that scanners are effective in certain situations but less so in others. Their greatest influence appears to emerge among budget shoppers. Shoppers find it easier to stick to their articulated budget when they have more control. If instead they have not yet decided how much to buy, they may be discouraged by seeing their total costs adding up on the scanner. Perceptions of handheld scanner use thus vary, depending on whether consumers see a scanner as helping them achieve their goals (budget condition) or as a reminder of their spending (no budget condition), in line with cognitive appraisal theories (Ellsworth and Smith

1988; Smith and Ellsworth 1985).

These results help explain Montinari, Runnemark, and Wengström's (2017) negative effects of handheld scanner usage while also replicating the positive effect found by van Ittersum et al. (2013) for smart shopping carts. In most of van Ittersum et al.'s studies, consumers received a predetermined shopping list and incentives to stay within financial budgets; we extend these results to shopping situations in which consumers are free to purchase as much or as little as they wish, without imposed penalties for exceeding their budget. The differences between our findings and Montinari, Runnemark, and Wengström's (2017) likely reflect the participants included and the influence of shopping enjoyment. Those authors exclude families and larger households to focus on people shopping alone or in pairs, so their study might be limited to consumers with smaller grocery shopping lists and needs, implying a short shopping trip. Longer trips might benefit more from the fun aspects of using a scanner, prompting the positive results of scanner use in our naturalistic study setting.

General Discussion

This study addresses several questions regarding handheld scanner use, so we structure our discussion around them. An overview of all study results is presented in Table 4.

---------INSERT TABLE 4 HERE--------

Key Questions

Does handheld scanner use increase or decrease sales? In two field studies with more than 200 hours of eye-tracking data, matched with sales receipts, combined with one field experiment matched with sales receipts and two lab experiments, we find consistently that handheld scanner use increases sales for shoppers with a budget. This result appears to be due to purchases of more unplanned, healthier, and impulsive items.

What mechanisms are responsible for increased sales? Consistent with embodied cognition (Barsalou 1999, 2008; Niedenthal et al. 2005) and cognitive appraisal (Ellsworth and Smith 1988; Smith and Ellsworth 1985) theories, the bodily movements required to use handheld scanners influence cognitive processes, which influence affective experiences, and then sales. Specifically, handheld scanner usage causes consumers to slow down, approach the product and shelf, and scan the item, reducing the pace at which consumers move through the aisles, which allows them to attend to more shelf information. The scanning process also gives them a sense of control over their budget and purchase decisions. These cognitive processes then influence their affective experiences, including product touching and shopping enjoyment. Both touching and shopping enjoyment lead to increased sales, by increasing the likelihood that an item gets placed in the consumer's shopping cart, reflecting the effects of a sense of proximity or ownership (Peck and Shu 2009). More impulse purchases also result from close proximity and touching (Rook and Fisher 1995).

Are there boundary conditions? We test for the role of relying on a financial budget. We find that handheld scanner use leads to increased sales for consumers on budgets. Estimates of those having some type of implicit or explicit budget when they shop vary widely, with upper limits near 90 percent (van Ittersum et al. 2010); As such, our findings likely have implications for a large segment of budget conscious shoppers.

Implications

This study extends embodied cognition theory to the context of handheld scanners showing how scanners, as a bodily extension, influence consumers' cognitions and affective experiences throughout the entire shopping trip. Specifically, embodied cognition theory predicts that bodily movements influence cognitive processes, which then influence affective

experiences. Rather than explore cognitive processes and affective experiences separately (e.g., Dabholkar 1996; van Ittersum et al. 2013), we explicitly consider their interrelatedness with a serial mediation model and test their effects on actual sales. We thus extend the theory to novel SST contexts and identify how multifaceted chains of behaviors and attitudes (i.e., shelf attention → product touching; perceptions of control → shopping enjoyment) result in proximity and ownership feelings and thereby influence sales. In addition, we identify behavioral mechanisms (shelf attention and product touching) that influence sales, despite being largely overlooked in prior SST literature. This study offers an initial analysis of how handheld scanner use leads to increased sales, which represents an extension of general theoretical knowledge about how behavioral usage influences purchases. Furthermore, we identify a boundary condition: Scanner use has the strongest influence on budget shoppers (van Ittersum et al. 2013), even in shopping situations in which consumers are free to purchase as much as they want.

