WHEN TECHNOLOGY IMITATES LIFE:

How Immersive Technologies Influence Consumer Judgments and Behaviors



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PREFACE

ABSTRACT

Immersive technologies have generated enormous industry investment and buzz, and marketers are beginning to embrace these technologies in hopes of transforming the customer experience. However, limited research has empirically explored how these nascent immersive technologies might actually influence consumers' judgments and behaviors.

This dissertation aims to address this gap by exploring consumer responses to two distinct immersive technologies: Augmented Reality (AR) and Dynamic Audio. First, this dissertation investigates the consequences of presenting food objects in AR. Across four empirical studies (presented in Chapters 3-6), we find that AR's unique ability to visually superimpose objects into consumers' real-time environments increases their ability to mentally simulate consuming a pictured food, which increases their desire and purchase likelihood for the food. Further, we find the increased mental simulation produced by AR is itself preceded and driven by increased personal relevance for the food items. Importantly, we find this effect manifests on both large (e.g., tablets) and small (e.g., smartphones) mobile devices, and holds across multiple food categories (including indulgent, non-indulgent, desirable, and undesirable foods).

Next, this dissertation investigates the consequence of adding dynamic audio (e.g., Spatial Audio) to AR advertisements of packaged food and beverage items. Across three empirical laboratory studies (presented in Chapters 9 – 11) we find that because dynamic audio produces distance-based variability in sound (i.e., the amplification/attenuation of sound when approaching/retreating from a geo-anchored target object, respectively), it increases consumers' sense of immersion in digitally-augmented advertisements, and accordingly improves consumer attitudes toward featured products. In addition, we

provide evidence for immersion as the underlying mechanism, and define theoretically and substantive boundary conditions for the effect.

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The DPhil can be a lonely time, and even more so when you're the only marketing DPhil in the entire program throughout all four years. Thank you to the faculty and researchers of FOMI, and wider SBS community, for your support and friendship throughout this experience. Special thanks to Alex, Amy, Anna, Cammy, Ewan, Felipe, Gillian, Greg, Jason, Jessica, Jonathan, Michael G., Michelle, and Natalia.

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of my life. I could go on forever, but I'll leave it here for now – I love you, and I can't wait to see what NYC has in store for us! We did it xx

DECLARATION OF CONTRIBUTION

Chapters 1 and 13. I wrote these chapters and implemented my supervisor's feedback.

Chapters 2, 7, 8, and 12. I reviewed the literature, motivated the research, and summarized the findings, incorporating feedback from my supervisors Dr. Rhonda Hadi and Professor Andrew Stephen. I developed the conceptual framework and theoretical support in chapter 2 and 8 together with Dr. Rhonda Hadi.

Chapters 3-6, 9-11. I designed the studies, worked directly in collaboration with industry partners, and collected the data. In chapters 3 and 4, I analyzed the data together with Dr. Rhonda Hadi, while in chapters 5-6 and 9-11 I analyzed the data independently. I wrote the manuscript in collaboration with Dr. Rhonda Hadi, and Professor Andrew Stephen provided feedback.

CHAPTER 1

INTRODUCTION

Digital consumption reached an all-time high during the ongoing COVID-19 pandemic, with consumers spending an average of 6 hours and 59 minutes per day streaming, socializing, and consuming digital content for pleasure (Koetsier 2020). While the long-term consequences of the pandemic on consumer behavior are still uncertain (Lee and Goldsmith 2022), this exponential increase in digital consumption resulting from socially-distanced global lockdowns continues to persist even as society transitions back from primarily online to in-person operations (Nielsen 2021). While consumption increased across nearly all digital channels during the pandemic, one category was uniquely positioned to aid in this transition: immersive technologies.

Immersive technologies (i.e., technologies capable of blending the physical and digital worlds via one or more sensory modality, generating a synthetic environment in which the user is immersed and co-exists with physical and digital objects; Suh and Prophet 2018; Slater 2009; Di Serio, Ibáñez, and Kloos 2013) have generated enormous industry investment and buzz, with the pandemic serving as a unique catalyst for both brand deployment and consumer adoption. Whether visually immersive (e.g., AR/VR, receiving over $31 billion in investment in 2021, Alsop 2021), auditorily immersive (e.g., Spatial Audio or dynamic audio, receiving over $5.6 billion in investment in 2021, Fortune Business Insights 2021), or haptically immersive (receiving over $13 billion in investment in 2021, Global Industry Analysts Inc. 2022), these technologies are being built with the purpose of sensorially enhancing traditional consumer-technology interactions. In fact, *The New Way of Working is Immersive* report from Forrester Research (2021) found that over half of fortune 500 companies reported the pandemic accelerated their implementation of immersive technologies, while one third of companies reported the pandemic triggered their initial implementation.

This increasing relevance of new and immersive technologies shows no indication of slowing down, with 30% of brands intending to utilize these technologies to market and sell their products in 2022, a 77% one-year growth rate over the previous year (Forrester Research 2021). Consumers are equally optimistic about the role these immersive technologies will play in their future. Prior to the 2021 holiday sales period, Meta reported a total of over 10 million Oculus Quest 2 VR headset units sold (Gartenberg 2021), making it the best-selling stand-alone immersive technology unit to date, with holiday sales expected to spike further after being included on Oprah's coveted "Favorite Things" 2021 list. A further 65% of parents reported intentions to purchase immersive technology (e.g., VR headset, wearable technology) for 2021 holiday gifts, making it one of the most popular gift categories that season (Xandra et al. 2021).

However, despite consumer and brand excitement surrounding the potential opportunity immersive technologies present, limited research within marketing has empirically explored how these relatively nascent technologies might actually influence consumers' judgments and behaviors. Given the interest within marketing for more relevant and impactful consumer-technology related research, coupled with the growing relevance of immersive technologies in the marketplace, it is evident that immersive technologies represent a domain ripe for further exploration.

This dissertation aims to address this gap in marketing research by exploring consumer responses to two distinct immersive technologies: Augmented Reality (AR) and Spatial Audio. While prior research in marketing has extensively explored consumers' visual and auditory sensory responses, AR and spatial audio each serve as independent and novel technological applications capable of evoking unique psychological processes and mechanisms. Building upon prior work which focused primarily on the content and context of consumers' sensory experiences, this research

instead explores how features of technology itself (e.g., AR's visual superimposition, spatial audio's distance-based sound variability) can influence today's consumer. In an effort to provide an initial understanding of how immersive technologies influence consumers' judgment and behavior, this dissertation utilizes online, laboratory, and field experiments, and expands upon well-established marketing theories (e.g., mental simulation, immersion, personal relevance). In addition, it provides evidence for the underlying mechanisms driving the observed effects, and identifies theoretically and substantively relevant boundary conditions for each effect, with the aim of providing relevant insights for both theory and practice.

Chapters 2 – 7 of this dissertation investigate the consequences of visually presenting food items in an augmented reality format through superimposition (verse both a static 2D format, and a more conservative dynamic 3D format). Across four empirical studies (presented in Chapters 3 – 6), we find that AR's unique ability to visually superimpose objects onto a real-time environment increases consumers' ability to mentally simulate consuming a pictured food, which increases their desire and purchase likelihood for the food. Further, we find the increased mental simulation produced by AR is itself preceded and driven by increased personal relevance for the food items. Importantly, we find this effect manifests on both large and small mobile devices, and holds across multiple food categories (including indulgent, non-indulgent, desirable, and undesirable foods).

Chapters 8 – 12 of this dissertation shifts the focus to different modality, exploring the consequence of adding dynamic audio (i.e. Spatial Audio) to AR advertisements of packaged food and beverage items. Across three laboratory studies (presented in Chapters 9 – 11) we find that because dynamic audio produces distance-based variability in sound (i.e., the amplification/attenuation of sound when

approaching/retreating from a geo-anchored target object, respectively), it increases consumers' sense of immersion in digitally-augmented advertisements, and accordingly improves consumer attitudes toward featured products. In addition, we provide evidence for immersion and enjoyment of the experience as the underlying sequential process explanation, and define theoretically and substantive boundary conditions for the effect.

Together, this work adopts a phenomenon-construct mapping approach (MacInnis et al. 2020). That is, motivated by the real-world phenomenon of the pervasive use of immersive technologies in the marketplace (AR and Spatial Audio in particular), this dissertation rigorously examines how these unique and theoretically distinct technologies influence consumers judgment and behavior, and identify the psychological constructs (e.g., personal relevance, mental simulation, immersion, enjoyment of the experience) explaining the observed effects. Accordingly, the contribution of this dissertation is largely substantive in nature (representing a "substantive contribution via deduction"; Lynch et al. 2012), providing evidence that allowing consumers to experience products in immersive formats may in fact be a worthwhile investment for brands.

CHAPTER 2

EXPLORING CONSUMER RESPONSES TO AUGMENTED REALITY

INTRODUCTION

Augmented Reality (AR), technology that superimposes digital content onto real-time physical environments (Tan et al. 2021), has generated enormous amounts of industry investment and buzz. Over US$3.4 billion was invested into the development and advancement of AR technologies in 2017, and that figure is projected to grow to nearly US$200 billion by 2025 (Liu 2020). Unlike virtual reality, which typically requires standalone headsets, AR simply requires a camera-equipped smartphone or tablet and allows the user to see virtual objects overlaid in the real world (Ko et al. 2013). The widespread popularity of AR applications, including Pokémon Go (147 million monthly users; Tassi 2018), Snapchat lenses (170 million daily users; Snap Inc. 2020), and Facebook (over one billion AR users in 2018 across Facebook, Messenger, Instagram, and Portal; Slater 2019) illustrates both the accessibility and appeal of this technology.

Brands across various industries have begun exploring how AR could potentially be harnessed to influence consumers' decision-making processes and shopping experiences. Interestingly, one domain which has been particularly quick to embrace AR technology is the food and beverage industry. Both large corporate fast-food chains (including Domino's Pizza, Dunkin Donuts, Subway and Panera Bread; QReal 2019) and small independent dining establishments are experimenting with AR for commercial and consumer-engagement purposes. For example, Domino's Pizza teamed up with AR developer QReal to create a "shoppable AR" lens for Snapchat, allowing users to see a floating pizza through their camera for direct ordering (Swant 2018). Famed New York bakery Magnolia Bakery debuted what they believed to be the world's first AR catering menu, giving customers the opportunity to view virtual cakes directly in front of them prior to making a final decision (Lamb 2018). In a similar vein, Backyard Betty's restaurant in Boston launched AR versions of many of their menu items, giving

customers a QR code to scan and subsequently view dishes at their table prior to ordering (McKinnon 2018). Many industry leaders believe this is just the beginning for AR food applications, due in part to advancements made by major tech platforms including Snapchat, Facebook, Apple, and Google (Alarcón 2019).

Despite the excitement surrounding such applications and the overall buzz around AR in general, limited research has empirically explored how this nascent technology might actually influence consumers' judgments and behaviors. While recent research has explored different configurations within AR applications (e.g., low versus high levels of personalization or interactivity; Carrozzi et al. 2019; Heller et al. 2019a; Hilken et al. 2017) or focused narrowly on virtual try-on applications (e.g., Javornik 2016; Poushneh and Vasquez-Parraga 2017; Yim et al. 2017; Smink et al. 2019), little research has assessed how AR presentation itself, that is the unique and fundamental ability to superimpose digital content onto a consumer's real-time environment, can influence consumers' assessments of products, nor explored the underlying mechanisms and boundary conditions that may exist.

We begin to address this gap by empirically examining how consumers respond to food items presented in AR. We focus on the domain of food for two primary reasons. First, as previously mentioned, the US$281 billion (Wunsch 2021) food and beverage industry has been particularly quick to embrace the potential of this new technology, experimenting with how AR might be used to enhance the decision-making process and dining experience both at restaurants and in the home. Thus, methodically understanding how consumers respond to AR applications in this domain is of substantive importance. However, our focus on food is also theoretically motivated. Specifically, prior research has shown that a critical antecedent for food craving and evaluation is consumers' ability to engage in mental simulation (e.g., Elder and Krishna 2012; Hildebrand et al. 2019), a

cognitive process particularly influential within highly sensorial product categories (MacInnis and Price 1987). Consequently, food is an especially ripe domain for investigating the effects of AR-driven mental simulation and represents an opportune realm to begin exploring this technology's potential influence[1].

We propose and demonstrate across two field studies involving real choice and purchase data (Chapters 3 and 4) and two laboratory studies (Chapters 5 and 6) that because AR visually superimposes objects onto a consumer's real-time environment (via a camera-enabled mobile device; Moro et al. 2017), this visual impression increases a consumer's ability to mentally simulate consuming the pictured food, which in turn increase the food's desriability and purchase likelihood. We also show that the increased mental simulation produced by AR is itself preceded and driven by an increased sense of personal relevance for the depicted food items. Importantly, that these effects hold across indulgent, non-indulgent, desirable, and undesirable food categories.

The current work adopts a phenomenon-construct mapping approach (MacInnis et al. 2020). That is, motivated by a real-world phenomenon (the pervasive usage of AR in the marketplace—particularly in the food domain), we rigorously examine how this technology influences consumers and identify psychological constructs (personal relevance and mental simulation) explaining the observed effects. Accordingly, our contribution is largely substantive in nature (representing a "substantive contribution via deduction"; Lynch et al. 2012), providing evidence that allowing consumers to view products in AR may in many cases be a worthwhile investment for food establishments and brands.

[1] While we focus this research within the food domain for aforementioned reasons, it is worth noting that AR is actively being used in a variety of different domains beyond food and beverages, including the entertainment industry, education, art, commerce, and more. See Chapter 14, Appendix A for additional marketplace examples.

Additionally, we provide a theoretical contribution to the literature on imagery and mental simulation by demonstrating and measuring how AR's ability to visually superimpose products onto a consumer's real-time environment is uniquely able to generate a sense of personal relevance that elicits mental simulation above and beyond visual stimuli that is not superimposed (e.g., static, 3D). We also add to the growing body of consumer-technology research in marketing that explores how technological features of mobile devices can meaningfully alter the ways consumers navigate and behave in the physical world.

CONCEPTUAL FRAMEWORK

To build a conceptual framework for how AR technology might systematically influence consumer responses to depicted foods, we first describe the technology itself, before integrating relevant literature on food imagery and mental simulation to build our theoretical framework.

Augmented Reality Technology

Augmented reality (AR) technology transforms a user's visual experience of the physical world in real-time, by allowing the user to, "see the real world, with virtual objects superimposed upon or composited with the real world," (Azuma 1997). While precise definitions of AR technology vary (Höllerer and Feiner 2004; Liao 2016; Liao 2019), most scholars agree that AR is fundamentally characterized by the combination of two integral components—superimposition and real-time transformation. In current AR applications, real-time superimposition is typically achieved by using a mobile device's camera to visually recognize one's immediate environment, on which digitally rendered images are instantaneously overlaid (Athsani and Kalaboukis 2007; Yim et al. 2017; Oh

and Bailenson 2017). Today, consumers are able to engage with AR technology through various devices (including stationary computers and headsets), but the overwhelming majority access AR applications on mobile devices (e.g., smartphones or tablets; Tankovska 2020). Regardless of the format, the technology is typically used to complement, supplement, or enhance the surrounding physical world with added visual information.

Although sometimes used interchangeably (albeit incorrectly), it should be noted that AR is both theoretically and practically distinct from Virtual Reality (VR). VR is a technology which entirely immerses the user in an artificial, virtually simulated world (Schmitt 2019; Tan et al. 2021). One way in which we conceptualize the distinction between AR and VR is by understanding the primary function of each technology: superimposition and transportation, respectively. Superimposition, one of the primary functions of AR, is the process of placing, or laying, something on top of directly viewed real-world scenes so that the two coexist and are both still evident (Milgram et al. 1994). This process utilizes the real-world surroundings as a natural backdrop upon which virtual elements are overlaid, providing the viewer with the advantage of visualizing virtual objects "without the vulnerability of being blind to the real world" (Tan et al. 2021), as is the case with VR. On the other hand, transportation, one of the primary functions of VR, removes many real-world sensations (e.g., obstructing the view of the real world via a head-mounted display) and "transports" individuals to another place that may or may not exist in reality (Sadowski and Stanney 2002; Tan et al. 2021). Put differently, AR leverages technology to visually alter the user's immediate environment, whereas VR leverages technology to visually remove the user from their immediate environment and transport them to a different, completely synthetic environment.

Despite the accessibility and acceptance of AR technology, little work in marketing has empirically explored the psychological implications of AR-enabled visualizations (Heller et al. 2019a; Oh and Bailenson 2017). In Table 1 below, we highlight a selection of marketing papers that have experimentally examined AR, making particular note of the specific manipulations employed and the contexts the in which AR was applied. Notably, the bulk of such work has exclusively focused on "virtual try-on" applications, which typically involve a webcam front-facing camera that superimposes clothing, accessories, or makeup onto the users themselves (Javornik 2016; Poushneh and Vasquez-Parraga 2017; Yim et al. 2017; Smink et al. 2019). Other work has examined how specific configurations of AR influence consumer responses. For example, scholars have examined aspects including the level of personalization (Carrozzi et al. 2019; Heller et al. 2019a), interactivity (Carrozzi et al. 2019; Heller et al. 2019a; Hilken et al. 2020), and mode of control (e.g., touch vs. voice, Heller et al. 2019b). Other scholars have explored how AR can aid in creative design (Jessen et al. 2020) or how it might be used to deliver supplemental information (vs. QR codes; Yaoyuneyong et al. 2016). However, none of this research has isolated and empirically examined what we consider the core, unique facet of AR presentation: the fundamental ability to superimpose digital content onto a consumer's real-time environment. Importantly, in addition to being the first to isolate this specific dimension, we explore how this can influence consumers' assessment and purchase likelihood of products, and investigate the underlying mechanisms that might explain such effects. To support our theorizing regarding such underlying mechanisms, we next turn to research on mental simulation.