From a managerial perspective, we illustrate the practical benefits of encouraging budget conscious consumers to use handheld scanners. When consumers use handheld scanners, they fixate on and touch more products; they feel more in control and enjoy shopping more. These behavioral and attitudinal measures illustrate the benefits of handheld scanners for retailers for this segment. Still, some retail managers might worry that the use of scanners helps consumers look more aggressively for sale items, but our results in Studies 1 and 2 should assuage these fears[12]. Neither the average price per item nor the relative number of deals differed across usage groups. Instead, the number of items purchased—and notably, unplanned purchases—increased when consumers used scanners.

[12] Another concern for managers might be that assigning more work to consumers could leave them dissatisfied with the store. Our results offer no evidence of such an effect. Please see Web Appendix I which shows that satisfaction with the shopping trip does not differ across handheld scanner/no scanner usage groups.

The boundary condition also suggests some managerial recommendations. As implied by other studies that prime different mindsets (Kühnen and Oyserman 2002; Monga and John 2007), our results suggest that retailers can prime consumers in ways that enhance the attitudinal effects of scanner usage, such as by posting signs that encourage them to be cautious with their financial budgets and note the benefits of using scanners to tally purchases (van Ittersum et al. 2013). Such in-store communications can benefit both the retailer (i.e., consumers spend nearly all of their budget, rather than leaving a buffer between actual purchases and their budget) and its shoppers (they do not exceed their budget). As another benefit for consumers, handheld scanner usage helps ensure pricing accuracy. When employees use traditional checkout scanners, consumers often fail to receive advertised discounts and are overcharged; Goodstein (1994) notes that 7% of consumers did not get advertised discounts, due to errors by scanners. Handheld scanners offer a solution, in that consumers can instantly verify that prices on the shelf coincide with those tallied by the scanner.

Limitations, Future Research, and Conclusions

With the eye-tracking data, we can study behavioral mechanisms, which minimizes self-reported errors, but the data also had to be manually coded, which creates the potential for coding errors. Our studies were conducted in a grocery context, where the use of handheld scanners is prevalent. Scanner technology is likely to spread to other types of stores though, so continued research should investigate the influences of scanners in these settings (e.g., department stores). We examine financial budgets; time constraints are critical for many consumers too and should be explored in further research.

Continued research also might explore the value derived from handheld scanners over time; for example, shopping enjoyment might stem from novelty perceptions during first usage

occasions but diminish with habitual usage. This idea is consistent with other researchers who have shown factors influencing usage and satisfaction change over time including Wang et al. (2013), Evanschitzky et al. (2015), and Vuegen et al. (2019). For example, Vuegen et al. (2019) show that inexperienced handheld scanner users buy less, presumably because scanners are effortful during initial usage occasions and might distract inexperienced users from the store environment; however, scanners have a positive impact on private label purchases as consumers gain more experience as cognitive resources and distraction due to the handheld scanners diminishes. Relatedly, Weijters et al. (2007) cite fun as an aspect of SST, therefore handheld scanners might influence affective experiences, even in the absence of cognitions. We see this result in Studies 4a and 4b (See Web Appendix G & H). In Study 3, we randomly assigned consumers to handheld scanner use/no use conditions; asking consumers to shop using a different method could cause irritation. Therefore, future research should explore affective (positive and negative) experiences of in-store technologies.

We examine sales as a function of planned and unplanned purchases, however, exploring brand switching behaviors might be a fruitful area of future research. Handheld scanners influence increased touching, which in turn increases ownership feelings (Peck and Shu 2009). As a result, brand switching might be more prevalent if consumers touch other brands than their normal, preferred brand.

Across multiple methodologies and studies, our results show that scanner use leads to increased sales, notably with budget conscious consumers. With such clear managerial implications, we hope these results stimulate further research on handheld scanner use, as well as other in-store technologies, such as mobile payments and other functions through mobile apps.