TABLE 1: MARKETING RESEARCH ON AUGMENTED REALITY

Authors	Journal	Context	Device	Camera Direction	Manipulation	Process Variables	Dependent Variables	Key Findings
Self as backdrop for AR (virtual try-on)								
Hilken et al. (2017)	*Journal of the Academy of Marketing Science*	Online Service Experiences (virtual try-on)	Desktop	Front-facing	AR configuration: - Control (None vs. Rotating) - Embedding (Control vs. Face)	- Spatial Presence - Decision Comfort - Utilitarian/ Hedonic Value	- Purchase - Word of Mouth	- AR-based service augmentation enhances customer value perceptions - Spatial presence mediates Decision Comfort
Javornik (2016)	*Journal of Marketing Management*	Retail (virtual try-on)	Mobile	Front-facing	Website viewing vs. AR viewing	- Perceived Augmentation - Flow	- Affective Responses - Cognitive Responses - Behavioral Intentions	- Flow mediates the effect of perceived augmentation on consumers' affective responses and behavioral intentions - AR does not increase perception of interactivity
Poushneh and Vasquez-Parraga (2017)	*Journal of Retailing and Customer Services*	Retail (virtual try-on)	Desktop	Front-facing	Interactivity (High vs. Middle vs. Low)	User Experience (UX)	- User Satisfaction - Willingness to Buy	- AR (the combination of high and middle interactivity conditions) positively influences UX - Increased UX mediates the positive effect of Interactivity on Satisfaction and Willingness to Buy
Smink et al. (2019)	*Electronic Commerce Research and Applications*	Retail (virtual try-on)	Desktop	Front-facing	Background (dynamic-self vs. static-self vs. static-other)	- Perceived Informativeness - Perceived Enjoyment - Perceived Intrusiveness	- Brand Attitude - Purchase Intention - Willingness to Share Personal Data	- Dynamic-self enhances Perceived Informativeness and Enjoyment - Informativeness increases Purchase Intentions and Willingness to Share Personal Data - Enjoyment increases Brand Attitude

Tan et al. (2021)	*Journal of Marketing*	Beauty Retail (virtual try-on)	Mobile	Front-facing	AR Available vs. AR Not-Available	Product Characteristics: - Brand Popularity - Product Appeal - Product Rating - Product Price Customer Characteristics: - New to Channel - New to Category	Sales	- AR (vs. no-AR) is associated with higher sales for brands that are less popular, products with narrower appeal, and expensive products - Effect of AR is stronger for customers new to the channel and category
Yim et al. (2017)	*Journal of Interactive Marketing*	Retail (virtual try-on)	Desktop	Front-facing	Website viewing vs. AR Try-on	- Immersion - Media Usefulness - Enjoyment	- Attitude toward AR - Purchase Intention	- AR's Interactivity and Vividness increases users' sense of Immersion (compared to a desktop website), which increases Enjoyment, Usefulness, and Attitude towards AR - Perceived AR Novelty increases Immersion - Prior experience with AR decreases Perceived AR Novelty
AR Configuration								
Carrozzi et al. (2019)	*Journal of Interactive Marketing*	Shared Experiences	Microsoft HoloLens	Rear-facing	AR configuration: - Customization (low vs. high) - Engagement (active vs. passive)	- Assimilation - Differentiation	Psychological Ownership	- Customization of AR holograms lets customers feel psychological ownership of digital products - Assimilation and Differentiation drive the relationship between Customization and Psychological Ownership of AR holograms in social settings

Heller et al. (2019a)	*Journal of Retailing*	Retail	Mobile	Rear-facing	AR configuration: - Imagery Generation (Low – text vs. High – image) - Imagery Transformation (Low – static vs. High – dynamic)	- Processing Fluency - Decision Comfort	- Choice - Word of Mouth (WOM)	- High Imagery Generation and Transformation improves Decision Comfort and WOM - The process is mediated by Processing Fluency and Decision Comfort
Heller et al. (2019b)	*Journal of Retailing*	Retail	Microsoft HoloLens	Rear-facing	AR configuration: - Control Modality (Touch vs. Voice)	- Mental Intangibility - Decision Comfort	Willingness to Pay (WTP)	- Touch control (vs. voice control) increases WTP - The process is mediated sequentially by Mental Intangibility and Decision Comfort
Hilken et al. (2020)	Journal of the Academy of Marketing Science	Shared Decision Making and Recommendations	Desktop	No Camera Used (pre-recorded static image and dynamic video used as stimuli)	AR configuration: - Point of View (Static Image vs. Dynamic Video) - Communication Style (Text-Only vs. Image-Enhanced)	Social Empowerment	- Recommendation Comfort - Choice - Desire for Product - Product Usage - WOM	- Static (vs. Dynamic) Point of View sharing, and Image-Enhanced (vs. Text-Only) communication increases Recommendation Comfort - Social Empowerment mediates this effect - Social Empowerment stimulates Desire for a Product and Behavioral Intentions
Hopp and Gangadharbatla (2016)	*Journal of Current Issues and Research in Advertising*	Advertising	Desktop	Front-facing	AR configuration: - Novelty (operationalized as time spent using AR)	Attitude toward AR	Attitude toward Brand	- Novelty was negatively related to Attitude toward AR - High Technological Self-Efficacy transferred negative Attitudes towards AR to the Brand

Other AR Research in Marketing								
Jessen et al. (2020)	Journal of Business Research	Creative Design Planning	Mobile	Rear-facing	Design Location (Desktop Room-Rendering vs. AR Physical Room)	- Customer Engagement - Customer Creativity	Anticipated Satisfaction	- Mobile AR Design (vs. Desktop Design) increases Anticipated Satisfaction with Purchase Decisions - This process is sequentially mediated by Engagement and Creativity
Yaoyuneyong et al. (2016)	Journal of Interactive Advertising	Print Advertisements	Mobile	Rear-facing	Supplemental Information to Print Advertisement (None vs. QR code vs. AR text)	N/A	Attitudes toward Advertisement	- AR Ad resulted in highest perception of informativeness, novelty and effectiveness - QR Ad resulted in higher irritation - Traditional Print-Ad resulted in higher time-effort

Visually Induced Mental Simulation

For aforementioned substantive and theoretical reasons, we focus our empirical investigation within the food domain, and research has shown that visual cues can play an especially pivotal role in influencing consumer experiences and decision-making with respect to food (Van der Laan et al. 2011). Notably, it is not just the attractiveness of a food itself that shapes consumers' responses—contextual visual cues have also been shown to play an influential role. For example, Hildebrand and colleagues (2019) demonstrate that displaying foods with an occasion-setting background (e.g., depicting a pizza inside a pizzeria) can increase overall consumer craving and purchase likelihood, especially for holistic thinkers. Elder and Krishna (2012) show that subtly portraying food in a manner more fluent with consumption (e.g., visually placing a fork on the same side as the viewer's dominant hand) increases the viewer's overall evaluations and purchase intentions. Importantly, in both of these examples, the process driving the positive effects from visual contextual cues is increased *mental simulation*, specifically, the viewer's increased tendency to imagine consuming the pictured food.

Mental simulation is a cognitive process in which one uses previous knowledge and sensory experiences to simulate a future experience or interaction within one's mind (Ceylan et al. 2022). In 1987, MacInnis and Price published their seminal review of the imagery literature, highlighting the important role it plays in many consumer contexts. Since then, many scholars have continued to explore and better understand the processes and mechanisms driving mental simulation. Findings from neuroscience suggest that what we see visually is used to prepare our motor responses, which then triggers our mind to simulate that action (Jeannerod 2001). Research has accordingly shown that mental simulation can engage parts of the brain associated with tasting, smelling, and hearing

stimuli (Schifferstein 2009; Krishna 2012). Others have found that mental simulation can even facilitate motor responses (Elder and Krishna 2012).

While mental simulation can be induced from all sensory modalities, visual images tend to be perceived the most vividly and therefore are the method most commonly used to induce mental simulation (Schifferstein 2009). This may have evolutionary roots, as our sense of sight at least partially developed in order to increase our species' chances of survival by identifying the most nutrient and energy-rich sources of food (Spence et al. 2016). Yet importantly, not all visual imagery is equally likely to induce mental simulation. For example, researchers have found differences across high quality versus low quality pictures (Petrova and Cialdini 2005; Rossiter and Percy 1980) and dynamic versus static images (Lutz and Lutz 1977; Lutz and Lutz 1978; Roggeveen et al. 2015; Schlosser 2003). Further, as mentioned earlier, subtle visual cues that make a product look immediately consumable have also been shown to increase mental simulation of consumption (Elder and Krishna 2012). Such literature suggests that mental simulation in turn exerts a positive effect on purchase intention and product evaluation (Elder and Krishna 2012; Hildebrand et al. 2019), particularly when the benefits of product use involve sensory stimulation (MacInnis and Price 1987).

Given that AR has the unique ability to visually superimpose digital objects on top of one's real-time visual environment, we expect that AR has a high potential of inducing mental simulation in consumers. This is because AR technology has the potential to create vivid illusions of a product's immediate presence in a real-world environment. In fact, at the conclusion of their meta-analysis on mental simulation, Ceylan and colleagues (2022) speculate that augmented imagery might facilitate mental simulation, and explicitly invite future research to explore this phenomenon.

The Current Research: How AR Influences Food Desirability

As mentioned above, much of the recent marketing research on augmented reality has focused on *how* consumers interact with AR applications (Tan et al 2021). These explorations have often focused narrowly on virtual try-on applications (e.g., Javornik 2016; Poushneh and Vasquez-Parraga 2017; Yim et al. 2017; Smink et al. 2019) or included manipulations of interactivity (e.g., being able to rotate the object versus not being able to; using touch versus voice commands; Hilken et al. 2017, Heller et al. 2019b, Hilken et al. 2020); shared experience (Carrozzi et al. 2019, Hilken et al. 2020); personalization (Carrozzi et al. 2019); and device type (e.g., desktop computer, mobile device, mixed-reality headset, voice; Carrozzi et al. 2019, Hilken et al. 2017, Heller et al. 2019a, Hilken et al. 2020, and Heller et al. 2019b). While such research has provided valuable insights into the optimal configuration of AR, our work instead focuses more fundamentally on how AR technology in and of itself – that is, the superimposition of digital stimuli onto consumers' real-time environment (the defining feature of AR) – can influence behavioral responses. By taking this approach, we also address the recent call by Tan and colleagues (2021) to explore how AR can most effectively be leveraged by the service and hospitality sectors and how this technology may influence consumers' judgments and decisions.

Notably, while AR can be presented in a variety of forms, we focus the current investigation on its manifestation through mobile devices, given their ubiquity and dominance as the primary form factor for consumer-facing AR applications (Tankovska 2020). Behavioral research in marketing has begun to explore how smart objects (Hoffman and Novak 2018) and mobile devices (Bart, Stephen, and Sarvary 2014) can systematically influence consumers' attitudes and behaviors. For example, scholars have demonstrated that the touchscreen feature on these devices can influence both

psychological ownership and consumer choices (Brasel and Gips 2014; Shen, Zhang, and Krishna 2016). Other work by Grewal and Stephen (2019) has shown how mobile devices can influence purchase intentions, specifically within the context of user generated content. Diehl and colleagues (2016) explored how the camera function on mobile phones allows consumers to increase their enjoyment experiences through increased photo-taking. Our research expands on this prior work by exploring how another unique capability of mobile devices, AR presentation using the integrated camera, can alter and drive consumer responses. Specifically, drawing from the literature on AR and mental simulation, we formally hypothesize:

> **H1**: Using AR to visually superimpose depicted food items onto a consumer's real-time environment will (a) increase desirability; and (b) improve purchase likelihood, relative to depicting the food item in a non-superimposed format.

> **H2**: The effects predicted in H1 will be driven by increased mental simulation.

While the effects of mental simulation on downstream variables have been well-documented (albeit not in the AR context) in extant literature (Elder and Krishna 2012; Hildebrand et al. 2019; MacInnis and Price 1987; Ceylan et al. 2022), little if any research thus far has explored the link between AR and mental simulation. Therefore, it is compelling to consider what specifically about AR might increase consumers' mental simulation in the first place. One possible explanation comes from AR's unique ability to visually superimpose a virtual object onto a consumer's peripersonal space (the immediate space around one's body which can be touched or manipulated, Holmes and Spence 2004). Objects which appear in one's peripersonal space are likely to be

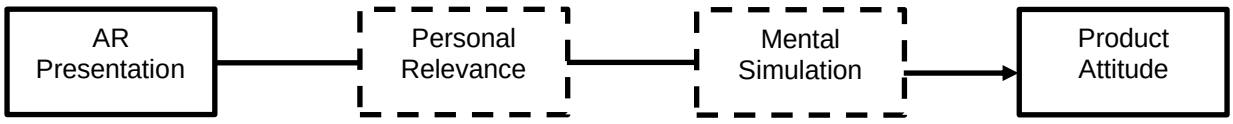
perceived as personally relevant, since people tend to surround themselves with objects they enjoy and that are of personal relevance, rather than objects which are not personally relevant. Therefore, it is plausible that by superimposing an object into one's peripersonal space via AR, that object should be perceived as more personally relevant to the individual, compared to the same object that is not superimposed into one's peripersonal space. Further, perceived personal relevance of an object or advertisement has been previously shown to increase both message processing (Ajzen et al. 1996), and mental simulation (Gutsell and Inzlicht 2010; Buckner et al. 2008; üLküMen and Thomas 2013). For example, üLküMen and Thomas (2013) found that when messages are framed with high personal relevance (versus low personal relevance), participants spontaneously simulated (mentally) the action of the message. Stringing these findings together, we argue that the superimposition of a virtual object into a users' peripersonal space should increase the perceived personal relevance of that object, which in turn will increase the ease of mentally simulating engaging with the superimposed object. Formally, we hypothesize:

> **H3:** The positive effect of AR superimposition on mental simulation will be driven by increased personal relevance of the virtual object.

Our theorizing is collectively illustrated in Figure 1. We test these hypotheses across four experimental chapters, which collectively provide empirical support for our proposed theorizing across both large (e.g., tablets; chapters 3-5) and small (e.g., smartphones; chapter 6) mobile devices, in the context of indulgent (i.e., dessert in Chapters 3 and 4), non-indulgent (Chapter 5), and both desirable and undesirable (Chapter 6) food categories. Chapter 3, a field experiment run at a restaurant,

demonstrates that presenting indulgent foods in AR (versus a non-superimposed format) can increase both desirability and consequential downstream variables (i.e., real purchase), supporting H1. In Chapter 4, a field experiment run at a café, we replicate the positive effect of AR presentation and provide preliminary support for mental simulation as the underlying process, hence supporting H2. In Chapter 5, conducted in a behavioral lab, we replicate the effect of AR presentation on desirability and purchase likelihood of a non-indulgent food item, use multi-item measures to more robustly support the mediational role of mental simulation, and additionally find support for personal relevance as an anteceding mediator (supporting H3, and fully testing the model illustrated in Figure 1). In the final study (conducted in a behavioral lab), we find converging support for our overarching model (Figure 1) using a smaller and more accessible mobile device (i.e., smartphone), extend the generalizability of our findings (by demonstrating that the results hold for both desirable and undesirable food items), and more precisely identify the type of mental simulation at play (i.e., process-oriented mental simulation).

FIGURE 1: PROPOSED CONCEPTUAL MODEL



CHAPTER 3

A FIELD STUDY OF THE EFFECT OF AR PRESENTATION ON FOOD DESIRABILITY AND PURCHASE

INTRODUCTION

The main purpose of chapter 3 was to examine the effect of AR presentation on food desirability and purchase behavior (testing H1). This study was a field experiment, run with the cooperation of a restaurant in a large international city. Specifically, we created an AR version of the restaurant's existing dessert menu, which allowed us to assess whether diners who viewed the menu in an AR format were more or less likely to purchase a dessert as compared to diners who viewed the menu in a non-superimposed (but still digital) format.

DESIGN AND PROCEDURE

One hundred and one diners[2] (41% female, 59% male, 0% nonbinary/other; M_{Age} = 37.95, SD = 13.04) participated in exchange for a £5 discount on their restaurant bill. The experiment used a two-level (presentation format: control versus AR) between-subjects design. We ran this experiment in collaboration with a brasserie-style restaurant in a large international city (see Chapter 14, Appendix B for photographs of the restaurant). To manipulate presentation format, we created two versions of the restaurant's existing paper-based dessert menu (six items, see Chapter 14, Appendix C for a list of all options on the dessert menu). For the control condition, we took high-resolution photographs of each dessert, and presented these as a digital menu on a tablet (an Apple iPad) given to diners. For the AR condition, we used a professional 3D scanning photography kit to take over 400 high-resolution photographs of each dessert from various angles. These images were then given to a professional AR developer

[2] All diners at the restaurant during dinner shift (6pm – 10:30pm) who ordered a "main dish" were approached (108 in total).

(QReal) for conversion into 3D renderings of each dessert that were viewable as AR objects using a mobile app installed on the tablet.

Importantly, while both menu formats were electronic and viewed in a mobile app on a tablet, the control menu displayed two-dimensional desserts on static blank backgrounds, whereas the AR menu displayed three-dimensional desserts superimposed in a diner's environment (i.e., on the restaurant table in front of them). The two presentation formats are illustrated in Chapter 14, Appendix D (while the AR condition included a manipulation of both dimensionality and superimposition in this chapter, our next three chapters attempt to separate these factors).

The experiment was run on two consecutive weekday evenings during the dinner shift (6pm – 10:30pm). After restaurant diners completed the main course of their meal, an experimenter blind to the hypothesis and posing as a waiter approached their table with a tablet and informed them that the restaurant had created a "digital dessert menu" and was offering diners a discount off their bill for simply looking at the menu and providing feedback (without any obligation to order anything if they did not wish to).

Each table was randomly assigned to view the dessert menu in either the control or AR format on an alternating basis (we adopted this procedure as opposed to random assignment at the individual level to prevent diners at the same table from becoming aware of the manipulation). While viewing the menu, participants completed a paper survey in which they assessed the desirability of each dessert on a 7-point scale (1 = "very undesirable" to 7 = "very desirable"). After placing their dessert orders (if any) with the experimenter, participants were asked their age, gender, and familiarity with augmented reality technology (on a 7-point scale, 1 = "very unfamiliar" to 7 = "very familiar; for complete list of all measures used in chapter 3, see Chapter 14, Appendix E). Afterwards, all diners were served any desserts they ordered. At the end of the meal, the

experimenter collected the corresponding receipts for each table, which indicated all food items and beverages ordered, how much money was spent, and the number of people at each table.

RESULTS AND DISCUSSION

Dessert Purchase.

A binary logistic regression found that participants were significantly more likely to order a dessert if they viewed options in the AR menu (41.2%) versus the control menu (18.0%[3]; Wald χ^2 (1) = 6.21, p = .01). Controlling for the number of people at each table and the average money spent per person strengthened this effect (Wald χ^2 (1) = 9.50, p < .01)[4]. Presentation format did not significantly influence choice share of any particular dessert relative to others (all p's > .15).

As a robustness check, we also calculated the average amount of money each diner spent on dessert (including participants who did not spend any money on dessert). ANOVA results demonstrated that those in the AR menu condition spent significantly more on dessert than those in the control condition ($M_{Control}$ = £1.38 versus M_{AR} = £2.93; $F(1, 99) = 7.58$, $p < .01$, $\eta_p^2 = .07$).

While the menus in both conditions were digitally presented on tablets, one could still reasonably argue that the AR menu format was more novel than the control menu format. Accordingly, to examine whether novelty might explain the positive effect of AR

[3] Receipts from the week following our data collection suggest that the typical likelihood of a restaurant diner ordering dessert at this restaurant (ordered off of a print-based menu) on a weekday evening is 7%. The increased likelihood of dessert purchase in our study (in both presentation format conditions) is likely due in part to the fact that diners were given a discount off their bill for looking at the menu. Importantly however, this cannot explain the difference we find across the control and AR conditions.

[4] As a robustness check, because individuals were nested in tables, we also ran a multilevel binary logistic regression that modelled table as a random factor to account for table-specific effects. Results of a model including presentation format as a predictor, dessert purchase as the dependent variable, and number of people at each table and the average money spent per person as covariates confirmed a significant effect of AR presentation ($F(1, 97) = 5.41$, p = .02).

presentation on purchase likelihood, we adopted a procedure from previous literature (Heller et al. 2019a; Venkatesh, Thong, and Xu 2012) by examining whether downstream responses to presentation formats differed according to diners' familiarity with AR technology. AR familiarity did not differ across the two presentation format conditions ($M_{Control}$ = 4.48 versus M_{AR} = 4.41; $F(1, 99) = .03$, $p = .87$). Importantly, neither the main effect of AR familiarity nor the interaction between presentation format and AR familiarity were significant predictors of purchase likelihood (both p's > .26). In other words, diners with both high and low levels of familiarity with AR technology responded the same way to the presentation format, suggesting that it is unlikely that the AR effect observed here can be explained by the novelty of the technology.

Desirability.

Given that diners rated the desirability of all desserts on the menu, we ran a repeated-measures ANOVA with dessert type as a within-subjects variable and presentation format as a between-subjects factor. Results demonstrated a significant effect of presentation format on dessert desirability ($F(1, 99) = 26.34$, $p < .001$, $\eta_p^2 = .21$) in the predicted direction; i.e., the average desirability of the desserts was higher in the AR menu condition than in the control menu condition. Additionally, there was no interaction between presentation format and the within-subject dessert type factor ($F(1, 99) = .06$, $p = .81$). As was the case with the purchase likelihood dependent variable, controlling for the number of people at each table and the average money spent per person strengthened the AR effect ($F(1, 97) = 30.17$, $p < .001$, $\eta_p^2 = .24$)[5]. Importantly, as was the case with purchase likelihood, neither the main effect of AR familiarity nor the interaction between

[5] We also ran a multilevel linear regression that modelled table as a random factor to account for table-specific effects. Results of a model including presentation format as a predictor, average dessert desirability as the dependent variable, and number of people at each table and the average money spent per person as covariates confirmed a significant effect of AR presentation ($F(1, 97) = 17.02$, $p < .001$).

presentation format and AR familiarity were significant predictors of desirability (both *p*'s > .25).

Ancillary Analysis.

We also examined whether participants' age or gender might act as significant covariates in the analyses above. Neither variable was significant in predicting the influence on dessert purchase (both *p*'s > .70) or dessert desirability (both *p*'s > .30), and our results continue to hold while controlling for these variables ($p < .001$ for the effect of presentation format on both dessert purchase and desirability).

In sum, our first study provided initial evidence under naturalistic conditions that presenting foods in AR (versus a non-superimposed format) can increase both desirability and purchase likelihood, supporting H1. Further, we rule out the potential effect of novelty, and demonstrate the effect holds regardless of a viewer's age or gender. Importantly, the control condition in this study was a non-superimposed two-dimensional image, as this represents an externally-valid depiction commonly used in restaurants. However, to better isolate the role of superimposition specifically, we employed a more conservative control condition in our remaining chapters (holding dimensionality constant).

CHAPTER 4

AUGMENTED REALITY REPLICATION AND EXAMINATION OF POST-CONSUMPTION ENJOYMENT

INTRODUCTION

Chapter 4 served several purposes. First, we sought to replicate the AR effect on desirability, this time using a more conservative control condition allowing us to isolate the effect of superimposition from visual dimensionality. Second, we wanted to begin exploring the underlying process (namely, mental simulation), to provide a preliminary test of H2. Finally, we took the opportunity to measure participants' post-consumption enjoyment of food items, allowing us to examine how AR presentation prior to consumption might ultimately influence this important post-consumption response. To maintain a high degree of external validity, we worked with a university catering team to run this field experiment in the café of a business school that was frequented by students and staff.

DESIGN AND PROCEDURE

One hundred and thirty participants (composed of business school students and staff) participated in this study in exchange for a free dessert. We used a two-level (presentation format: control versus AR) between-subjects design. For this study, we worked closely with the university catering team that wanted to showcase three new dessert items developed by their chef for the café (see Chapter 14, Appendix F for pictures of these desserts). We again used a professional 3D scanning photography kit to take over 400 high resolution photographs of each dessert from various angles and worked with the same AR developer to convert these photographs into 3D renderings. To manipulate presentation format in this study, we again created two versions of a digital dessert menu. This time, both conditions featured food items which were visually identical in every possible way (e.g., in scale, resolution, dimensionality, etc.). In the control condition, the menu featured the 3D renderings of each dessert over a static blank

background. In the AR presentation, as in chapter 3, the same 3D renderings for the control condition were superimposed onto the viewer's real-time environment using the tablet's camera. Accordingly, the only difference across conditions was the background behind the dessert item: the dessert was featured on a static background for the control condition, or the dessert was visually superimposed in real-time in the AR condition. In both conditions, participants were equally able to interact with the stimuli by using their fingers on the touchscreen of the tablet to rotate, reposition, and resize the featured foods as they desired. The two presentation formats are illustrated in Chapter 14, Appendix G.

The experiment was run in the café on a weekday afternoon during lunch hours. An experimenter blind to the hypothesis approached students and staff who were seated and appeared to have just finished having lunch and informed them that the catering team was testing new desserts. Participants were offered a free dessert in exchange for providing feedback on a brief paper survey about the new menu items. Participants were then randomly shown either the control or AR digital dessert menus, done on an alternating basis. After viewing the menu, participants were asked to choose the item they would like to receive. They then indicated the desirability of the dessert ("I am craving the dessert I chose") and responded to a one-item measure of mental simulation ("When viewing the dessert, I could imagine myself eating it," taken from Elder and Krishna 2012; we use more comprehensive scales in chapter 5), both measured on a 7-point scales (1 = "strongly disagree" to 7 = "strongly agree"). After completing these items, participants were served the dessert they had selected. After consumption, they indicated how much they enjoyed the dessert ("I enjoyed the dessert, measured on a 7-point Likert scale 1 = "strongly disagree" to 7 = "strongly agree"; see Chapter 14, Appendix H for complete list of all measures).

RESULTS AND DISCUSSION

Desirability.

After 109 participants had completed the study, the kitchen ran out of one of the dessert options (chocolate brownie). Accordingly, the final batch of participants (N = 21) were only given two dessert options to choose from. Results did not demonstrate any difference between the two batches of participants on any of our dependent variables (all *p*'s > .25). Accordingly, we did not exclude any participants and simply include participant batch as a covariate in our remaining analysis. ANCOVA results demonstrated a significant effect of presentation format on dessert desirability ($M_{Control}$ = 4.90 versus M_{AR} = 5.46; $F(1, 127) = 8.40$, $p < .01$, $\eta_p^2 = .06$) in the same direction as chapter 3 (thus adding support for H1): desirability was higher for the chosen dessert when it was viewed in the AR (versus control) menu format. The effect of presentation format did not differ according to which dessert was chosen ($p = .26$).

Mental Simulation.

An identical ANCOVA with the mental simulation item as the dependent variable demonstrated a significant effect of presentation format, in that participants were more likely to imagine eating the chosen dessert when they had viewed it in the AR (versus control) format ($M_{Control}$ = 5.49 versus M_{AR} = 5.90; $F(1, 127) = 5.19$, $p = .02$, $\eta_p^2 = .04$). To assess whether mental simulation could explain the increased desirability induced by the AR (versus control) presentation, we ran a mediation analysis (model 4, Hayes 2018) with 10,000 resamples. Results demonstrated a significant indirect effect (indirect effect = .1159, 95% CI: .0082 to .2816), confirming our predictions and supporting H2.

Post-Consumption Enjoyment.

ANCOVA results also demonstrated a significant effect of presentation format on participants' enjoyment of the dessert upon consuming it ($M_{Control}$ = 5.59 versus M_{AR} = 6.03; $F(1, 127) = 4.02$, $p = .05$, $\eta_p^2 = .03$), in that participants who had viewed the dessert in the AR menu pre-consumption reported greater post-consumption enjoyment than those in the control menu condition. While we did not have formal *a priori* predictions about the effect of AR presentation on post-consumption enjoyment, these results are consistent with previous work showing that savoring an upcoming experience increases enjoyment of that experience both in real-time as it is happening (i.e., during consumption), and when it is remembered later on (Chun, Diehl, and MacInnis 2017)[6].

In sum, our second study provided further evidence under naturalistic conditions that presenting foods in AR (versus a control format) can increase a food's desirability. Importantly, this study allowed us to isolate superimposition (versus dimensionality) as the fundamental AR characteristic behind this effect. In addition, we provide preliminary evidence that mental simulation is the underlying process explaining the positive effect of AR on desirability, supporting H2. Finally, we demonstrate that AR presentation does not only influence pre-consumption variables (i.e., desirability and purchase likelihood), but can also exert an influence on post-consumption variables (specifically, consumption enjoyment).

Notably, our finding that increased mental simulation improves desirability (i.e., the second path of our proposed theorizing), has already been well-established in extant

[6] While we had no *a priori* predictions about the effect of AR presentation on post-consumption enjoyment, we tested an exploratory mediation analysis (model 4, Hayes 2018) with 10,000 resamples) to see whether mental simulation could also explain the increased post-consumption enjoyment induced by AR. Results did not demonstrate a significant indirect effect (indirect effect = -.0386, 95% CI: -.1509 to .0465). We discuss other potential mechanism in the general discussion.

literature. However, this research is the first to empirically demonstrate that the real-time superimposition afforded by AR can increase mental simulation (the first path in our model). Accordingly, to better understand this relationship between AR presentation and mental simulation, we wished to examine what preceding mediators might explain the link between AR presentation and mental simulation to begin with.

Thus, in our next study, in addition to more definitively and robustly testing the effect of AR on desirability and purchase likelihood as well as the proposed mediating role of mental simulation, we test a number of additional processes that could possibly explain the link between AR and mental simulation or that could serve as alternative processes explanations more generally.

CHAPTER 5

ESTABLISHING THE PSYCHOLOGICAL EFFECT OF AUGMENTED REALITY ON DESIRABILITY AND PURCHASE LIKELIHOOD

INTRODUCTION

Results from the previous field experiments established the effect of AR presentation on desirability and purchase likelihood and provided initial evidence of the key role mental simulation plays in this process. Chapter 5 served several additional purposes. First, while Chapters 3 and 4 focused on indulgent desserts, this study allowed us to extend our examination to a non-indulgent food category (lamb shawarma; as verified in the pretest reported in Chapter 14, Appendix I). Importantly, the laboratory setting also provided the opportunity to collect a multi-item measure of our proposed mediator (mental simulation; allowing us to more definitely test H2).

Further, as mentioned earlier, while the effects of mental simulation on downstream variables have been well-documented (albeit not in the AR context) in extant literature (Elder and Krishna 2012; Hildebrand et al. 2019; MacInnis and Price 1987; Ceylan et al. 2022), little is known about how and why AR induces mental simulation to begin with. This study allowed us to explore whether the positive effect of AR presentation on mental simulation and subsequent desirability might be driven by an increase in perceived personal relevance (hence testing H3). Accordingly, this study allowed us to test the complete model proposed in Figure 1.

Finally, due to the relative nascency of AR technology, it is possible that alternative, or multiple, processes could explain the link between AR presentation and mental simulation. Therefore, we leant on both extant literature and intuitive logic to compile an extensive list of potential alternative processes to assess. For example, previous research has suggested that consumers may perceive ownership of digitally displayed products (Brasel and Gips 2014; Atasoy and Morewedge 2018), and this seemed particularly worth exploring given AR's ability to superimpose products onto one's peripersonal space. Work by Elder and colleagues (2017) shows how imagined

sensory experiences vary in psychological distance, which can positively influence product attitudes. Accordingly we examined whether AR might exert an effect on psychological distance (either spatial or temporal distance). Finally, we explore a number of potential processes called for by Wedel and colleagues (2020) in their recent conceptual framework on AR and VR for consumer marketing, including: presence, attention, fluency, realism, and mood.

DESIGN AND PROCEDURE

One hundred and eight volunteers from a university setting (46% female, 54% male, 0% nonbinary/other; M_{age}=29.73, SD=6.61) participated in this experiment in exchange for monetary compensation. The study employed a 2 cell (presentation format: control versus AR) between-subjects design. Presentation format was manipulated as in chapter 4 (keeping scale, resolution, dimensionality, and interactivity constant): the control condition featured the 3D food item over a static blank background, while the AR condition superimposed the 3D food item onto the viewer's real-time environment), except this time the target stimuli was a lamb shawarma (see Chapter 14, Appendix J for videos and photographs of the stimuli).

This study was conducted during the COVID-19 pandemic in a university that was allowing students to attend classes in person with appropriate protection measures and social distancing in place. To comply with local COVID-19 government regulations, we modified a lecture theater to serve as a laboratory (see Chapter 14, Appendix K for complete list of precautions taken to ensure participant safety and regulatory compliance). Once participants arrived at the lab, they scanned a QR code with their mobile phone to access a mobile survey that included the consent form and survey questions. Participants were told that they would view and evaluate lamb shawarma on a tablet, but before

viewing the item, they were asked to indicate their previous experience with the food ("I have eaten lamb shawarma before*,"* with the options, "yes", "no", or "unsure"). Then, all participants were given a tablet to view the lamb shawarma in either the control or AR presentation format, according to their randomly assigned condition. Importantly, due to social distancing requirements, participants were sat far enough apart as to not be able to interact or engage with one another.

Participants responded to survey questions on their mobile phones while continuing to view the lamb shawarma on the tablet (should they wish to). To take advantage of the laboratory setting, participants were asked to respond to a battery of measures (see Chapter 14, Appendix L for a full list of items). Our dependent variables of interest in this study were desirability (3-item scale including those from chapters 3 and 4; α = .89) and purchase likelihood ("After viewing the lamb shawarma, how likely would you be to order it if it was offered on a menu?"). Our proposed mediators were personal relevance (2-item index; e.g., "This is similar to other foods I eat"; r = .56) and mental simulation (6-item scale adapted from Hildebrand et al. 2019; e.g., "I could imagine myself eating the lamb shawarma displayed"; α =.89). In addition, we measured potential alternative process explanations including: presence (3 items adapted from Slater, Usoh, and Steed 1994; e.g., "The lamb shawarma felt like it was on the table in front of me"; α = .68), attention to background ("I paid more attention to the lamb shawarma than I did the background behind it,"), perceptual fluency (2 items adapted from Labroo et al. 2008, e.g., "It was easy for me to evaluate this food item"; r = .85), psychological ownership (2 items adapted from Atasoy and Morewedge 2018; e.g., "I felt like the lamb shawarma was already mine"; r = .65), spatial and temporal distance (items adapted from Elder et al. 2017; spatial: "How close do you think the restaurant offering the lamb shawarma is located?", temporal: "How quickly do you think the restaurant

could deliver this lamb shawarma to you?"), enjoyment of the experience (2 items, e.g., "It was fun to view this item"; r = .77), and realism (4 items, e.g., "This lamb shawarma looks real"; α = .86). Finally, participants indicated their mood (2 items, e.g., "I am in a good mood right now"; r = .67), familiarity with AR Technology (as measured in chapter 3), gender and age.

RESULTS AND DISCUSSION

Desirability and Purchase Likelihood.

Consistent with our previous findings, ANOVA results revealed significant main effects of presentation format on the desirability of the lamb shawarma ($M_{Control}$ = 4.64 versus M_{AR} = 5.15; $F(1,106) = 4.52$, $p = .04$, $\eta_p^2 = .04$) and purchase likelihood ($M_{Control}$ = 4.54 versus M_{AR} = 5.50; $F(1,106) = 8.82$, $p < .01$, $\eta_p^2 = .08$). These results add support for H1, in that participants who viewed the lamb shawarma in the AR condition rated both the desirability of the dish and their purchase likelihood of the dish as significantly higher than those who viewed the same lamb shawarma in the control (non-superimposed) condition.

As desirability and purchase likelihood are arguably related constructs and were highly correlated (r = .76; $p < .001$), we conducted a factor analysis which demonstrated that all items loaded onto the same factor (the only factor with an eigenvalue greater than 1, accounting for 78% of the variation). Accordingly, we combined all 4 items into one aggregate "product attitude" scale (α = .90) to streamline the reporting of the mediation analyses (described below). As expected, ANOVA results indicated a significant effect of presentation format on this aggregated product attitude measure ($M_{Control}$ = 4.61 versus M_{AR} = 5.24; $F(1,106) = 6.39$, $p = .01$, $\eta_p^2 = .06$).

Personal Relevance and Mental Simulation.

To begin testing our proposed processes explaining the positive effect of AR presentation on product attitude, we ran an ANOVA with presentation format as the predictor and both mental simulation and personal relevance as dependent variables. ANOVA results revealed a significant positive effect of presentation format on personal relevance ($M_{Control}$ = 4.63 versus M_{AR} = 5.55; $F(1,106) = 12.07$, $p = .001$, $\eta_p^2 = .10$), where participants in the AR (vs. control) condition perceived the lamb shawarma to be more personally relevant to them. Similarly, ANOVA results revealed a significant positive effect of AR format on the degree to which participants engaged in mental simulation ($M_{Control}$ = 4.59 versus M_{AR} = 5.14; $F(1,106) = 5.11$, $p = .03$, $\eta_p^2 = .05$), replicating the initial finding in the previous study.

Next, to test H2 and replicate the mediation results from the previous study, we ran a mediation analysis to determine whether the positive effect of presentation format on product attitude could be explained through an increase in mental simulation. Mediation results (PROCESS Model 4, Hayes 2018; with 10,000 resamples) with presentation format as the predictor variable, product attitude as the dependent variable, and mental simulation as the mediator revealed a significant indirect effect (indirect effect = .3724, 95% CI: .0511 to .7420). Following the successful mediation through mental simulation, we next ran a sequential mediation analysis in order to test H3, the role of personal relevance as the precursory mechanism explaining the positive effect of AR presentation on mental simulation. Sequential mediation results (PROCESS Model 6, Hayes 2018; with 10,000 resamples) with presentation format as the predictor variable, product attitude as the dependent variable, and personal relevance followed by mental simulation as the sequential mediators revealed a significant indirect effect (indirect effect

= .1636, 95% CI: .0440 to .3361)[7], thus supporting H3 and the model proposed in Figure 1. In other words, these results suggest that presenting the lamb shawarma in AR (vs. a non-super imposed format) led participants to deem it as more personally relevant, facilitating their mental simulation of consuming it, which ultimately improved their product attitude[8].

Alternative Process Measures.

To begin systematically assessing the potential alternative process measures, we first ran a series of ANOVAs with presentation format as the predictor and each potential process measure as a dependent variable. The full results are presented in table 2.

[7] While the reverse sequential mediation pathway (i.e., mental simulation followed by personal relevance) also produced a significant indirect effect (indirect effect = .0734, 95% CI: .0070 to .1926), the larger effect size of the predicted sequential mediation suggests to us that it represents a more likely process explanation than the reverse. This path is also theoretically supported by extant research (üLküMen and Thomas 2013), demonstrating that high (vs. low) levels of personal relevance increases consumers' tendency to spontaneously engage in mental simulation.

[8] While we had no *a priori* predictions about the effect prior experience with a food item would have on the effect of AR presentation on product attitude, and the sequential mediation through personal relevance and mental simulation, we tested an exploratory moderated mediation analysis (model 85, Hayes 2018) with 10,000 resamples) to see whether prior experience could moderate our proposed process. Interesting, results revealed that when participants *had not previously eaten* lamb shawarma, there was a significant indirect effect of presentation format on product attitude through personal relevance and mental simulation (indirect effect = .1704, 95% CI: .0141 to .4067). However, when participants *did have prior experience* with lamb shawarma the indirect effect of presentation format on product attitude through personal relevance and mental simulation was no longer significant (indirect effect = .0609, 95% CI: -.0211 to .1842).

TABLE 2: EFFECT OF AR PRESENTATION ON POTENTIAL PROCESS MEASURES

DV	Mean		*F*	*p*	η_p^2
	Control	**AR**	**(1, 106)**		
Presence	-0.2*	0.2*	7.91	.006	.07
Attention to Background	1.57	1.93	3.03	.09	.03
Enjoyment of Experience	5.79	6.19	3.52	.06	.03
Fluency	5.41	5.72	1.68	.20	.02
Psychological Ownership	3.42	3.67	.68	.41	.01
Spatial Distance	4.81	4.87	.06	.81	.00
Temporal Distance	4.56	4.76	.76**	.38	.01
Realism	5.96	5.98	.01	.91	.00
Mood	5.84	5.84	.00	1.00	.00

*Z-score

***F*(1,104)

ANOVA results revealed that of the nine potential alternative process explanations, presentation format exerted a significant positive effect on only one of the variables—presence ($M_{Control}$ = -0.2* versus M_{AR} = 0.2* (*Z-scores); $F(1,106) = 7.91$, $p = .006$, $\eta_p^2 = .07$), suggesting that participants in the AR condition perceived the lamb shawarma to be more present in their peripersonal space than those in the control condition. In addition, results revealed marginally significant effects of presentation format on attention to the background ($M_{Control}$ = 1.57 versus M_{AR} = 1.93; $F(1,106) = 3.03$, $p = .09$, $\eta_p^2 = .03$) and overall enjoyment of the experience ($M_{Control}$ = 5.79 versus M_{AR} = 6.19; $F(1,106) = 3.52$, $p = .06$, $\eta_p^2 = .03$), in that participants in the AR condition reported paying more attention to the background and reported enjoying the experience more than those in the control condition. However, ANOVA results revealed no significant effects of presentation format on the remaining process measures, including fluency, psychological ownership, spatial and temporal distance, mood, or realism.