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TABLE 1
ILLUSTRATIVE STUDIES OF SELF-SERVICE TECHNOLOGIES THAT ASSIST IN SCANNING PRODUCTS DURING THE SHOPPING TRIP AND AT CHECKOUT

Source	Setting	Area	Dependent Variable	Cognitive Mechanisms Measured	Affective Mechanisms Measured	Behavioral Mechanisms	Budget Boundary Condition Measured (Yes/No)	Findings
Burke (2002)	Survey	Tech usage; handheld devices	Uses of handheld devices	--	--	--	No	Younger adults and men are more interested in using handheld devices that assist them in information searches and evaluations of alternatives.
Weijters et al. (2007)	Supermarket	Handheld scanners	Use of SST	Attitude toward SST; Perceived ease of use	Fun	--	No	Attitude toward handheld scanners is influenced by perceived ease of use, usefulness, reliability, and fun; attitude predicts actual usage.
Kowatsch and Maass (2010)	Fictive store	Handheld devices	Patronage and purchase intentions	Perceived ease of use and usefulness	--	--	No	The perceived ease of use for product information search on the portable device leads to higher perceived usefulness, which increases purchase and patronage intentions.
Van Ittersum et al. (2013)	Supermarket	Smart shopping cart	Spending; Type of product	Spending uncertainty	Stress	Share of store brands	Yes	Real-time feedback from smart shopping carts allowed budget shoppers to increase their spending without going over their budget; nonbudget shoppers decreased their spending, as smart carts made total expenditures salient.
Wang, Harris, and Patterson (2013)	Supermarket	Checkout kiosk	Repeat SST use	Self-efficacy	Satisfaction	--	No	Longitudinal adaptation to SST: shoppers progress from rational decisions for use (self-efficacy), to emotionally driven decisions (satisfaction) to habitual behaviors (habit).
Duane, O'Reilly, and Andreev (2014)	Survey	Mobile phone	Willingness to M-pay	Perceived usefulness; Ease of use; Trust	--	--	No	Trust is the strongest predictor of consumers' willingness to use their smartphones to make M-payments; perceived usefulness and ease of use influence willingness but to a much lesser extent.
Evanschitzky et al. (2015)	Supermarket	Personal shopping assistant (PSA)	Trial and use of PSA; Spending	Trust, Perceived ease of use; Market mavenism; Need for interaction	Anxiety, Novelty Seeking	--	No	Drivers of trial and use of PSA differ. Technology anxiety (-), trust, novelty seeking and market mavenism influence trial; Perceived ease of use and need for interaction (-) influences continued use. PSA use increases spending.
Dominici et al. (2016)	Survey	Smart shopping cart	Intentions to use	Attitude toward use; Perceptions of function	--	--	No	Beliefs that smart carts are functional and convenient influence intentions to use; Italian consumers are more positive about using smart carts than Croatians
Montinari, Runnemark, and Wengstrom (2017)	Supermarket	Handheld scanner	Spending & number of items; Length of trip	Self-control	--	--	No	Scanner use in the general population had no effect; Scanners give control to those with low self-control, such that spending is reduced when these consumers use scanners. They also spend more time in the store, likely using the scanner to decide whether to buy certain items.
Vuegen et al. (2019)	Supermarket	Handheld scanner	Total spent amount; number of items	Experience level; Time pressure;	--	Promoted, private label, need share	Yes	Scanner has a significant negative spending effect for low experience segment (more pronounced for price-oriented chain) and a positive effect for high experience segment. Time pressured shoppers use scanners less.
Present study	Supermarket	Handheld scanners	Retailer sales	Shelf attention; Perceived control	Touch; shopping experience	Shelf attention; touch	Yes	Handheld scanners increase sales, especially unplanned purchases. The effect is mediated by behavioral and attitudinal mechanisms including time in store, product categories visited and touched, perceived control, and fun. The scanner effect increases when consumers have a budget.