To test the efficacy of the three significant or marginally significant process measures, we then ran a parallel multiple mediation model with 10,000 resamples (Model

4, Hayes 2018) including presentation format as the predictor (coded as control = 0 and AR = 1), product attitude as the dependent variable, and presence, attention to background, and enjoyment of the experience as mediators. Mediation results did not reveal a significant indirect effect of presentation format on product attitude through any of the three potential processes (with 95% confidence intervals straddling 0 for each measure). Therefore, we are able to reasonably rule out presence, attention to the background, and enjoyment of the experience as alternative process explanations, confirming the sequential mediation of personal relevance and mental simulation in H3 as the primary process explaining the positive effect of AR presentation on product attitudes.

Ancillary Analysis.

As in chapter 3, to examine whether novelty might explain the positive effect of AR presentation on product attitude, we test whether participants' attitudinal response to presentation format differed according to their familiarity with AR technology. Once again, AR familiarity did not differ across the two presentation conditions ($M_{Control}$ = 4.67 versus M_{AR} = 4.52; $F(1, 106) = .217$, $p = .64$, $\eta_p^2 = .00$). Importantly, neither the main effect of AR familiarity nor the interaction between presentation format and AR familiarity were significant predictors of product attitude (both *p's* > .59). This reinforces the findings in chapter 3, suggesting that it is unlikely the positive attitudinal responses to foods presented in AR can be explained by the novelty of this technology.

In sum, results of this laboratory experiment corroborate the findings of Chapters 3 and 4 by demonstrating, in a controlled setting, that the real-time superimposition afforded by AR presentation increases both the desirability and purchase likelihood of depicted foods. Importantly, while this study replicated the mediational role of mental simulation, we were also able to identify personal relevance as the anteceding mediator in

the process. In other words, superimposing a food onto a consumer's real-time peripersonal space (via AR) leads consumers to deem it as more personally relevant, which facilitates their mental simulation of consuming it, and accordingly improves their attitude toward the food. While our results also demonstrate significant or marginally significant positive effects of AR presentation on other potential mechanisms (e.g., presence, attention to background, and enjoyment of the experience), they are unable to explain the effect of AR presentation on product attitude.

CHAPTER 6

REPLICATING THE PSYCHOLOGICAL PROCESS AND EXTENSION TO LESS DESIRABLE FOOD CATEGORY

INTRODUCTION

Results from the previous three chapters collectively established the positive effect of AR presentation on product attitudes, while supporting the sequential role of personal relevance and mental simulation as the underlying process explaining the observed effect. Aside from replicating the findings of chapters 3, 4 and 5, chapter 6 served three additional purposes. First, the previous three chapters utilized a mobile tablet (i.e., an iPad) to view both presentation formats (thus contributing theoretically to behavioral research in marketing that explores how technological features in mobile devices can systematically influence the way consumers process information and behave). However, given that consumer ownership and usage of mobile phones is significantly higher than that of tablets (Enge 2021), we wished to extend the generalizability and robustness of our findings by examining the effect of AR presentation executed via a smartphone devices. Therefore, participants in all conditions of this study viewed the depicted food item on smartphone, allowing us to determine whether the results hold and replicate on a significantly smaller digital screen. Second, while chapters 3 and 4 focused on indulgent desserts, and chapter 5 focused on a non-indulgent food item, chapter 6 explicitly included a manipulation of food desirability, to examine whether the effects would continue to hold for relatively undesirable food items. Previous research (Labroo and Nielsen 2010) has found that mental simulation can improve consumer attitudes towards not only desirable stimuli, but toward neutral and undesirable stimuli as well. For example, Labroo and Nielsen (2010) found that participants who were instructed to mentally simulate approaching an undesirable item (in this case curried grasshoppers) reported significantly improved evaluations and willingness to pay compared to participants who were not instructed to mentally simulate approach.

Finally, our previous chapters (and indeed, most research exploring mental simulation) treated mental simulation as a unidimensional construct, and accordingly focused on measuring the amount or level of mental simulation present (Castaño et al. 2008). However, recent work has added nuance to the mental simulation literature by distinguishing between two distinct types of mental simulation, each of which have been shown to influence consumers' judgments and behavior: process-focused simulations and outcome-focused simulations, respectively (Escalas and Luce 2004; Taylor et al. 1998; Zhao et al. 2007; Castaño et al. 2008; Ringler et al. 2020). Process-focused simulations, or "how-thinking", makes salient the process of engaging in an activity through the use of sensory cues to influence product attitudes and behavioral outcomes, including willingness to pay, purchase intention, goal completion, and consumption (Taylor et al. 1998; Escalas and Luce 2003; Castaño et al. 2008; Ringler et al. 2020). Conversely, outcome-focused simulations, or "why-thinking", makes salient the outcome from engaging in an activity, without consideration for how that outcome was achieved (Escalas and Luce 2003, 2004; Castaño et al. 2008). Based on this difference, the mental simulation facilitated through AR presentation should likely be driven by a process-focused mindset rather than an outcome-focused one, as the superimposition facilitated by AR provides users with the opportunity to imagine "engaging" with, or consuming, the food item, rather than the result from completing the activity (e.g., in this case, feeling full or satiated). To test this prediction, we measure mental simulation using the same 6-item scale used in Chapter 5, while adding additional items to distinctively measure both process-oriented and outcome-oriented simulation as well.

DESIGN AND PROCEDURE

One hundred and seventy-three volunteers (44% female, 0% Non-binary/other; M_{Age} = 29.87, SD = 7.00) from a university setting participated in this experiment in exchange for monetary compensation. This study employed a 2(presentation format: control vs. AR) x 2(food item: undesirable vs. desirable) between-subjects design. Presentation format was manipulated as in chapters 4 and 5 (keeping scale, resolution, dimensionality, and interactivity constant): the control condition featured the 3D food item over a static blank background, while the AR condition superimposed the 3D food item onto the viewer's real-time environment. To manipulate food-item desirability, participants either viewed fermented trout (determined as "undesirable" in the pretest reported in Chapter 14, Appendix M), or parmesan fries (determined as "desirable" in the pretest reported in Chapter 14, Appendix M). Images of the stimuli are presented in Chapter 14, Appendix N.

Once participants arrived at the lab, they scanned a QR code with their personal mobile phone to access a survey that included the consent form and survey questions. Participants were told that the purpose of this study was to view and evaluate a food item. Next, participants were provided with a Samsung S21 smartphone, and were randomly assigned to view either the undesirable food item (i.e., fermented trout), or the desirable food item (i.e., parmesan fries), in either the control or AR format. Prior to viewing the randomly assigned item, but after being told what food item they would be viewing, participants were asked to indicate their previous experience with the assigned food ("I have eaten fermented trout/parmesan fries before*,"* with the options, "yes", "no", or "unsure").

Participants responded to survey questions on their mobile phones while continuing to view the food item on the mobile phone provided (should they wish to).

Our dependent variable of interest in this study was product attitude (using the 4-item scale from chapter 5; α = .96). In an attempt to measure and replicate the sequential mediation observed in chapter 5, participants responded to the same personal relevance (r = .72), and mental simulation (α =.91) measures that were employed in chapter 5. To further investigate the type of mental simulation participants might engage in, they were also asked to respond to a 2-item index measuring process-oriented simulation (2-item measure adapted from Castaño et al. 2008; e.g., "I thought about how I would eat this food item", "I thought about the process of eating this food item"; r = .72), and a 2-item index measuring outcome-oriented simulation (2-item measure adapted from Castaño et al. 2008; e.g., "I thought about why I would eat this food item", "I thought about the benefits I would gain from eating this food item"; r = .34). Finally, participants indicated the realism of the stimuli (α = .85), their overall mood (r = .74), and their familiarity with AR Technology, all measured as in chapter 5. Finally, they indicated their gender and age.

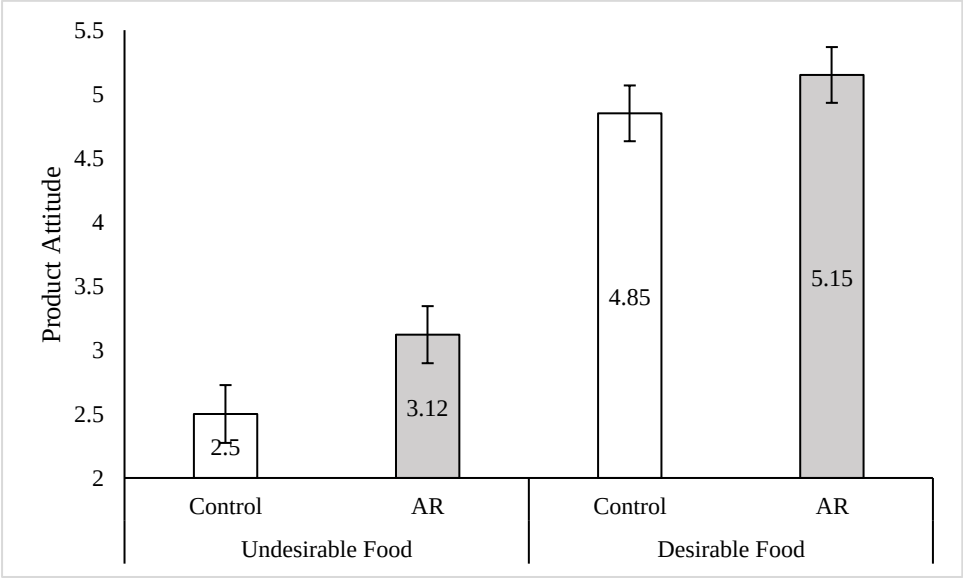
RESULTS AND DISCUSSION

Product Attitude.

Upon entering the lab, one participant mentioned they were familiar with the research as one of the researchers was their instructors. We accordingly excluded this participant from analysis, in addition to one participant whose evaluation of the undesirable food item was more than two standard deviations above the mean (i.e., an outlier; Porath et al. 2010), resulting in one hundred and seventy-one observations for analysis (we include the results of the analysis while retaining these participants in Chapter 14, Appendix P). A 2x2 ANOVA revealed significant main effects of presentation format (F(1, 167) = 4.39; p = .04, η_p^2 = .03) and food item (F(1, 167) =

98.21; $p < .001$, $\eta_p^2 = .37$) on overall product attitude. As was the case in our previous chapters, product attitude was higher in the AR condition ($M_{AR} = 4.14$) compared to product attitude in the control condition ($M_{Control} = 3.67$). As to be expected, product attitude was also higher in the Desirable (i.e., parmesan fries) condition ($M_{Desirable} = 5.00$), compared to product attitude in the Undesirable (i.e., fermented trout) condition ($M_{Undesirable} = 2.81$). The interactive effect was not significant ($F(3, 167) = .50$, $p = .48$), suggesting that AR presentation boosted desirability ratings for both products in a similar manner. An illustration of means is presented in Figure 2.

FIGURE 2: INTERACTIVE EFFECT OF PRESENTATION FORMAT AND FOOD-ITEM DESIRABILITY ON PRODUCT ATTITUDE



Personal Relevance.

2x2 ANOVA results for personal relevance follow the same pattern observed on product attitude, indicating a significant main effect of presentation format ($F(1, 167) = 8.93$; $p < .01$, $\eta_p^2 = .05$) on personal relevance, suggesting that participants in the AR condition ($M_{AR} = 4.32$) perceived the food items to be more personally relevant to them,

compared to participants in the control condition ($M_{Control}$ = 3.58). Similarly, ANOVA results revealed a significant main effect of food item ($F(1, 167) = 41.31$; $p < .001$, $\eta_p^2 = .20$) on personal relevance, again suggesting that participants who viewed the desirable food item ($M_{Desirable}$ = 4.75) perceived it to be more personally relevant than those who viewed the undesirable food item ($M_{Undesirable}$ = 3.15). The interactive effect between presentation format and food item was not significant ($F(3, 167) = 1.35$; $p = .25$, $\eta_p^2 = .01$).

Mental Simulation.

2x2 ANOVA results on mental simulation followed the same pattern as product attitude and personal relevance. ANOVA results revealed significant main effect of presentation format ($F(1, 167) = 4.24$; $p = .04$, $\eta_p^2 = .03$) on our 6-item measure of mental simulation, suggesting that participants in the AR condition (M_{AR} = 4.78) reported significantly higher mental simulation of consuming the food item compared to participants in the control condition ($M_{Control}$ = 4.33). Similarly, ANOVA results revealed a significant main effect of food item ($F(1, 167) = 14.97$; $p < .001$, $\eta_p^2 = .08$) on mental simulation, suggesting that participants who viewed the desirable food item ($M_{Desirable}$ = 4.98) reported significantly higher mental simulation of consuming the depicted food compared to those who viewed the undesirable food item ($M_{Undesirable}$ – 4.13). Once again, the interactive effect was not significant ($F(3, 167) = 1.61$, $p = .21$, $\eta_p^2 = .01$). We next ran a sequential mediation analysis to test H3 and replicate the mediation observed in chapter 5 to explore whether the effect of presentation format on product attitude could be explained through an increase in personal relevance, followed by an increase in mental simulation. Specifically, we conducted a sequential mediation analysis (PROCESS Model 6, Hayes 2018; using 10,000 resamples) with presentation format as the predictor (coded

as control = 0, AR = 1), product attitude as the dependent variable, personal relevance followed by mental simulation as the sequential mediators, and food item as a covariate. Results revealed a significant indirect effect of presentation format on product attitude through personal relevance and mental simulation (indirect effect = .1272, 95% CI: .0379 to .2410), supporting H3 and replicating the results of chapter 5.

To determine specifically what type of mental simulation might explain the observed results, we next tested the effect of our manipulations on both process-oriented and outcome-oriented simulation. ANOVA results revealed that presentation format did not exert a significant main effect on either process-oriented simulation ($F(1, 167) = 1.05$, $M_{Control} = 4.07$, $M_{AR} = 4.34$; $p = .31$, $\eta_p^2 = .01$) or outcome-oriented simulation ($F(1, 167) = 2.52$, $M_{Control} = 3.27$, $M_{AR} = 3.59$; $p = .11$, $\eta_p^2 = .01$). However, to more rigorously explore how these two different types of mental simulation might relate to our 6-item mental simulation measure, we conducted a factor analysis with all 10 mental simulation items (2 process-oriented, 2 outcome-oriented, 6 general mental simulation) to determine whether the items loaded on different factors. Results indicated that the two process-oriented items loaded onto the same factor as all 6 mental simulation items used in our original mental simulation scale (the only factor with an eigenvalue greater than 1.3, accounting for 51% of the variation). Accordingly, we combined all 8 items into one aggregate "process-oriented mental simulation" scale ($\alpha = .90$).

2x2 ANOVA results on the new 8-item process-oriented mental simulation scale revealed a significant main effect of both presentation format ($F(1, 167) = 3.95$, $M_{Control} = 4.25$, $M_{AR} = 4.67$; $p = .05$, $\eta_p^2 = .02$) and food item ($F(1, 167) = 12.69$, $M_{Undesirable} = 4.09$, $M_{Desirable} = 4.83$; $p < .001$, $\eta_p^2 = .07$), while the interactive effect was not significant ($F(3, 167) = 1.08$; $p = .30$, $\eta_p^2 = .01$). To determine whether the new process-oriented mental simulation scale could replicate the sequential mediation observed by our original scale,

we again ran a sequential mediation analysis with 10,000 resamples (PROCESS Model 6, Hayes 2018) with presentation format as the predictor variable, product attitude as the dependent variable, personal relevance followed by process-oriented mental simulation as the sequential mediators, and food item as a covariate. Results indicated a significant indirect effect of presentation format on product attitude (indirect effect = .1174, 95% CI: .0361 to .2232), providing further support for the role of both personal relevance and mental simulation as the underlying processes explaining the observed effect of AR presentation on product attitude, thus supporting H3, as well as identifying process-oriented simulation as the type of mental simulation explaining the effect.

In sum, results of this laboratory experiment further supported the findings of Chapters 3, 4, and 5 by demonstrating that the real-time superimposition afforded by AR presentation increases the perceived personal relevance of the depicted food item, which increases the process-oriented mental simulation participants experience of consuming the depicted food item, ultimately increasing the overall attitude toward the product. Importantly, while this study replicated the sequential mediational role of personal relevance followed by mental simulation, we were also able to uncover the specific type of mental simulation observed: process-oriented simulation. In other words, it appears as though the increased personal relevance resulting from the superimposition of a food item onto a consumer's real-time peripersonal space (via AR) leads the consumer to simulate, mentally, the process of interacting with and consuming the depicted food item (compared to imaging the outcome resulting from eating the food item), ultimately improving their attitude toward the food.

Importantly, this study allowed us to explore whether the positive effect of AR presentation works only for desirable food items (as tested in the previous 3 chapters), or if AR presentation could also improve attitudes for undesirable food items. Consistent

with previous literature (Labroo and Nielsen 2010), findings from this study demonstrate that the positive effect of AR presentation does not only manifest for desirable food items (e.g., parmesan fries), but also extends to less-desirable food items (e.g., fermented trout).

Finally, chapter 6 provided an opportunity to test whether the observed results from the previous three chapters could be replicated on a smaller, yet more accessible, mobile device (i.e., smartphones). While we did not explicitly manipulate and compare device form (i.e., iPad vs. smartphone) in this study, the positive effect of AR presentation, and the replication of the sequential process from the previous study, add to the robustness of our investigation extend the generalizability and relevance of our investigation.

CHAPTER 7

AUGMENTED REALITY: A DISCUSSION

AR technology has generated enormous industry investment and buzz, and this trend shows no signs of slowing down. All the major tech players, including Apple, Amazon, Facebook, Google, and Microsoft, are either rumored or confirmed to be developing new consumer AR software and hardware (Molla 2017; Swanner 2019). As mentioned earlier, many marketplace applications of the technology have been in the food industry, with several major restaurant chains and independent dining establishments jumping on the AR bandwagon. However, little research has empirically examined how this still relatively nascent, yet increasingly ubiquitous technology can influence consumers' judgments and behaviors.

Our research demonstrates that because AR visually superimposes objects onto a consumer's real-time environment, it leads consumers to percieve depicted foods to be more personally relevant, increasing mental simulation and improving downstream attitudes and behaviors. Across two field studies (Chapters 3 and 4) and two lab experiments (Chapters 5 and 6) we showed that presenting foods in AR (versus either an externally valid 2D static format or a more conservative dynamic 3D format) can increase desirability (Chapters 3, 4, and 5) and purchase likelihood (Chapters 3 and 5). Although this effect is likely driven by multiple processes (including perceived presence, attention to the background, and enjoyment of the experience), we focus on one dominant underlying mechanism—mental simulation (Chapters 4 and 5)—which is itself likely driven by an increased sense of personal relevance (Chapter 5). Importantly, we find the positive effect of AR presentation holds for indulgent (Chapters 3 and 4), non-indulgent (Chapter 5), desirable and undesirable (Chapter 6) food categories, regardless of whether the food is immediately available for consumption (Chapters 3 and 4) or not (Chapters 5 and 6).

The current work addresses recent calls to explore how AR affects sensory perceptions, decision-making, attitude formation, and pre/post purchase behavior and evaluations (Tan et al. 2021) and how new immersive consumer technologies—including AR—can affect consumers' mental simulation and imagery generation (Ceylan et al. 2022). We demonstrate that AR technology, due to its ability to visually superimpose products onto a consumer's real-time environment, is uniquely able to generate mental simulation *above and beyond* visual stimuli that is not superimposed, contributing to this literature by both identifying and measuring the psychological process driving this effect.