TABLE 2
EFFECTS OF HANDHELD SCANNER DEVICES ON SALES WHEN CONTROLLING FOR RELEVANT COVARIATES

PANEL A: STUDY 1

Model 1: Control variables on log_{10}(Sales)

	b	t	ß	*p*
Constant	2.05	12.28		.000
Using Shopping list	.37	6.65	.35	.000
Weekend	.07	1.30	.07	.194
Price consciousness	-.02	-1.19	-.06	.235
Trip satisfaction	-.02	-.92	-.05	.356
Age	.01	3.51	.19	.001
Gender	.05	1.19	.06	.234
Number of children	.06	3.05	.16	.002

Overall model: $F_{(7, 286)} = 10.80$, $p < .001$

$r^2 = .21$

Model 2: Handheld scanner and control variables on log_{10}(Sales)

	b	t	ß	*p*
Constant	2.05	12.50		.000
Hand-held scanner	.14	3.08	.16	.002
Using shopping list	.34	6.04	.32	.000
Weekend	.07	1.43	.08	.154
Price consciousness	-.02	-1.23	-.07	.219
Trip satisfaction	-.03	-1.12	-.06	.262
Age	.01	3.42	.18	.001
Gender	.05	1.11	.06	.270
Number of children	.06	3.00	.16	.003

Overall model: $F_{(8, 285)} = 10.92$, $p < .001$

$r^2 = .23$

PANEL B: STUDY 2

Model 1: Control variables on log_{10}(Sales)

	b	t	ß	*p*
Constant	2.04	18.80		.000
Planned spend	.00	24.04	.69	.000
Using shopping list	.09	3.06	.09	.002
Weekend	.02	.56	.02	.576
Price consciousness	-.01	-1.55	-.04	.123
Trip satisfaction	-.02	-1.27	-.03	.204
Age	.00	2.73	.08	.007
Gender	-.02	-.86	-.02	.388
Household income	.05	3.76	.11	.000
Household size	-.01	-1.51	-.04	.131

Overall model: $F_{(9, 587)} = 89.93$, $p < .001$

$r^2 = .58$

Model 2: Handheld scanner and control variables on log_{10}(Sales)

	b	t	ß	*p*
Constant	2.00	18.61		.000
Handheld scanner	.11	4.19	.12	.000
Planned spend	.00	22.63	.66	.000
Using shopping list	.07	2.59	.07	.010
Weekend	.02	.69	.02	.490
Price consciousness	-.01	-1.33	-.04	.184
Trip satisfaction	-.01	-1.14	-.03	.256
Age	.00	2.67	.07	.008
Gender	-.02	-.89	-.02	.376
Household income	.05	3.78	.11	.000
Household size	-.01	-1.40	-.04	.161

Overall model: $F_{(10, 586)} = 84.97$, $p < .001$

$r^2 = .59$

PANEL C: STUDY 3

Model 1: Control variables on log_{10}(Sales)

	b	t	ß	*p*
Constant	2.09	11.39		.000
Planned time	.01	5.87	.54	.000
Gender	-.00	-.02	-.00	.981
Age	-.00	-.22	-.02	.829
Household size	.07	2.46	.23	.016

Overall model: $F_{(4, 76)} = 11.19$, $p < .001$

$r^2 = .37$

Model 2: Handheld scanner and control variables on log_{10}(Sales)

	b	t	ß	*p*
Constant	2.02	11.11		.000
Handheld scanner	.13	2.05	.18	.044
Planned time	.01	5.83	.53	.000
Gender	-.00	-.03	-.00	.975
Age	-.00	-.17	-.02	.862
Household size	.07	2.43	.23	.017

Overall model: $F_{(5, 75)} = 10.17$, $p < .001$

$r^2 = .40$

TABLE 3
STUDY 2, TYPES OF PRODUCTS BOUGHT

Healthfulness				Impulsiveness			
Handheld scanner	No scanner	$t_{(576)}$	*p*	Handheld scanner	No scanner	$t_{(576)}$	*p*
4.43 (.06)	4.25 (.05)	2.24	.025	3.72 (.02)	3.64 (.02)	2.27	.024
Hedonicity				**Stockpilability**			
Handheld scanner	No scanner	$t_{(576)}$	*p*	Handheld scanner	No scanner	$t_{(576)}$	*p*
4.06 (.03)	4.13 (.02)	1.70	.089	4.34 (.02)	4.41 (.03)	1.83	.068
Planned items bought				**Unplanned items bought**			
Handheld scanner	No scanner	$t_{(591)}$	*p*	Handheld scanner	No scanner	$t_{(591)}$	*p*
39% (2%)	47% (2%)	2.70	.007	57% (2%)	50% (2%)	2.37	.018
Partially planned items bought				**Omitted planned items not bought**			
Handheld scanner	No scanner	$t_{(591)}$	*p*	Handheld scanner	No scanner	$t_{(550)}$	*p*
4% (1%)	3% (1%)	.76	.445	16% (2%)	15% (1%)	.40	.692