We also add to a growing body of behavioral research in marketing that explores how technological features in mobile devices can systematically influence the way consumers process information and behave. While previous scholars have examined the touchscreen (Brasel and Gips 2014; Shen, Zhang, and Krishna 2016) and photo-taking (Diehl et al. 2016) functionality of mobile devices, and considered the assumptions consumers make about reviews written on mobile devices (Grewal and Stephen 2019), the current research demonstrates that AR superimposition using a mobile device's camera can also alter consumers' perceptions and influence real-world behaviors.

In practical terms, our findings suggest that offering consumers the ability to view products in an AR format may be a worthwhile investment, and this can be implemented in a number of ways. In the context of the food/restaurant industry that we have focused on, many dining establishments (e.g., restaurants, cafeterias, bars) already offer patrons digital menus via handheld tablets (Anindita 2018). These digital menus can easily be upgraded with AR-enabled renderings of the menu items, allowing patrons to visually preview dish on their table before placing an order (similar to the procedure we used in Chapters 3 and 4). This AR format could also facilitate the inclusion of additional product relevant information, such as nutrition or allergy information, however results from an

excluded study suggest adding utilitarian information might not always benefit the consumer, depending on the product it relates to (see Chapter 14, Appendix P for excluded study). Catering firms and bakeries that provide custom offerings (e.g., personalized cakes) can use AR technology to facilitate potential customers' ability to visualize what yet-to-be-created products will look like, before going through any irreversible production process. Our research suggests that such efforts should make the viewed food items more desirable and lead to increased purchase likelihood. Further, given our finding that AR previewing improves consumers' evaluation of the consumption experience itself, it is likely to increase customer satisfaction (itself a critical determinant of marketplace behaviors such as repurchase, recommendation, and willingness to pay; Anderson and Sullivan 1993; Homburg, Koschate, and Hoyer 2005) and result in fewer returns and complaints.

Additionally, because AR technology simply requires a camera-enabled mobile device, these implications carry over to consumers' at-home viewing of foods. This has become an increasingly relevant given that online food ordering (e.g., Uber Eats, Seamless, Deliveroo) and online grocery shopping have both been on the rise (Kats 2019, Littman 21019), and even more so since the Covid-19 pandemic (Venkataramakrishnan 2020). AR technology can give consumers the opportunity to view food offerings in their own homes, on their own dining room tables, before placing any orders. In addition, the camera-enabled nature of mobile devices means these implications can also extend to mobile marketing efforts. Brand managers can use AR tools embedded within Snapchat, Instagram, or TikTok filters to present foods in consumers real-time environments and can even enable transactions through those channels (as Domino's pizza did; Swant 2018). These opportunities will likely become more common in the future given the developments of AR glasses by the aforementioned tech giants (Swanner 2019).

Importantly, the nascent nature of AR technology and it's expanding marketplace applications pave several exciting avenues for potential future research, both within the food domain and beyond. For example, while the current work focused on how AR technology can be used during consumers' previewing and ordering of foods, it would also be interesting to examine how AR can also be applied during consumers' consumption of foods and beverages. For example, at Sublimotion, the world's most expensive restaurant, diners wear headsets and are treated to a 15-course gastronomic show combining gourmet cuisine with AR intended to, "play with emotions, the senses, the set, the aromas, and the taste to be able to create absolutely unique experiences for each scene [course]," (Strause 2015). In the beverage space, Australian wine company *19 Crimes* created an AR app allowing consumers to bring the wine bottle's label to life through their mobile devices: criminals featured on each bottle become animated and tell their story, enriching the drinking experience by simultaneously engaging both the mind and taste buds (Stone 2017). It is likely that such applications can significantly transform consumers' consumption experiences, turning them into highly interactive and experiential episodes.

While AR applications in the food domain provided a theoretically and externally valid area to begin exploring the effect of AR presentation on consumer responses, this represents the tip of the iceberg. Brands across various other categories have also begun implementing AR-enabled applications for consumer engagement purposes. For example, the Ikea Place app allows customers to see how 2,000 furniture items would look and fit in their homes (Dasey 2017), and L'Oréal acquired an AR company, ModiFace, to allow consumers to virtually try on makeup and hair products, as well as scan their skin to identify blemishes to be treated with skincare products (L'Oréal 2018). Since our research demonstrates mental simulation is one of the critical mechanisms through which AR

exerts its effects on consumer responses, these positive consumer responses should theoretically manifest when mental simulation is an advantageous process. Given previous research suggesting that mental simulation is most beneficial for highly sensorial/hedonic (as opposed to utilitarian) product attributes (MacInnis and Price 1987), it could be interesting to examine systematic boundary effects of AR presentation across product categories, or cases where AR might induce negative consequences or effects. This may be particularly interesting to explore because unlike real-world or VR experiences where a consumer is fully situated within one environment, AR requires consumers to simultaneously attend to both the virtual and real-world, potentially resulting in cognitive depletion (Oh and Bailenson 2017).

While mobile AR is here now (enabled on the billions of Android and Apple smartphones worldwide), the imminent fusion of AR technology into wearable devices (i.e., glasses) will make it an even more ubiquitous phenomenon. One tech executive described this future by saying, “The world is about to be painted with data,” (Fink 2018). In such an analogy, marketers may very well be holding the paintbrushes, and we hope to see more research exploring how AR can best be used to enhance the customer experiences and marketing outcomes accordingly.

CHAPTER 8

EXPLORING CONSUMER RESPONSES TO SPATIAL AUDIO

INTRODUCTION

Consumers today are exposed to more digital audio than ever before. For example, over 95% of Americans listen to some form of digital audio daily, with the average adult consuming over four hours each day (Paris 2021). This shift in audio consumption is due in part to a proliferation of audio-centric applications and content, including music-streaming services (e.g., Spotify, with 406M active monthly users; Steele 2022), social platforms hosting sound-led user videos (e.g., TikTok, with 1.5B active monthly users; Hutchinson 2022) and newly-popular audio chatrooms (e.g., Clubhouse, with 700,000 new rooms created daily; Santora 2022). This boom in audio consumption has also been facilitated by the widespread adoption of wireless headphones (e.g., Apple AirPods, with $12 billion in annual revenue; Cohen 2020), and advancements in infrastructure (e.g., 5G expansion), which help support seamless audio delivery for users.

Perhaps unsurprisingly, Big Tech has been quick to capitalize on consumers' increased audio consumption, resulting in a surge of investment into audio hardware and software that might enhance the audio experience for users. Notably, tech giants including Apple, Facebook, and Dolby have cumulatively invested billions into the advancement of "spatial audio" technology (Fortune Business Insights 2020). Spatial audio refers to "a set of devices and signal processing algorithms which can create the perception in listeners that the audio comes from any directed position," (Tashev 2019). Put differently, spatial audio uses hardware (e.g., gyroscopes and accelerometers) and software in mobile devices and headphones to geographically anchor (geo-anchor) sounds in a manner that mimics real-world sound. This creates an immersive artificial audio experience where the listener has the freedom to move in relation to anchored sounds, digitally replicating the dynamism of real-life sound.

While the early development of spatial audio technology was largely pioneered by the music sector (in efforts to deliver the best audio experience possible to listeners; Derksen 2019), many contemporary applications of spatial audio are motivated by the emergence of (and the hype surrounding) visually immersive digital experiences (e.g., augmented reality and virtual reality content) and anticipated Web3 networks (e.g. the Metaverse). These visually immersive contexts provide a domain in which content creators and brands are beginning to experiment with spatial audio usage (Keller 2022; Konik 2021), often in an effort to further heighten a user's sense of immersion and overall engagement in the experience.

Yet despite the excitement surrounding spatial audio (and immersive experiences in general), no research has empirically explored how this nascent technology might actually influence consumers' judgments and behaviors. While recent research in marketing has begun to explore consumer responses to different applications and configurations of both AR and VR technology (i.e., Carrozzi et al. 2019; Heller et al. 2019; Hilken et al. 2017), a natural tendency has been to focus almost exclusively on the visual stimuli produced in such technologically-mediated experiences, without considering the role of stimuli from other modalities (e.g., audition). Furthermore, while some research in consumer behavior has explored how audio can influence consumer responses to advertising, sparse research has explored how specific technological features of audio might play a role. Given the dearth of auditory-centric consumer research (Krishna 2012; Argo, Popa, and Smith 2010; Spence 2012; Tavassoli and Lee 2003; Yorkston and Menon 2004; Hagtvedt and Brasel 2016) and the increased prevalence of spatial audio in the marketplace, it is compelling to consider whether and how dynamic audio might shape perceptions and influence consumer judgments in digital advertising contexts.

Thus, motivated by both academic interest and substantive importance, the current work explores how and when dynamic audio might influence consumer responses to advertising. We propose and demonstrate across three empirical chapters (in collaboration with a major social media platform and three legacy CPG brands), that because dynamic audio produces distance-based variability in sound (i.e., the amplification/attenuation of sound when approaching/retreating from a geo-anchored target object, respectively), it increases consumers' sense of immersion in digitally-augmented advertisements, and accordingly improves consumer attitudes toward featured products. In addition to demonstrating this effect across various CPG categories, we provide evidence for the underlying mechanism, and define theoretically and substantive boundary conditions for the effect. Before describing our empirical work in detail, we turn to extant literature to develop our theoretical framework and support our specific hypotheses.

THEORETICAL DEVELOPMENT

Audio in Advertising

Academic research has long acknowledged that audio plays a significant role in shaping consumer reactions to advertising. Some work had focused on the role of music, finding that music is often the single most powerful component of a commercial (Hecker 1984; Morris and Boone 1998). For example, MacInnis and Park (1991) find that music increases advertising message processing and involvement for low-involvement consumers due to its ability to trigger emotion-laden memories associated with the music. Other research has found that music can serve as a "peripheral persuasion cue", increasing the emotional state of low-involvement consumers which increases attitudes about the advertisement and ultimately the brand itself (Gorn 1982; Petty, Cacioppo, and Schumann 1983; Park and Young 1986; Stout and Leckenby 1988; Morris and Boone

1998). Conversely, some research has found music has the potential to distract and interfere with consumers' ability to process information about a brand's attributes (Park and Young 1986). Additional research has looked at specific characteristics of music, including its tempo (Stout and Leckenby 1988), pitch (Bruner 1990), and congruence with an advertisement's message (Alpert and Alpert 1990; MacInnis and Park 1991; Kellaris, Cox, and Cox 1993; Morris and Boone 1998),

Other research has focused on how audio in advertising can influence consumers' attention. Cross-modal attention research has shown that "a signal sensed in one modality (e.g., auditory) draws attention to itself in other modalities (e.g., visual) as well," (Driver and Spence 1998a, 1998b; Shen and Sengupta 2014). Gopher (1973) demonstrated that when participants were exposed to two channels of audio played through headphones (i.e., one audio channel played in each ear) and were told to follow a specific channel, participants shifted their eyes in the corresponding direction of the audio channel, "looking where they listened". More recently, Hagtvedt and Brasel (2016) demonstrated that high-frequency (low frequency) audio guides consumer attention towards visually light (dark) stimuli, and this attention influences both message recall and purchase behavior.

Beyond traditional advertising contexts, research has found that auditory cues from products themselves can influence consumer perceptions and evaluations. For example, literature on cross-modal correspondences (e.g., Spence 2012, 2015, 2016) has repeatedly demonstrated that sounds produced by a food/drink can influence consumers' taste evaluation and overall consumption. For example, Zampini and Spence (2004) found that participants rated potato chips as significantly "fresher" and "crisper" when the manipulated audio sound level and frequency were higher, compared to when the audio sound intensity and frequency were attenuated. Outside the food domain, product sounds

have also been shown to significantly influence perceptions of quality, functionality, and utility. For example, consumers evaluated an electronic mixer as being more powerful, more functional, and stronger overall when the mixer's sound was heard, compared to when the sound was absent (Cox 1967). More recently, Ringler and colleagues (2020) found that consequential product sounds (i.e., sounds produced by a product in use) enhance willingness to pay for a featured product. In their studies, they demonstrate that a loud (versus quiet) consequential product sound (specifically, the sound of an electric blender in use) signals "powerfulness" of the product consumers, thereby increasing willingness to pay for the featured product.

Thus collectively, extant research suggests that audio can influence consumer responses to advertising and can shape consumer evaluations of products. However, as far as the authors are aware, no research has explored how specific technological features of audio might play a role in shaping consumer perceptions in such contexts. We address this gap by exploring how one specific feature of audio—it's dynamism—might influence consumer responses to audio in advertisements. To examine this notion, we next define and describe the technology which enables sound dynamism—spatial audio.

Spatial audio and sound dynamism

The primary technological advancement allowing users to experience dynamic sounds is known as spatial audio. Spatial audio technology uses a combination of hardware (e.g., accelerometers and gyroscopes) and software within mobile devices and headphones to create a dynamic, three-dimensional sound-scene tied to geo-anchored objects (Sodnik and Tomažič 2015). The term "geo-anchored" refers to a specific location in the real-world that a virtual object is positioned, allowing a user (through the assistance of a mobile device such as a smartphone or a VR headset) to move around and actively

engage with virtual objects as though they were physically present (Bujari et al. 2013). By anchoring sounds to physical locations in a user's real surroundings, spatial audio creates a sense of "space" beyond traditional, standard audio, allowing the listener to perceive a specific location (e.g., above/below, left/right, near/far, etc.) and source producing a sound, and to interact with that sound in real-time (Derksen 2019). To illustrate, if a user were to view a visual representation of a kitchen mixer superimposed on their countertop (via an AR application), just as that visual representation would change according to the user's movements (e.g., appearing larger or smaller as the user moves closer to or further away from the depicted appliance, respectively), any audio geo-anchored to the kitchen mixer would also change dynamically in response to the user's movement (e.g., sounding louder or quieter as the user moves closer to or further away from the depicted appliance, respectively; see Chapter 15, Appendix A to experience a similar simulation). Thus, spatial audio can help build compelling and realistic AR and VR experiences, given its ability to dynamically mimic real-world auditory perception (Tashev 2019). Traditionally, spatial audio's inclusion within these virtual environments has been limited, given the significant computational resources and rendering that real-time implementation of the technology requires (Lu and Qi 2021; Arend et al. 2021). However, this lag in spatial audio implementation is quickly changing, due in part to the proliferation of 5G wireless speeds, advancements in mobile-computing chips, and the growing consumer demand for more engaging and authentic audio experiences.

One way scholars have illustrated the experiential difference between standard audio and spatial audio is by defining the location in which the sound is perceived when heard through headphones. When standard audio is played through headphones, the sound is perceived as "inside the head" (Tashev 2019). This means that the listener is unable to

perceive any dimensionality of the sound. Additionally, as the listener moves their head or mobile device, the audio remains "fixed" or "static", meaning the user cannot influence the audio through their movement either. On the other hand, when spatial audio is played through headphones, the audio scene is perceived as external, coming from specific geo-anchored locations, from a defined direction and distance outside of the listener's head (Tashev 2019; Kolarik et al. 2016; Catic et al. 2013; Hartmann and Wittenberg 1996). The perception of these two dimensions—direction and distance—is fundamental to the spatial audio experience, as it facilitates the perception of dynamism in digitally produced sound experiences (Lin and Wang 2021)[9]. We describe these two dimensions in detail next.

Direction perception. Most humans can accurately perceive the direction of an audio source through the subtle differences heard between the two ears. This difference typically manifests through interaural time difference. Interaural time difference (ITD) results when a sound source is off-center, creating "a subtle time delay between the signal reaching the nearer ear and the further one," (Derksen 2019). The further left or right a sound source is, the larger the delay between the near and far ear will be, resulting in stronger and clearer perception of audio direction. Although this delay between ears occurs too quickly to consciously recognize, ITD more commonly is perceived through the attenuated volume heard in the further ear compared to the volume level in the closer ear (Kolarik et al. 2016). This difference is particularly strong for sounds heard within a listener's peripersonal space (i.e., distances up to approximately 1 meter from the listener), with specific directional accuracy reducing as distance from the sound source

[9] Spatial audio is a rapidly evolving technology, both in terms of hardware and software. Therefore, the experience facilitated by spatial audio technology can differ dramatically, particularly in regards to active versus passive experiences, monaural versus binaural experiences, audio-only versus multi-sensory experiences, and more. Some of these nuances and experiential differences will be explored in the empirical work that follows, while others will be discussed in the future work section of the general discussion.

increases (Brungart, Durlach, and Rabinowitz 1999; Duda and Martens 1998; Greene 1998; Kolarik et al. 2016). Auditory directional cues from ITD are so powerful that listeners can accurately perceive the direction of non-visible sound sources, or even digitally created immersive scenes where the user is not "physically" present (Lin and Wang 2021).

Distance perception. Although a fundamental component of spatial hearing, auditory distance perception remains an under-researched phenomenon compared to directional auditory perception (Kolarik et al. 2016; Zahorik 2002; Zahorik et al. 2005). This may partially be due to findings suggesting that perceived auditory distance estimates are generally poorer and less accurate compared to perceived auditory directional judgments (Middlebrooks and Green 1991; Kolarik et al. 2016). Nevertheless, audio intensity (i.e., loudness) was identified as a primary acoustic cue for distance over a century ago (Thompson 1882), and subsequent researchers have empirically documented the overall relationship between audio intensity and distance (Stevens and Guirao 1962). More recently, Störig and Pörschmann (2013) empirically find that sound pressure level (i.e., the measurement of loudness) is the main parameter for distance perception in a virtual environment. In other words, the louder (quieter) a sound, the closer (further) people estimate the source of that sound to be.

The Effect of Sound Dynamism on Immersion and Product Attitudes

As described above, spatial audio technology mimics the dynamism of real-world auditory experiences, and accordingly, the sound experience will depend on a user's movements (i.e., audio output will vary based on a user's distance and direction relative to geo-anchored sounds). This responsiveness to consumer movement/activity should be valuable in and of itself, given research showing that adding auditory feedback during

product interactions results in higher levels of engagement (Bialkova and Van Gisbergen 2017) and increased product perceptions and evaluations (Petit, Velasco, and Spence 2019; Petit et al. 2015; Hagtvedt and Brasel 2016; Heller et al. 2019; Wedel, Bigńe, and Zhang 2020). While the aforementioned literature suggests consumer responses to dynamic audio should generally be positive, more central to our theorizing is how such dynamism may increase consumers' sense of immersion in an experience.

Immersion as a psychological process. Immersion is a form of cognitive and emotional absorption, emerging from physical, mental, or emotional engagement with a task or activity (Georgiou and Kyza 2017; Brooks 2003; Cheng et al. 2015; Weibel et al. 2010). Brown and Cairns (2004) describe conceptualize immersion as, "a gradated psychological process…consisting of engagement, engrossment, and total immersion", with total immersion serving as the optimum level of immersion in which the individual reaches a sense of presence (i.e., "being there") and flow (i.e., complete mental involvement; Georgiou and Kyza 2017).

Notably, virtual 3-dimensional product images (Faust et al. 2012; Ryan 1999) and visually interactive media (e.g., AR and VR) have been shown to facilitate an increased sense of immersion (Dede 2009; Georgiou and Kyza 2017) and to evoke subjective and psychological responses similar to those conjured by corresponding real environments (Meehan et al. 2002; Wedel, Bigńe, and Zhang 2020). Other researchers have found that visual dynamism in imagery and logos can increase consumers' attentional vigilance, engagement and attitudes (Brasel and Hagtvedt 2016; Cian, Krishna, and Elder 2014, 2015). While such research focused on visual stimuli, following a similar logic, increased dynamism in audio should also lead to an increased sense of engagement and immersion.

Furthermore, extant research suggests that in general, immersion in advertising contexts can improve consumers' attitudes towards the experience and towards featured

products (MacInnis and Park 1991; Meyers-Levy, Bublitz, and Peracchio 2009). In virtual environments specifically, work by Schlosser (2003) found that increased immersion in virtual environments can increase consumer's purchase intentions for featured products. This is consistent with the notion that interactive technology facilitates increased involvement and engagement with both the technology itself, as well as the focal content produced by the technology (Hoffman and Novak 1996). Based on these collective findings, we formally hypothesize the following:

H1: Dynamic (versus standard) audio will improve a consumer's attitude toward a featured product.

H2: The effect described in H1 will be driven by an increased sense of immersion in the experience.

Physical Approach as a Prerequisite. While spatial audio technology mimics the dynamism of real-world audio experiences, users are unlikely to experience certain aspects of the dynamism if they do not physically interact with the featured stimuli. Specifically, a user will not experience one of the critical dimensions of dynamism, distance perception, if they do not vary the physical space between themselves and the target object. In other words, distance-based variability in sound (i.e., the amplification/attenuation of sound when approaching/retreating from a target object) is only experienced if the user physically approaches or moves away from a featured product (otherwise, there would be no opportunity for the user to experience the amplification/attenuation). In virtual environments, "physical approach" can manifest in a number of different ways, whether by moving one's fingers (e.g., moving a joystick in

VR; pinching one's fingers on a touch-screen in AR), moving one's hand/arm (e.g., extending an arm to move the phone closer to a virtual object in AR; reaching out and grabbing a virtual object in VR), or moving one's entire body (e.g., walking closer to a virtual object in AR or VR). In any case, such physical interaction is a prerequisite for experiencing the distance-based variation in sound afforded by dynamic audio. Thus, the positive effects of dynamic audio described in H1 and H2 should only manifest if a user physically approaches the target object during the auditory experience. Thus formally, we hypothesize:

> **H3:** The effect of dynamic (versus standard) audio on immersion and product attitudes should only manifest if users physically approach the featured products.

The Current Research: Exploring the Effects of Dynamic Audio in AR Advertisements

To being exploring how dynamic audio might influence consumer responses and to test our specific hypotheses, we situated our investigation in the context AR advertising in the CPG category (food and beverage in particular). These decisions were motivated by both practical and theoretical concerns. The selection of AR as a platform was practically motivated by the fact that experiencing spatial audio requires the sound to be geo-anchored to a specific location, allowing the observer to interact with, and move in relation to the source. Because AR only requires a camera-equipped mobile device to visually superimpose a virtual object onto a consumer's real-time environment, allowing the user to interact with the object as though it was physically present, AR represents an ideal domain to test and explore dynamic audio, by anchoring sound to the virtual AR object. Our decision to focus on the food and beverage category was inspired not only by the vast size of the industry (with a 2021 global market value of $281 billion; Wunsch

2021), but by the aforementioned extant research on product sounds, which has predominantly focused on auditory cues (e.g., the crunch, fizzing, or crackling sounds) emanating from edible products. Such work suggests that food/beverage is an especially opportune domain for investigating the effects the potential influence of auditory-related manipulations.

Our empirical work consists of three experimental chapters, which collectively provide support for our proposed theorizing. Chapter 9 supports H1 by demonstrating that dynamic audio does in fact improve attitudes towards a featured product compared to standard audio. In Chapter 10, we replicate the positive effect of dynamic audio on product attitudes (further supporting H1) and provide evidence (via mediation) for immersion as the underlying process (H2). Chapter 10 also allowed us to isolate the critical dimension of audio dynamism driving the effects (distance perception). Finally, Chapter 11 replicates the effect of dynamic audio on both product attitudes and immersion (adding support for H1 and H2), and demonstrates the role of physical approach as a necessary boundary condition (supporting H3). We describe the details of this empirical work next.

CHAPTER 9

THE EFFECT OF DYNAMIC AUDIO ON PRODUCT ATTITUDES

INTRODUCTION

Chapter 9 served as an initial examination of the effect of dynamic audio on consumer attitudes towards a featured product (testing H1). The dynamic audio condition in this study was represented by a spatial audio format (including both distance-based and direction-based dynamism). While the central focus of this study was to examine how dynamic (vs. standard) audio influences consumers' attitudes, we also included a 'no audio' condition for exploratory purposes, given the current ubiquity of 'sound-off' digital advertising (we had no *a priori* predictions of how that condition might perform relative to the two audio conditions of primary interest).

DESIGN AND PROCEDURE

One hundred and thirty-nine volunteers from a university setting (52% female, 1% nonbinary/other; M_{Age} = 29.34, SD = 7.01) participated in this experiment in exchange for monetary compensation. The experiment used a three-level (audio format: no audio vs. standard audio vs. spatial audio) between-subjects design. To create the stimuli in this study, we collaborated with a large social media company and a multinational beverage manufacturer to create three visually-identical augmented reality mobile advertisements. In all conditions, the advertisement featured a bottle of sparkling water with an arrow pointing to it with accompanying text that read, "Open & Dive In" (hence encouraging the user to move the phone towards the bottle- the cap would pop off upon this approach). In the no audio condition, there was no sound accompanying the advertisement. In the standard audio condition, participants first heard ambient noise, a "pop" as the bottle-cap popped off, and then a "bubbly fizz" for the remainder of the experience as the room filled with bubbles. Notably, in this condition the audio was not dynamic, in that it did not indicate distance (i.e., no increase or decrease in volume upon approach), nor did it

provide directional cues (i.e., sound did not differ in one ear versus the other) throughout the experience. In the spatial audio condition, participants heard the exact same sounds as in the standard audio condition; however, in this case the volume was dynamic, meaning that the sound (e.g., the bubbly fizz) heard was anchored to a visual object (in this case, the bottle of sparkling water) and would increase/decrease as participants approached/retreated from the bottle, and would shift from ear to ear as participants panned to the right or left of the bottle. The stimuli and simulated experience for each condition can be found in Chapter 15, Appendix B.

After indicating consent, each participant was seated in the laboratory and given a Samsung S21mobile phone and DT770M over-ear headphones (see Chapter 15, Appendix C). To begin, participants were instructed to watch an unrelated short filler video. This served as an opportunity to ensure the headphones and mobile phones were working properly, and it also provided an unobtrusive way to make sure participants in all conditions were wearing headphones while viewing the following advertisement. Participants were then randomly assigned to view one of the three advertisements according to experimental condition. After viewing the advertisement, participants rated the desirability of the sparkling water (3 items: desire, craving, and urge to drink; $\alpha = .91$) measured on 7-point Likert scales (1 = "strongly disagree" to 7 "strongly agree"), and their purchase likelihood ("how likely would you be to purchase this water if it was offered at a store?"; 7-point scale, 1 = "extremely unlikely" to 7 = "extremely likely"). In addition, participants responded to battery of experiential, sensory, and process measures (see Chapter 15, Appendix D for full list of items and results). Finally, participants respond to an audio-format manipulation check item ("As I approached the bottle, the sound became louder"), were asked to indicate their familiarity with spatial audio

technology ("How familiar are you with Spatial Audio?"), their age, and their gender, and were thanked for their time.

RESULTS AND DISCUSSION

Manipulation Check.

ANOVA results supported the efficacy of the audio format manipulation by revealing a significant main effect of audio format on perceived volume change ($F(2, 136) = 17.41$, $M_{NoAudio} = 3.65$, $M_{StandardAudio} = 3.96$, $M_{SpatialAudio} = 5.33$; $p < .001$, $\eta_p^2 = .25$). As expected, an analysis of contrasts revealed a significant difference in perceived volume change between the spatial audio format and both the standard audio ($p < .001$) and no audio formats ($p < .001$), while there was no significant difference between standard audio and no audio format ($p = .39$).

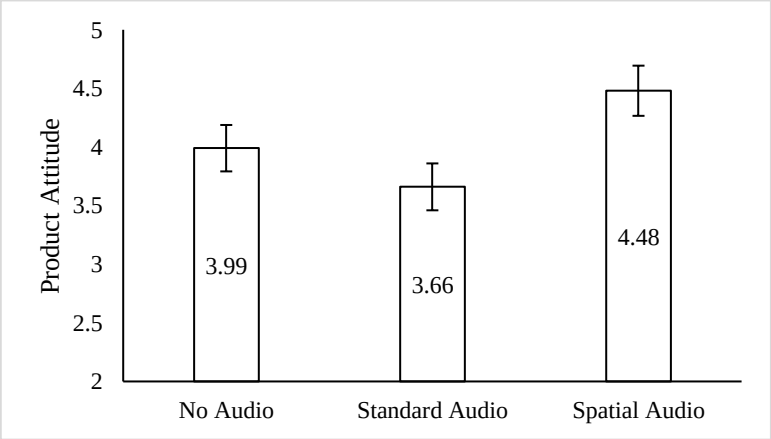
Product Attitude.

ANOVA results revealed a significant main effect of audio format on product desirability ($F(2, 136) = 3.81$; $M_{NoAudio} = 3.91$; $M_{StandardAudio} = 3.64$; $M_{SpatialAudio} = 4.44$; $p = .02$, $\eta_p^2 = .05$), and purchase likelihood ($F(2, 136) = 3.18$; $M_{NoAudio} = 4.25$; $M_{StandardAudio} = 3.71$; $M_{SpatialAudio} = 4.57$; $p = .05$, $\eta_p^2 = .05$). As desirability and purchase likelihood are related constructs and were highly correlated ($r = .77$; $p < .001$), we conducted a factor analysis which demonstrated that all items loaded onto the same factor (the only factor with an eigenvalue greater than 1, accounting for 88% of the variation). Accordingly, we combined all 4 items into one aggregate "product attitude" scale ($\alpha = .92$) to streamline the remaining analysis and reporting of the results[10].

[10] The results for desirability and purchase likelihood separately follow the same pattern and overall significance levels, as reported in Chapter 15, Appendix E.

As expected, ANOVA results indicated a significant effect of audio format on this aggregated product attitude measure, $F(2, 136) = 3.93$, $p = .02$, $\eta_p^2 = .06$. Per our hypotheses, the focal contrast of interest was between the standard and spatial audio conditions. An analysis of contrasts revealed that participants in the spatial audio condition ($M_{SpatialAudio} = 4.48$) reported significantly higher product attitude compared to the standard audio condition ($M_{StandardAudio} = 3.66$; $p < .01$) and marginally significantly higher product attitude compared to the no audio condition ($M_{NoAudio} = 3.99$; $p < .10$). Interestingly, there was no significant difference between the no audio and standard audio conditions ($p = .24$). An illustration of means is presented in Figure 3.

FIGURE 3: THE EFFECT OF AUDIO FORMAT ON PRODUCT ATTITUDE



Ancillary Analysis.

While participants in all three experimental conditions were presented with headphones and a mobile phone for the experiment, one might reasonably argue that spatial audio is more novel than standard audio, and this novelty might explain the observed differences in product attitude. Accordingly, to examine whether novelty might explain the positive effect of audio format on product attitude, we adopted a procedure

from previous literature (Heller et al. 2019a; Venkatesh, Thong, and Xu 2012) by examining whether downstream responses to audio formats differed according to participants' familiarity with spatial audio technology. Spatial audio familiarity did not differ across the three audio format conditions ($F(2, 135) = 1.60$, $M_{NoAudio} = 3.25$, $M_{Standard} = 3.38$, $M_{Spatial} = 3.91$; $p = .21$, $\eta_p^2 = .02$). Importantly, neither the main effect of spatial audio familiarity nor the interaction between audio format and spatial audio familiarity were significant predictors of product attitude (both p's $> .13$[11]). In other words, participants at both high and low levels of familiarity with spatial audio technology responded the same way to the audio format, suggesting that it is unlikely that the effect observed here can be explained by the novelty of the technology.

In sum, this first study provides initial evidence under controlled laboratory conditions that dynamic audio (and spatial audio, in particular) in AR advertisements can increase individuals' overall attitudes towards a featured product (supporting H1). Further, we rule out the potential effect of novelty as an explanation for the positive effect of audio format on product attitude. Although the central focus of our investigation was to examine how dynamic (vs. standard) audio influenced consumers, the findings with respect to the no audio condition is noteworthy as it implies that audio in and of itself provides no added improvement to an AR advertisement unless it is spatially formatted. While we expand on the potential implication of this finding in the general discussion, our remaining chapters strictly employ standard audio as the control condition.

[11] We continue to measure participants' familiarity with spatial audio technology in the remaining chapters, and it continues to exert no main or interactive effect on the DVs (see Chapter 15, Appendix F for these details).

CHAPTER 10

SUPPORT FOR EXPERIENTIAL IMMERSION AS THE UNDERLYING MECHANISM

INTRODUCTION

Chapter 10 served four key purposes. First, we sought to replicate the effect of audio dynamism on product attitude, this time testing with a packaged food item rather than a beverage. Second, we wished to explore our proposed underlying process mechanism, immersion (thus providing support for H2), and test additional potential process mechanisms that might concurrently or alternatively drive any observed effect on product attitude. Third, we tested a potential boundary condition to the effect of dynamic audio on product attitudes by examining the impact of product-relevant versus product-irrelevant sounds. Specifically, in Chapter 9 the sounds emitted were idiosyncratically characteristic of the featured product (i.e., the 'fizz' and 'bubbling' of the sparkling water). However, in practice, many advertised products may lack any distinct accompanying sounds. Accordingly, in chapter 10 we manipulate the relevance of sound emitted to explore whether generic, product-neutral sounds produced in a dynamic audio format function similarly to product-specific sounds in increasing overall product attitude.

The final purpose of chapter 10 was to test a dynamic audio format with more limited functionality (a format we hereafter refer to as "spatial lite"). While full spatial audio allows the user to perceive dynamism with respect to both the *distance* and *direction* of an object's sound, "spatial lite" only allows the user to detect varying distance.[12] This means that the volume of sound in a spatial-lite audio condition will increase/decrease as a participant approaches/retreats from a target object, but the volume level is always identical both ears, irrespective of the participant's position relative to the target object. Examining this spatial-lite format is not only valuable for practical reasons, given most AR advertising platforms (including SparkAR, which supports Meta

[12] Technically speaking, the distinction between full spatial and spatial lite formats stems from the ability of the former to enable binaural hearing (the ability to hear different levels of sound in each ear), while the latter only enables monaural hearing (the same level of sound is always heard in both ears).

platforms such as Facebook, Instagram, and Messenger) are currently only capable of enabling spatial lite (rather than full spatial audio) experiences, but it also allows us to empirically isolate whether the positive effects of dynamic audio stem from the affordance of distance- versus direction-based perceptions.

DESIGN AND PROCEDURE

One hundred and seventy-four volunteers from a university setting (44% female, 0% nonbinary/other; M_{Age} = 29.84, SD = 6.98) participated in this experiment in exchange for monetary compensation. This study employed a 2(audio format: control vs. spatial-lite) x 2(product sound relevance: relevant vs. irrelevant) between-subjects design. To create the stimuli in this study, we collaborated with a large social media company and a multinational packaged foods manufacturer to create four visually-identical augmented reality mobile advertisements. In all conditions, the advertisements featured a cannister of potato chips floating in a space-themed background. The viewer is instructed to first tap the cannister (hence encouraging the user to move towards the cannister, after which the lid of the canister pops off), and then to tap the chips that come bursting out of the cannister. This process was repeated three times (for three different flavor variations).

In the relevant product sound conditions, the cannister emitted a “popping” sound when the lid burst off the can, and a “crunching” sound when participants tapped to break each chip. In the irrelevant product sound conditions, the cannister emitted a harmonic “chiming” sound in lieu of the “popping” and “crunching” sounds. The control audio conditions in this study were analogous to the “standard audio” condition in chapter 9 (the audio was not dynamic, in that it did not vary based on the phone’s distance or direction relative to the featured product). In the spatial-lite conditions, the audio was dynamic the sense that it varied according to the phone’s distance from the target (i.e., the

volume would increase/decrease as the user approached/retreated from the potato chips). The stimuli and simulated experience for all four conditions can be found in Chapter 15, Appendix G.

After indicating consent, participants were seated in the laboratory and given the same phone and headphone combination used in chapter 9. After completing an unrelated study on the mobile phones, participants were randomly assigned to view one of the four aforementioned advertisements according to experimental condition. After viewing the advertisement, participants responded to the same product attitude scale as in chapter 9 (α = .92). Next, participants were asked to respond to a battery of measures designed to assess various potential process explanations. These included participants' experience of immersion (our proposed process explanation, measured on a 7-item Likert scale adapted from Georgiou and Kyza 2017, e.g., "I was so involved in the experience, that in some cases I wanted to interact with the Pringles directly"; α = .88), enjoyment of the experience (7 Likert-scale items, e.g., "I enjoyed this experience"; α = .93;), auditory realism (2 Likert-scale items, e.g., "The 'crunch' the Pringles chips made when tapped sounded real"; r = .73), and mood (2 Likert-scale items, e.g., "I'm in a good mood right now"; r = .74). For a full list of items, including exploratory measures less central to our theorizing, see Chapter 15, Appendix H. Finally, participants indicated their familiarity with spatial audio technology (as in chapter 9), their age, and their gender, and responded to two manipulation check items (one to assess the audio format manipulation: "As I approached the Pringles Can and Chips, the volume increased"; and on to assess the product sound relevance manipulation: "The audio in this experience seemed relevant to Pringles").

RESULTS AND DISCUSSION

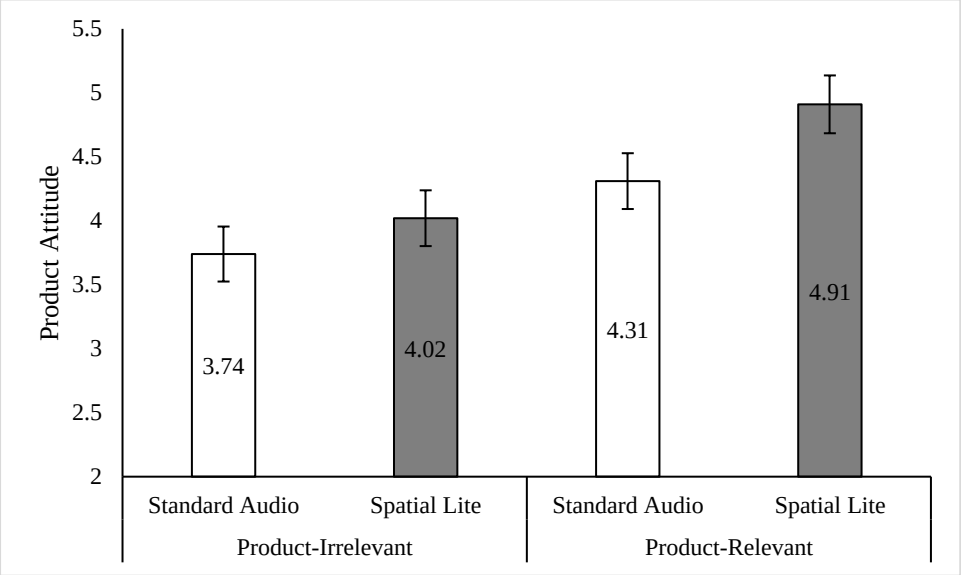
Manipulation Check.

ANOVA results supported the efficacy of the audio format manipulation by revealing a significant main effect of audio format on perceived volume change ($F(1, 172) = 12.69$, $M_{Control} = 4.06$, $M_{SpatialLite} = 4.83$; $p < .001$, $\eta_p^2 = .07$). A separate ANOVA confirmed the efficacy of the product sound relevance manipulation, producing a significant main effect of the product sound relevance manipulation on perceived product relevance ($F(1, 172) = 81.30$, $M_{ProductAgnostic} = 2.92$, $M_{ProductCongruent} = 5.27$; $p < .001$, $\eta_p^2 = .32$).

Product Attitude.