Notes: Health, impulsiveness, hedonicity, and stockpilability are rated on seven-point scales, where 7 is extremely high and 1 is extremely low. Shoppers rated health by responding to the question, "Please tell us how healthy you think each one is. We realize that among the different products within each category, some are healthier than others but we are interested in your overall perception of the healthfulness of the category." For stockpilability, we asked "Please tell us how easy it is to store extra quantities of this category. We realize that among the different products within each category, some are easier to store than others but we are interested in your overall storability of the category." For impulsivity we asked: "Please tell us how often you buy this category on a whim when you pass by it in the store? We realize that among the different products within each category, some are more impulsive than others but we are interested in your overall impulsiveness of the category." For hedonicity we asked: "Hedonic is defined as pleasant and fun, something that is enjoyable and appeals to the senses. Please rate the following categories on how hedonic they are." We used the procedures suggested by Ailawadi, Ma, and Grewal (2018) and their ratings for 165 product categories. The planned items analysis refers to the fraction of items in the shopping basket that appears in that specific cell. The standard errors are in parenthesis.

TABLE 4
OVERVIEW OF STUDY RESULTS

Study 1: Eye-Tracking Field Study of Handheld Scanner Use (n = 294, 39.5% women, M_{age} = 41.5; Field study [Observational])				
	Handheld Scanner[a] (n = 97)	No Scanner[a] (n = 197)	$F_{(1, 285)}$	*p*
log_{10}(Sales [SEK])	2.43 (.04)	2.29 (.03)	9.51	.002
log_{10}(Sales [items])	1.15 (.04)	.99 (.03)	12.25	.001
Sales (SEK)	383.43 (27.26)	293.16 (18.97)	7.23	.008
Sales (items)	18.76 (1.24)	14.31 (.87)	8.42	.004
Shelf attention	74.18 (4.81)	52.89 (3.35)	12.93	.000
Touch (picked up)	17.78 (1.11)	12.50 (.77)	15.02	.000
Categories visited	9.71 (.46)	7.14 (.32)	20.68	.000
Time in grocery aisles	474.56 (32.31)	308.94 (22.48)	17.33	.000
Indirect effect[a]	Handheld Scanner → Shelf Attention → Touch → log_{10}(Sales [$]): .07, 95% CI[.03, .11]			
Main Finding	*Real-life shopping data shows that customers using handheld scanners buy more. They look at more products, touch more items, spend more time in grocery aisles, and visit more categories*			
Study 2: Eye-Tracking Field Study with Planned Spending (n = 597, 63.8% women, M_{age} = 41.9; Field study [Observational])				
	Handheld Scanner[a] (n = 205)	No Scanner[a] (n = 392)	$F_{(1, 586)}$	*p*
log_{10}(Sales [SEK])	2.45 (.02)	2.34 (.01)	17.53	.000
log_{10}(Sales [items])	.96 (.02)	.84 (.02)	19.95	.000
Sales (SEK)	402.03 (14.46)	362.32 (10.28)	4.77	.029
Sales (items)	12.67 (.47)	10.66 (.34)	11.37	.001
Shelf attention	53.85 (3.14)	40.98 (2.23)	10.60	.001
Touch (picked up)	22.37 (.81)	19.71 (.57)	6.87	.009
Categories visited	6.79 (.18)	5.85 (.13)	18.03	.000
Time in grocery aisles	9.47 (.37)	6.21 (.26)	48.28	.000
Indirect effect[a]	Handheld Scanner → Shelf Attention → Touch → log_{10}(Sales [$]): .01, 95% CI[.00, .03]			
Main Finding	*Real-life shopping data replicated previous patterns that customers using handheld scanners buy more, even when controlling for shoppers' planned spend. Shoppers also buy healthier and more impulsive items.*			
Study 3: Field Experiment (n = 81, 54.3% women, M_{age} = 53.6; Field study [Experimental]))				
	Handheld Scanner[a] (n = 44)	No Scanner[a] (n = 37)	$F_{(1, 75)}$	*p*
log_{10}(Sales [SEK])	2.58 (.04)	2.45 (.05)	4.20	.044
Sales (SEK)	485.86 (37.06)	393.78 (40.42)	2.81	.098
Main Finding	*The causal effect of handheld scanners on sales is confirmed by replicating it in a field experiment.*			
Study 4a: Attitudinal Process Mechanisms (n = 272, 46.3% women, M_{age} = 37.7; Online Mturk simulation [experiment])				
	Handheld Scanner (n = 139)	No Scanner (n = 133)	$t_{(270)}$	*P*
Sales ($)	67.42 (1.36)	61.79 (1.88)	2.44	.015
Sales (items)	11.88 (.28)	10.95 (.32)	2.19	.029
Shopping enjoyment	5.56 (.12)	4.90 (.14)	3.60	.000
Control	6.05 (.09)	5.67 (.10)	2.93	.004
Indirect effect	Handheld Scanner → Control → Enjoyment → Sales ($): .72, 95% CI[.16, 1.61]			
Main Finding	*Consumers using handheld scanners buy more. This is explained by increased perceptions of control, leading to higher shopping enjoyment, which in turn drives more sales.*			