A 2x2 ANOVA revealed a significant main effect of audio format ($F(1, 170) = 3.97$, $M_{Control} = 4.03$, $M_{SpatialLite} = 4.46$; $p = .05$, $\eta_p^2 = .02$) and product sound relevance ($F(1, 170) = 11.16$, $M_{NonProductAudio} = 3.88$, $M_{ProductAudio} = 4.61$; $p = .001$, $\eta_p^2 = .06$) on overall product attitude. The interactive effect was not significant ($F(3, 170) = 0.53$, $M_{Control/NonProduct} = 3.74$, $M_{Control/Product} = 4.31$, $M_{Spatial/NonProduct} = 4.02$, $M_{Spatial/Product} = 4.91$; $p = .47$, $\eta_p^2 < .01$), suggesting that while irrelevant product sounds were not as effective in boosting product attitude as product relevant sounds were, the effect of spatial audio format gave a boost to product attitudes in both cases. An illustration of means is presented in Figure 4. As a result of the non-significant interaction, we run the remainder of the analysis focusing specifically on the audio format manipulation while holding product sound relevance as a covariate, given our primary interest in understanding the process explaining the effect of audio format on increased product attitudes. A complete analysis of product sound relevance and the interaction between audio format and product sound relevance on all measures can be found in Chapter 15, Appendix I.

FIGURE 4: INTERACTIVE EFFECT OF AUDIO FORMAT AND SOUND-TYPE ON PRODUCT ATTITUDES



Immersion.

ANOVA results revealed a significant main effect of audio format on the degree to which participants felt immersed in the experience ($F(1, 171) = 5.30$, $M_{Control} = 3.50$, $M_{SpatialLite} = 3.99$; $p = .02$, $\eta_p^2 = .03$), suggesting that participants in the spatial lite audio format condition felt more immersed in the overall experience compared to those in the control audio condition. We next ran a mediation analysis to test H2, exploring whether the effect of audio format on product attitudes could be explained through an increase in immersion. Specifically, we conducted a mediation analysis (PROCESS Model 4, Hayes 2018; using 10,000 resamples), with audio format as the predictor (coded as control audio = 0, spatial lite = 1), product attitude as the dependent variable, and product sound relevance as a covariate. Results revealed a significant indirect effect of audio format on

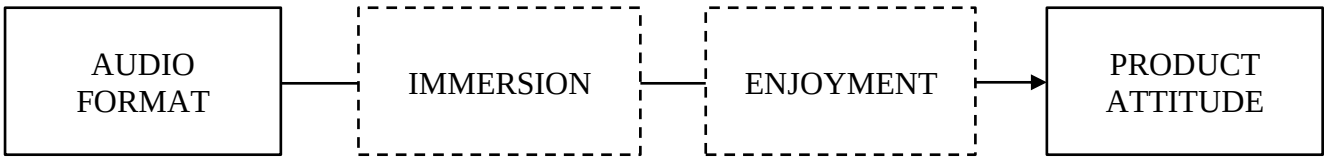
product attitude through immersion (indirect effect = .2534, 95% CI: .0327 to .5222), supporting H2.

Enjoyment of the Experience.

ANOVA results revealed a significant main effect of audio format on the overall enjoyment of the experience ($F(1, 171) = 3.81$, $M_{Control} = 4.56$, $M_{SpatialLite} = 4.99$; $p = .05$, $\eta_p^2 = .02$), indicating that participants who experienced the advertisement in the spatial lite format reported enjoying the experience significantly more compared to those who viewed the advertisement in the control condition.

To test whether enjoyment of the experience could serve as an additional process explanation to our theorized mediation through immersion, we ran a sequential mediation model with 10,000 resamples (PROCESS Model 6, Hayes 2018). Results of the sequential mediation analysis with audio format as the predictor (coded as control audio = 0, spatial lite = 1), product attitude as the dependent variable, sound-type as the covariate, and immersion followed by enjoyment of the experience as sequential mediators revealed a significant indirect effect of audio format on product attitude through immersion followed by enjoyment of the experience (indirect effect = .2020, 95% CI: .0329 to 3952; see Figure 5 below for the sequential mediation model)[13].

FIGURE 5: SEQUENTIAL MEDIATION MODEL



[13] To confirm the directionality of the sequential mediation model, we reran Model 6 with the order of immersion and enjoyment of the experience variables reversed. Consistent with our theorizing and expectations, the reversed order sequential mediation (audio format -> enjoyment -> immersion -> product attitude) was not significant (indirect effect = .0291, 95% CI: -.0158 to .1111).

Ancillary Analysis.

We conducted additional ANOVAs to systematically assess any potential underlying role of auditory realism and/or mood. ANOVA results did not reveal significant main effects of audio format on either auditory realism ($F(1, 171) = 0.10$, $M_{Control} = 4.40$, $M_{SpatialLite} = 4.47$; $p = .76$, $\eta_p^2 < .01$), or mood ($F(1, 171) = 0.49$, $M_{Control} = 5.37$, $M_{SpatialLite} = 5.50$; $p = .49$, $\eta_p^2 < .01$), suggesting these factors are unlikely to serve as alternative processes explaining the effect of audio format on product attitudes.

In sum, our second study provided further evidence that adding dynamic audio, compared to standard audio, to an AR advertisement can increase consumer's attitudes towards the featured product (this time, a packaged food). We provide preliminary evidence supporting the role of immersion as the primary process driving the positive effect of audio format on product attitudes, thus supporting H2. In addition, we identify enjoyment of the experience as a potential sequential process mechanism that explains the effect of immersion on product attitudes. Importantly, findings from this study demonstrated that the positive effect of dynamic audio does not only manifest with respect to product-relevant sounds, but also extends to non-relevant product sounds. This suggests that the benefits of dynamic audio can be reaped in categories without idiosyncratically characteristic product sounds.

Finally, this study demonstrated that despite the limited functionality of spatial lite audio (compared to full spatial audio), the distance-based auditory dynamism was powerful enough to exert a significant positive effect on product attitudes. In addition to the theoretical implications of this finding, it is also practically relevant for marketers today, given the immediate ability to produce spatial lite audio experiences (e.g., via SparkAR).

CHAPTER 11

ESTABLISHING SPATIAL AUDIO BOUNDARY CONDITIONS

INTRODUCTION

Results from the previous chapters established the effect of audio dynamism on product attitudes and supported the underlying role of immersion and enjoyment of the experience in driving this effect. Aside from replicating the findings of chapters 9 and 10, chapter 11 served two additional purposes. First, while chapter 10 introduced the spatial lite manipulation to see it would improve product attitudes (and it did indeed produce a boost), in chapter 11 we wished to explicitly compare the control audio format condition with both spatial lite and full spatial audio formats, to assess whether any incremental value is offered by the latter over and above the former. The second purpose this study was to test a potential boundary condition which is both practically relevant and strongly linked to our theorizing (H3): physical approach. If, as we predict and as suggested by chapter 10, the effect of dynamic audio on product attitudes stems primarily from distance-based variability in sound (i.e., the amplification/attenuation of sound when approaching/retreating from a target object), then the positive effect of dynamic audio should only manifest if users do indeed physically approach a featured product (otherwise, there would be no opportunity for the user to experience the amplification/attenuation). Accordingly, while chapters 9 and 10 explicitly asked participants to approach the target products (to pop off the cap and open the cannister of chips in chapters 9 and 10 respectively), in this study we employed deliberately more vague interaction instructions, so that physical approach might vary across participants, allowing us to test its role as a potential moderator (thereby testing H3).

DESIGN AND PROCEDURE

One hundred and seventy volunteers from a university setting (46% female, 1% nonbinary/other; M_{Age} = 26.38, SD = 6.40) participated in this experiment in exchange for

monetary compensation. This study employed a three-level (audio format: control vs. spatial-lite audio vs. spatial audio) between-subjects design. To create the stimuli for this study, we collaborated with a large social media company and a multinational chocolate manufacturer to create three visually-identical augmented reality mobile advertisements. In all conditions, a text-based prompt first instructed users to "Look around to find all five KitKats". A chocolate candy bar would then appear floating in front of the participant (accompanied by an acoustic "humming" sound), and users were instructed to 'break' the candy bar by tapping on it (upon which they would hear a "breaking" sound, characteristic of a chocolate wafer). This process was repeated five times in total, with the chocolate bars in different positions each time.

To manipulate audio format, participants either experienced standard audio (the control condition), spatial-lite audio, or full spatial audio. These audio formats were analogous to those described in previous chapters: the control audio condition lacked any dynamism, the spatial lite condition provided variability based on distance (but not based on direction), and the full spatial condition provided variability based on both distance and directionality. The stimuli and simulated experience for all three conditions can be found in Chapter 15, Appendix J.

After indicating consent, participants were seated in a laboratory and given the same phone and headphone combination used in the previous chapters. Participants were randomly assigned to view one of the three advertisements according to the aforementioned experimental conditions before completing a follow up survey. Product attitude (α = .89), immersion (α = .83), enjoyment of the experience (α = .85), and the audio format manipulation check were all measured as in chapter 10. In addition, to assess whether participants physically approached the chocolate bars, they were asked to respond to one binary item, "I extended my arm, moving the phone closer to the KitKat

bars during the experience"; (0 = no, 1 = yes). For a full list of items, including exploratory measures less central to our theorizing, see Chapter 15, Appendix K. Finally, participants indicated their familiarity with spatial audio technology (as in chapters 9 and 10), their age, and their gender.

RESULTS AND DISCUSSION

Manipulation Check.

ANOVA results revealed a significant main effect of audio format on perceived volume change ($F(2, 167) = 8.78$, $M_{Control} = 3.98$, $M_{SpatialLite} = 4.54$, $M_{FullSpatial} = 4.97$; $p < .001$, $\eta_p^2 = .10$. Contrasts revealed significant differences between the control and spatial lite condition ($p = .02$), and between the control and full spatial condition ($p < .001$). In addition, there was a marginally significant difference between spatial lite and full spatial audio conditions ($p = .07$), which makes sense since the audio in the latter condition did indeed vary more than in the former.

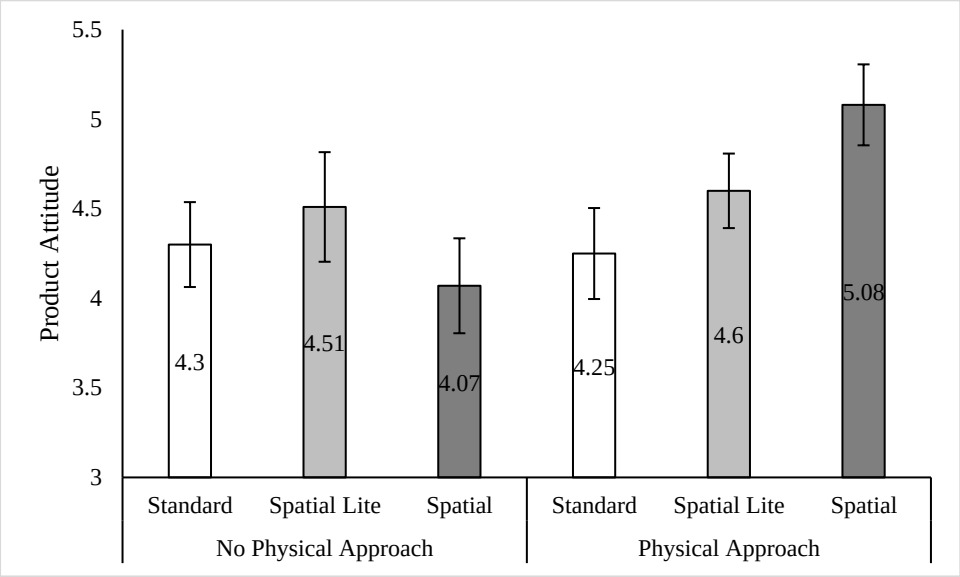
Physical Approach.

58% of participants reported physically approaching the chocolate bars. A binary logistic regression found a marginally significant difference in physical approach behavior across the three conditions (Wald χ^2 (2) = 5.50, $p = .06$), suggesting these two factors were not completely independent. Nonetheless, due to our a priori predictions, we assessed whether physical approach would moderate the effect of spatial audio format on our dependent variable and process measures, as described below.

Product Attitude.

An ANOVA with audio format and physical approach as predictors and product attitude as the dependent variable revealed a marginally significant main effect of physical approach on product attitude ($F(1, 168) = 2.91$, $M_{Approach} = 4.65$, $M_{NotApproach} = 4.30$; $p = .09$, $\eta_p^2 = .02$). The main effect of audio format on product attitude was not significant ($F(2, 168) = 0.94$, $M_{Control} = 4.28$, $M_{SpatialLite} = 4.56$, $M_{FullSpatial} = 4.58$; $p = .39$, $\eta_p^2 = .01$). However, consistent with our theorizing and H3, the interaction of audio format on product attitude was marginally significant ($F(2, 168) = 2.71$, $p = .07$, $\eta_p^2 = .03$). As predicted, the effect of audio format on product attitude was significant for people who did physically approach the chocolate bars ($F(2, 168) = 3.09$, $M_{Control} = 4.25$, $M_{SpatialLite} = 4.60$, $M_{FullSpatial} = 5.08$; $p = .05$, $\eta_p^2 = .04$). An analysis of contrasts demonstrated that product attitude in the full spatial audio condition was significantly greater than in the control condition ($p = .02$). The differences between spatial lite and the full spatial audio condition ($p = .12$) and the control condition ($p = .29$) were not significant; however, the pattern of means suggests that overall, the more dynamic the audio, the more positive the product attitudes (a polynomial contrast testing the linear pattern was significant; $p = .009$). The effect of audio format on product attitude was not significant for people who did not physically approach the chocolate bars ($F(2, 168) = 0.60$, $M_{Control} = 4.30$, $M_{SpatialLite} = 4.51$, $M_{FullSpatial} = 4.07$; $p = .55$, $\eta_p^2 = .01$). An illustration of means is presented in Figure 6.

FIGURE 6: INTERACTIVE EFFECT OF AUDIO FORMAT AND PHYSICAL APPROACH ON PRODUCT ATTITUDE

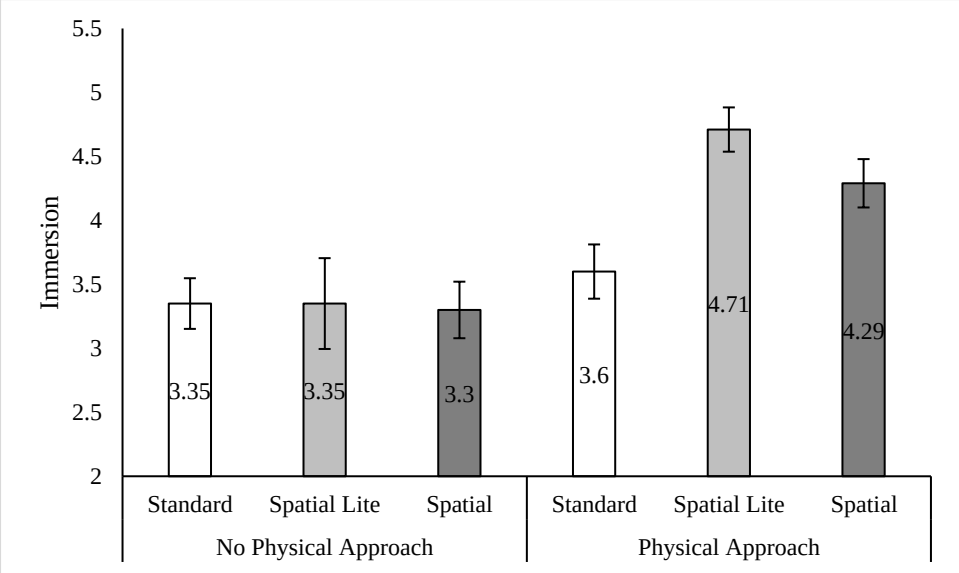


Immersion.

ANOVA results with audio format and physical approach as predictors and immersion as the dependent variable revealed significant main effects of audio format ($F(2, 168) = 3.45$, $M_{Control} = 3.48$, $M_{SpatialLite} = 4.03$, $M_{FullSpatial} = 3.80$; $p = .03$, $\eta_p^2 = .04$) and physical approach ($F(2, 168) = 25.84$, $M_{Approach} = 4.20$, $M_{NotApproach} = 3.33$; $p < .001$, $\eta_p^2 = .14$), in addition to a significant interaction ($F(2, 168) = 3.57$, $p = .03$, $\eta_p^2 = .04$). Similar to the results on product attitude, probing the interaction revealed that the effect of audio format on immersion was significant for people who did physically approach the chocolate bars ($F(2, 168) = 8.09$, $M_{Control} = 3.60$, $M_{SpatialLite} = 4.71$, $M_{FullSpatial} = 4.29$; $p < .001$, $\eta_p^2 = .09$). An analysis of contrasts demonstrated that compared to the control condition, immersion perceptions were higher in the full spatial audio condition ($p = .02$) and the spatial lite condition ($p < .001$). There was no significant difference in immersion between the full spatial and spatial lite condition ($p = .11$). The effect of audio format on immersion was not significant for people who did not physically approach the chocolate

bars ($F(2, 168) = 0.02$, $M_{Control} = 3.35$, $M_{SpatialLite} = 3.35$, $M_{FullSpatial} = 3.30$; $p = .98$, $\eta_p^2 < .01$). An illustration of means is presented in Figure 7.

FIGURE 7: INTERACTIVE EFFECT OF AUDIO FORMAT AND PHYSICAL APPROACH ON IMMERSION



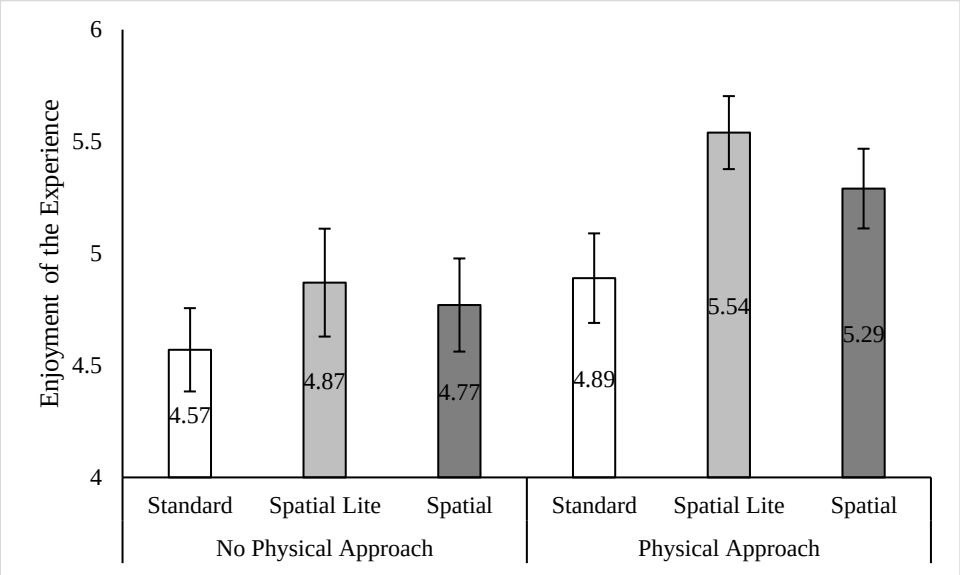
To determine whether immersion explains the effect of audio format on product attitude under conditions of physical approach, we ran a moderated mediation analysis. As the primary focus of our investigation was to examine the difference between standard audio and dynamic audio (the latter including both spatial-lite + full spatial audio), we simplified the mediation analysis and reporting of results by collapsing the two dynamic audio conditions into one category and comparing that to the control audio condition. A moderated mediation analysis (PROCESS Model 8, Hayes 2018) with 10,000 resamples with binary audio format as the predictor (0 = control audio, 1 = dynamic audio), product attitude as the dependent variable, physical approach as the moderator, and immersion as the mediator, revealed that when participants did physically approach the chocolate bars, there was a significant indirect effect of audio format on product attitude through

immersion (indirect effect = .4222, 95% CI: .1599 to .7581). The indirect effect was not significant when participants did not physically approach the chocolate bars (indirect effect = -.0129, 95% CI: -.2226 to .2102).