Study 4b: Financial Budget Boundary Condition (n = 874, 61.8% women, M_{age} = 37.9; Online Mturk simulation [experiment])								
	$80 budget constraint				No budget constraint			
	Scanner (n = 227)	No Scanner (n = 224)	$F_{(1, 870)}$	*p*	Scanner (n = 212)	No Scanner (n = 211)	$F_{(1, 870)}$	*p*
Sales ($)	68.13 (2.20)	62.12 (2.21)	3.72	.054	70.37 (2.28)	84.78 (2.28)	20.02	.000
Main Finding	*The positive effect of self-scanners appears when shoppers have a budget constraint. However, when shoppers do not have a budget constraint, hand-held scanners may actually decrease sales.*							

[a] Estimated marginal means/effects when controlling for relevant control mechanisms as reported in each study description.

FIGURE 1

CONCEPTUAL MODEL

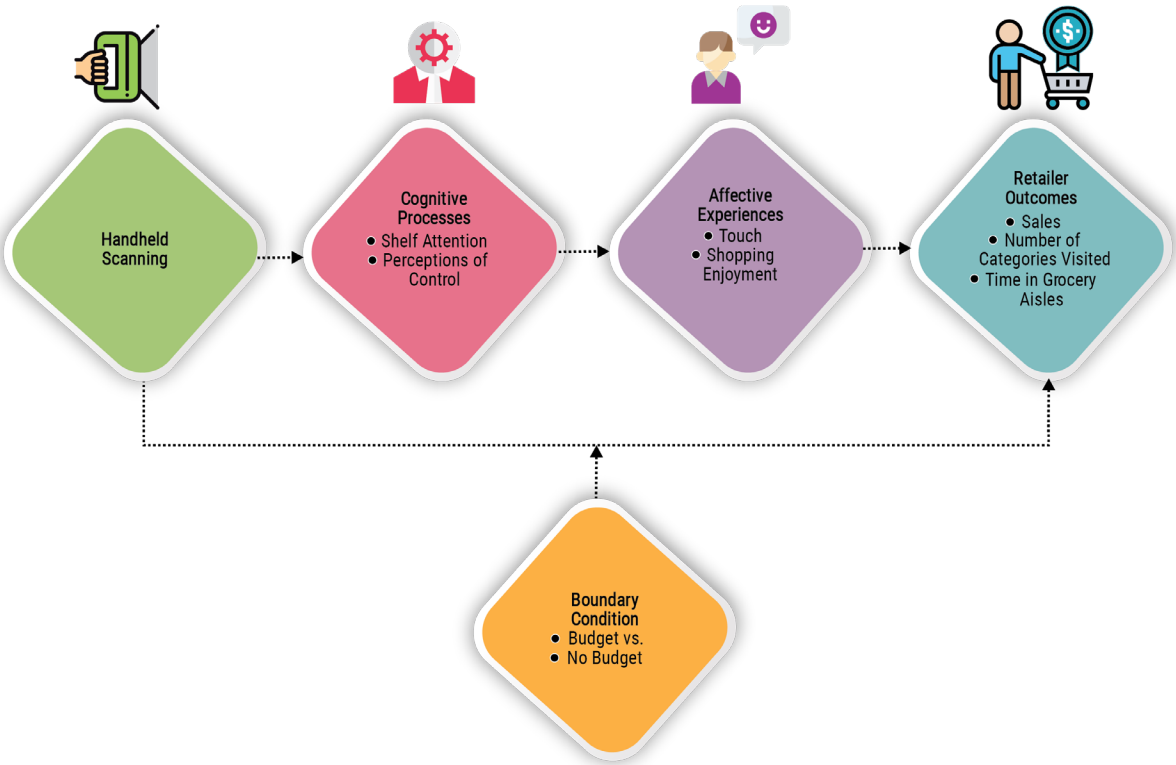


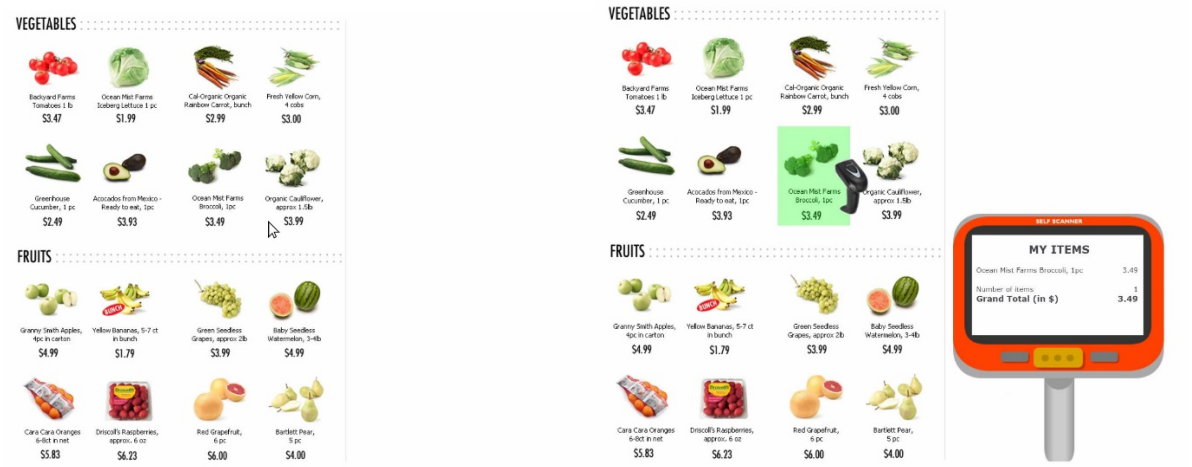
FIGURE 2

SNAPSHOTS FROM THE EYE-TRACKING VIDEO RECORDINGS

Notes: The red circle indicates where the shopper is fixating. Red lines close to the red circle indicate the last two seconds of saccades (eye movements).

FIGURE 3

CONTROL AND SCANNING CONDITIONS IN STUDIES 4A & 4B



Notes: Control condition (left); scanning condition (right); A video recording of the scanner stimuli is available at https://www.dropbox.com/s/pjy43sqep8ahgzk/Shopping%20Study%20Example.mp4?dl=0.

APPENDIX A

SCALE ITEMS AND QUESTIONS

Variable	Items	Source
Shopping enjoyment	• Shopping was enjoyable today. • Shopping for my items was fun.	Dabholkar (1994)
Perceived control	• I am confident about my ability to make good shopping decisions today. • I decided on my own what to buy today. • I was in control of what I purchased today. • I felt in control of how much money I spent.	Dabholkar (1996); Hui and Bateson (1991)
Shopping efficiency	• Shopping from this retailer is an efficient way to manage my time. • Shopping from this retailer makes my life easier. • Shopping from this retailer fits with my schedule.	Mathwich, Malhotra, and Rigdon (2001)
Trip satisfaction	• How satisfied are you with your store visit today?	Eroglu and Machleit (1990)
Price consciousness	• I am very price conscious.	
Demographic items	• What is your age? • What is your gender? • No of children in household? • Do you have a shopping list? • Shopping day of the week [Weekday or Weekend day]	

Notes: The items, other than the demographics, used 7-point scales.

APPENDIX B

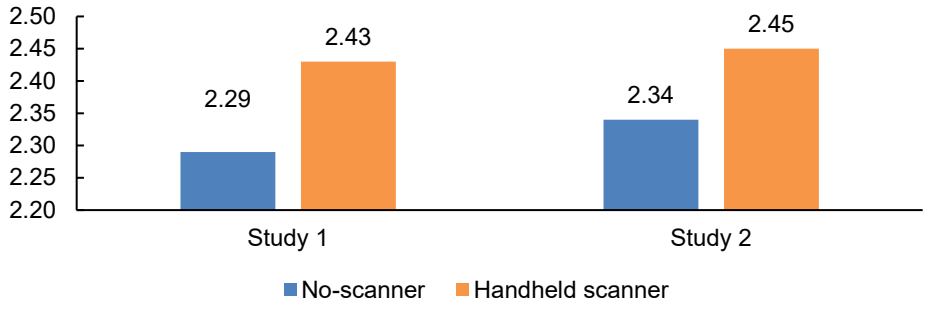
CORRELATIONS. STUDY 1 IN THE TOP-RIGHT WHITE SHADED AREA. STUDY 2 IN THE BOTTOM-LEFT GREY SHADED AREA.

	Handheld scanner usage	Sales (SEK)	Log_{10} (Sales)	Sales (items)	Shelf attention	Products touched	Planned spend (SEK)	Using shopping list	Trip satisfaction	Weekend shopping	Price consciousness	Age	Gender	Household income	Household size[a]
Handheld scanner usage		.21**	.24**	.23**	.24**	.27**	N/A	.19**	.06	-.04	.03	.07	.06	N/A	.02
Sales (SEK)	.30**		.87**	.90**	.69**	.77**	N/A	.38**	-.09	.07	-.02	.11*	.06	N/A	.15*
log_{10}(Sales)	.34**	.85**		.81**	.63**	.70**	N/A	.38**	-.06	.08	-.05	.19**	.07	N/A	.16**
Sales (items)	.32**	.85**	.76**		.72**	.78**	N/A	.41**	-.05	.03	.02	.10	.10	NA	.10
Shelf attention	.26**	.51**	.50**	.62**		.82**	N/A	.27**	-.15*	.11	-.02	-.01	.08	N/A	.14*
Products touched	.30**	.87**	.77**	.89**	.58**		N/A	.35**	-.11	.04	-.02	.00	.10	N/A	.12*
Planned spend (SEK)	.29**	.84**	.74**	.76**	.47**	.78**		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Using shopping list	.19**	.24**	.28**	.29**	.19**	.25**	.26**		-.05	.06	-.01	.08	.05	N/A	-.01
Trip satisfaction	-.04	-.03	-.06	-.05	-.03	-.08*	-.05	-.02		-.05	.16**	.16**	.12*	N/A	-.08
Weekend shopping	-.02	-.01	.03	.00	-.03	-.02	.01	.00	-.05		-.12*	-.14*	-.07	N/A	.05
Price consciousness	-.08*	-.10*	-.14**	-.08*	-.11**	-.05	-.11**	-.04	.00	-.14**		.08	.16**	N/A	.08
Age	.06	.10*	.15**	.11**	.13**	.11**	.09*	.05	.10*	-.02	.03		-.03	N/A	-.05
Gender	.03	.05	.05	.09*	.04	.10*	.09*	.04	.03	-.06	.03	.09*		N/A	.08
Household income	.08	.25**	.27**	.22**	.08*	.20**	.22**	.13**	.01	.05	-.14**	.08*	.01		N/A
Household size[a]	.00	.11**	.06	.10*	-.02	.08*	.13**	.00	-.03	.05	-.09*	-.22**	.04	.28**	

**$p < .01$, *$p < .05$. Note: [a] Measured as number of children in household in Study 1 and total household size in Study 2. N/A means that it was not measured in Study 2.

APPENDIX C

FIGURE C1. MEANS FOR LOG_{10}(SALES) IN DIFFERENT CONDITIONS IN STUDIES 1 AND 2



Notes: These values are estimated marginal means between shoppers using handheld scanners, with the covariates reported in the study at their respective mean values.