Enjoyment of the Experience.

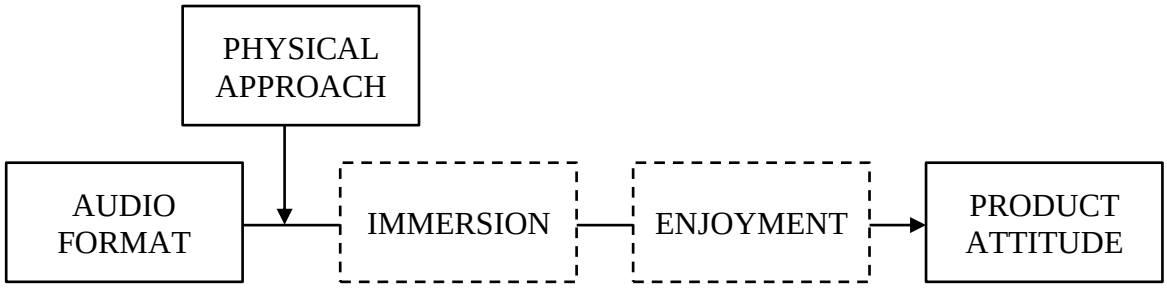
ANOVA results with audio format and physical approach as predictors and enjoyment of the experience as the dependent variable revealed a marginally significant main effect of audio format on enjoyment of the experience ($F(2, 168) = 2.92$, $M_{Control} = 4.73$, $M_{SpatialLite} = 5.20$, $M_{FullSpatial} = 5.03$; $p = .06$, $\eta_p^2 = .03$), as well as a significant main effect of physical approach on enjoyment of the experience ($F(2, 168) = 9.69$, $M_{Approach} = 5.24$, $M_{NoApproach} = 4.74$; $p = .002$, $\eta_p^2 = .06$). The interactive effect was not significant ($F(2, 168) = 0.38$, $p = .69$, $\eta_p^2 < .01$, but we examined the effect of audio format under each physical approach condition due to our a priori predictions. Results revealed that the effect of audio format on enjoyment of the experience was significant for people who did physically approach the chocolate bars ($F(2, 168) = 3.12$, $M_{Control} = 4.89$, $M_{SpatialLite} = 5.54$, $M_{FullSpatial} = 5.29$; $p = .05$, $\eta_p^2 = .04$), but not significant for those who did not approach the chocolate bard ($F(2, 168) = 0.55$, $M_{Control} = 4.57$, $M_{SpatialLite} = 4.87$, $M_{FullSpatial} = 4.77$; $p = .58$, $\eta_p^2 = .01$). An analysis of contrasts within the physical approach condition revealed that compared to the control condition, enjoyment was significantly higher in the spatial lite condition ($p = .01$), however there was no significant difference in enjoyment between the control condition and full spatial ($p = .13$) or full spatial and spatial lite condition ($p = .32$). An illustration of means is presented in Figure 8.

FIGURE 8: INTERACTIVE EFFECT OF AUDIO FORMAT AND PHYSICAL APPROACH ON ENJOYMENT OF THE EXPERIENCE



Finally, we ran a moderated sequential mediation analysis in an effort to replicate the sequential mediation revealed in Chapter 10, this time only under conditions of physical approach. Moderated mediation analysis (PROCESS Model 85, Hayes 2018), with 10,000 resamples with binary audio format is the predictor (0 = standard audio, 1 = dynamic audio), product attitude as the dependent variable, physical approach as the moderator, and immersion followed by enjoyment of the experience as the sequential mediators revealed that when participants did physically approach the chocolate bars, there was a significant indirect effect of audio format on product attitude through immersion followed by enjoyment of the experience (indirect effect = .1349, 95% CI: .0185 to .3043). However, when participants did not physically approach the chocolate bars, the indirect effect of audio format on product attitude through immersion and enjoyment of the experience was no longer significant (indirect effect = -.0041, 95% CI: -.0801 to .0693; see Figure 9 for an illustration moderated sequential mediation model).

FIGURE 9: MODERATED MEDIATION MODEL



Overall, results from chapter 11 provide further evidence that dynamic audio exerts a positive effect on consumer attitudes towards products featured in AR advertisements (supporting H1). Further, chapter 11 replicates evidence for the sequential process explaining the positive effect of dynamic audio on product attitudes: dynamic audio increases users' sense of immersion, making them enjoy the experience more, and consequently improves their attitudes towards featured products (supporting H2). Importantly, these effects only manifest for participants who physically approached the virtual objects, suggesting that the distance-based variability in sound (i.e., the amplification/attenuation of sound when approaching/retreating from a virtual object, which can only be experienced through active user movement) is necessary for the positive effect to manifest (thereby supporting H3).

While the results overall replicate the findings of chapters 9 and 10, other findings (e.g., comparing spatial lite and full spatial audio) were somewhat variable. Despite not having formal *a priori* predictions for how spatial lite would perform compared to full spatial audio, one could reasonably presume that the provision of distance *and* direction-based cues in full spatial audio (compared to only distance-based cues in spatial lite) should result in improved consumer responses. However, results from this study suggest that in the context of AR advertisements, while distance-based cues (provided in both

spatial lite and full spatial audio formats) are critical to influencing consumer's attitudes towards the featured product, there is little (if any) incremental benefit from the addition of direction-based cues (which were only present in the full spatial audio condition). One potential explanation for this finding is that the distance-based cues produced in both dynamic audio formats heightened the realism of physical approach, and given that prior research has shown how physical approach in itself can improve product attitudes (Labroo and Nielsen 2009; Hagtvedt and Brasel 2016), any auditory cues which make the perception of physical approach more salient should have a beneficial impact.

CHAPTER 12

SPATIAL AUDIO: A DISCUSSION

Tech companies, brand managers and consumer behavior researchers all seem to agree: sound matters. Indeed, the increasing popularity of music streaming platforms, audio-centric video content, and audio chatrooms has made digital audio consumption today more pervasive than ever before. However, not all sound operates in the same way, and accordingly, billions of dollars have been dedicated to improving consumers' auditory experiences (Yang et al. 2020). Spatial audio has been a particular target of industry interest and investment (Fortune Business Insights 2020), yet no research had empirically explored how this nascent technology might actually influence consumers' judgments and behaviors.

Our research addressed this gap by examining how and when dynamic audio might influence consumer responses to advertising. Collectively, we proposed and demonstrated that because dynamic audio produces distance-based variability in sound (i.e., the amplification/attenuation of sound when approaching/retreating from a geo-anchored target object, respectively), it increases consumers' sense of immersion in digitally-augmented advertisements, and accordingly improves consumer attitudes toward featured products. Specifically, chapter 9 demonstrated that spatial audio improves attitudes towards a featured beverage (sparkling water) compared to standard audio. Chapter 10 replicated this effect via a limited form of spatial audio (spatial lite) in a different product category (potato chips) and demonstrated sequential mediation of immersion and enjoyment of the experience, respectively. Findings from this study also suggest that the positive effect of dynamic audio does not only manifest with respect to product-relevant sounds, but also extends to non-relevant product sounds. In chapter 11, we replicate the effect of dynamic audio on product attitudes (this time, towards a chocolate bar) and add further support for the mediational role of immersion and enjoyment of the experience. Importantly, these effects only

manifest for participants who physically approached the virtual objects, further suggesting that distance-based variability in sound is necessary for the positive effect to manifest.

The current work contributes to various academic literatures. First, we contribute to research exploring the role of audio in driving advertising effectiveness. Such research has mostly focused on the role of ambient audio (e.g., music) as a tool to increase recall, involvement, and/or persuasion in advertising (e.g., Kellaris et al. 1993, MacInnis and Park 1991, Park and Young 1986). We compliment such work by focusing on a specific technological feature (dynamism) of non-ambient audio in advertisements. In doing so, we also contribute to research on product-based auditory cues, which has mostly examined how the presence (vs. absence) and volume of sound can influence consumer perceptions and evaluations of products (e.g., Ringler et al. 2020, Zampini and Spence 2004). We add to this literature stream by showing that specific technological features of audio (namely the distance-based dynamism afforded from spatial audio) can also influence consumers' product-based judgments.

Our work also contributes to broader literatures on stimuli dynamism, immersion and consumer behavior in virtual environments. While previous research has demonstrated that visual dynamism can increase consumers' sense of immersion and engagement in both virtual (Faust et al. 2012; Georgiou and Kyza 2017) and non-virtual (Brasel and Hagtvedt 2016; Cian, Krishna, and Elder 2014, 2015) contexts, the current research is the first to suggest auditory dynamism can also function to increase such feelings, and to accordingly demonstrate the downstream effects on product attitudes.

In addition to the theoretical contributions, our work carries a number of important implications for practitioners. Many social media platforms have only recently recognized the true potential audio can play in shaping user experiences. For example,

75% of users view Instagram Reels with sound on, and video completion was over twice as high when viewed with sound-on vs. sound-off (Meta 2022). Separately, research on the TikTok platform has found that nine out of ten users view sound as a vital element of the overall viewing experience (Hutchinson 2022). The power of audio also extends to brand metrics on such platforms, with industry research finding that brand recall increased eight-fold when distinctive brand sounds were leveraged (Hutchinson 2022). However, our research emphasizes that the decision to employ audio is not merely a binary one, and the precise execution matters. In particular, our work suggests that brands can benefit from incorporating dynamic audio into their social media advertisements. This is particularly the case for advertisements in an AR format, in which products are geo-anchored to specific locations. Our finding that spatial lite appears to perform as well full spatial audio suggests that brands can take advantage of this insight immediately, given that spatial lite integration is already available via SparkAR (a software studio which supports Meta platforms including Facebook, Instagram, and Messenger).

Importantly, this implication does not only apply to food products that have well-recognized product sounds. Our second study shows that the positive effect of dynamic audio extends to non-relevant product sounds, suggesting that the benefits of dynamic audio can be reaped in categories without idiosyncratically characteristic product sounds. However, regardless of the product, findings from our third study highlight that physical approach is a necessary prerequisite for reaping the beneficial effect of dynamic audio on product attitudes. Accordingly, to take advantage of the benefits, advertisers should encourage physical approach either explicitly (i.e., via instructions) or implicitly (e.g., via arrows or other visual signals).

This research also carries managerial implications for brands and marketers contemplating how to promote content within the metaverse. Much investment has gone

into creating visually immersive content for the metaverse (e.g., via augmented and virtual reality), but the other senses have largely been ignored, which could be a missed opportunity. Our findings suggest that when thinking about creating content in the metaverse, brands should consider investing in audio content that "matches" the dynamism of any visual content. Spatial audio, in particular, allows users to “hear in 3D”, just as virtual reality allows them to see in the 3D. Brands can leverage this auditory feature to create more engaging experiences and enhance attitudes towards featured products accordingly.

Importantly, the nascent nature of dynamic audio technology and it’s expanding marketplace applications pave several exciting avenues for potential future research, both within the advertising domain and beyond. For example, the current work was focused on edible products, since extant literature demonstrated the food and beverage category to be an especially suitable domain for investigating the potential influence of auditory-related manipulations. However, future researchers may wish to explore how and when dynamic audio can augment attitudes towards products in various other categories (e.g., appliances). Future work might also focus on whether dynamic audio could influence consumer reactions to ambient or environmental sounds that are not anchored to a product per se, but that might still vary according to a user’s movements in virtual spaces.

Beyond advertising, it is interesting to consider how spatial audio might be applied in various stages of the customer journey. For example, M&S (a U.K. based grocery chain) teamed up with Dent Reality to map the location of every item in their store, providing customers with an in-store AR map that can direct people to the exact location of the item they are searching for, with the aim of increasing conversion and satisfaction (Somerville 2022). While this technology currently only utilizes visual AR, Microsoft research has found that dynamic audio can be used to improve navigation

(Clemenson et al. 2021). Therefore, future research could consider ways in which dynamic audio can complement and improve customer experiences in retail and various other non-advertising contexts.

It is also compelling and potentially consequential to consider how dynamic audio, and other sensorially immersive technologies in general, might play a role outside traditional commercial functions. For example, technology industry leaders (e.g., Microsoft; Smith 2021) and major public sector organizations (e.g., the World Economic Forum; Jiang 2021) have called for further research exploring how emergent technologies might aid in closing the "disability divide". Indeed, the Partnership on Employment and Accessible Technology (a division of the United States Department of Labor), created *The Accessibility Playbook for Emerging Technology Initiatives*, which explicitly calls for more research focused on the opportunities and benefits accessible emerging technologies might provide for differently-abled individuals (Boyle 2021). In this spirit, it could be interesting, for example, to explore ways in which dynamic audio might help create more realistic and interactive experiences for those unable to sufficiently process visual stimuli (e.g., participants who are visually blind or suffer from poor eyesight). We are encouraged by such possibilities, and hope marketing academics consider accessibility and inclusivity when conducting future research on immersive technologies.

While dynamic audio is here today, the hybrid digital-physical future of tomorrow is still largely unknown. As tech companies continue to rapidly develop and deploy sensory immersive technologies capable of augmenting the physical human experience, research is needed now more than ever before to understand how consumers interact with these technologies, which underlying psychological processes drive any effects, and what nuance may come into play.

CHAPTER 13

GENERAL DISCUSSION

The goal of this dissertation was to serve as an initial empirical exploration of the effect immersive technologies have on consumers' judgment and behavior, motivated by real-world phenomena deserving dedicated investigation. Split across two sensorially-unique immersive technologies, this dissertation empirically examined how the technological features of AR's superimposition and spatial audio's distance-based sound variability can each influence product desirability and purchase likelihood, while documenting the underlying psychological processes responsible for each effect.

Across chapters 2-7 we make three theoretical contributions. First, extending prior research in marketing on visually induced mental simulation (Ceylan et al. 2022), we find that AR's unique ability to superimpose products onto a consumer's real-time environment facilitates increased mental simulation *above and beyond* dynamic 3D visual stimuli that is not superimposed. Second, our focus on AR's fundamental feature of visual superimposition adds to the growing body of research on how technology can influence sensory perceptions, decision-making, attitude formation, and pre/post purchase behavior (Tan et al. 2021). Finally, we add to the emerging body of behavioral research in marketing that explores how technological features in mobile devices (in this case, both tablets and smartphones) can systematically influence the way consumers process information and behave.

Specifically, this research demonstrates that presenting foods in AR (versus either an externally valid 2D static format or a more conservative dynamic 3D format) can increase desirability (Chapters 3, 4, and 5) and purchase likelihood (Chapters 3 and 5). We identify one dominant underlying process mechanism—mental simulation (Chapters 4, 5, and 6)—which is itself driven by an increased sense of personal relevance (Chapters 5 and 6). Importantly, we find the positive effect of AR presentation holds for both indulgent (Chapters 3 and 4) and non-indulgent (Chapter 5) food, and both desirable and

undesirable food items (Chapter 6), regardless of whether the food is immediately available for consumption (Chapters 3 and 4) or not (Chapters 5 and 6). Finally, we find that the positive effect of AR presentation appears to manifest on both large (e.g., tablets) and small (e.g., smartphones) mobile devices.

Across chapters 8-12, we similarly make three theoretical contributions. First, extending the rich prior research on the role of audio in advertising (Kellaris et al. 1993, MacInnis and Park 1991, Park and Young 1986), this section identifies a new and specific technological feature of non-ambient audio in advertisements capable of driving advertising effectiveness, specifically auditory dynamism. Second, we contribute to research on product-based auditory cues by identifying the distance-based dynamism produced by spatial audio as the primary technological feature influencing consumers' product-based judgments. Finally, this work contributes to the wider literature on stimuli dynamism, immersion, and consumer behavior in virtual environments by suggesting that auditory dynamism can increase consumers' sense of immersion in virtual contexts and subsequently increased product attitudes in a similar way to visually dynamic stimuli (Faust et al. 2012; Georgiou and Kyza 2017; Brasel and Hagtvedt 2016; Cian, Krishna, and Elder 2014, 2015).

Specifically, this work demonstrates that spatial audio improves attitudes towards a featured beverage (sparkling water) compared to standard audio (Chapter 9). Chapter 10 replicated this effect via a limited form of spatial audio (spatial lite) in a different product category (potato chips) and demonstrated sequential mediation of immersion and enjoyment of the experience, respectively. Findings from this chapter also suggest that the positive effect of dynamic audio does not only manifest with respect to product-relevant sounds, but also extends to non-relevant product sounds. In Chapter 11, we replicate the effect of dynamic audio on product attitudes (this time, towards a chocolate

bar) and add further support for the mediational role of immersion and enjoyment of the experience. Importantly, these effects only manifest for participants who physically approached the virtual objects, further suggesting that distance-based variability in sound is necessary for the positive effect to manifest.

Future Directions

While Chapters 7 and 12 each outline future research opportunities for Augmented Reality and Spatial Audio, respectively, these future directions merely scratch the surface for research needed to better understand immersive technologies' influence on consumers. In addition to the aforementioned directions, future research could contribute to the sporadic literature on the remaining sensory modalities, specifically exploring consumers' responses to immersive haptic, olfactory, and taste technologies.

Immersive technologies are not limited to just visual or auditory immersion, but can manifest through any sensory modality. While visual and auditory immersive technologies are two of the most ubiquitous senses catered for in the market today, there exists a rich opportunity for investigating how consumers' sense of touch, smell, and taste might also be immersed and influenced by technology. For example, only limited research (e.g., Hadi and Valenzuela 2020) has explored how haptic feedback accompanying mobile communications (i.e., vibrations from a mobile phone or wearable device) can influence consumers responses, despite the prevalence of such a frequent and universal experience. Other novel technologies are also actively being developed with the goal of mimicking and influencing consumers sense of smell and taste. For example, Olorama Technology has created the world's first mobile interactive scent technology, capable of producing up to 10 different smells from food scents (e.g., freshly baked

muffins) to product scents (e.g., leather), and even locations (e.g., the beach; Olorama Technology 2021). Similarly, Professor Homei Miyashita has created a device called *Taste the TV (TTTV)*, which uses ten flavor canisters in combination to spray and create a specific taste on hygenic film that the consumer can lick, imitating the real salty, sour, sweet, bitter, spicy, or savory taste of an object viewed on a screen (Murayama and Swift 2021). While these immersive olfactory and taste technologies might not yet be available for consumer use, they represent an interesting and exciting opportunity for future research.

Immersive technologies are profoundly transforming consumer-tech interactions. As these technologies continue to be developed and integrated throughout society, researchers and academics have a crucial role to play in accelerating our collective understanding for how these technologies influence consumer judgment and behavior, and ensuring such learnings are disseminated so that companies and policymakers can make informed and empathetic decisions to improve user experiences while simultaneously prioritizing consumer wellbeing.

CHAPTER 14

APPENDIX: CHAPTERS 2 – 7

APPENDIX A: CHAPTER 2 APPLICATIONS OF AR IN CONSUMER EXPERIENCE DOMAINS

INDUSTRY	CASE*
Art	**Apple ART Walk** In 2019, Apple commissioned interactive AR art from six of the world's premier contemporary artists to connect participants with public spaces in six international cities. 
Beauty	**ModiFace** ModiFace, acquired by L'Oréal in 2018, allows potential consumers to virtually "try-on" a variety of beauty products from foundation and lipstick to different hairstyles or colors. 
Education	**Google Arts and Culture** Google has compiled over 1000+ unique (and free) AR & VR immersive learning experiences to enable students and teachers to explore some of the world's most famous landmarks, museums, environments, and more, all from the comfort of their own home or classroom.

	
Entertainment	**British National Theatre Immersive Storytelling Studio** The United Kingdom's National Theatre has established a cutting-edge experimental studio to explore how VR, AR, 360º film and other immersive technologies can be used to enhance and broaden the audience experience of traditional live performances. 
Retail	**IKEA Place App** The IKEA Place App allows customers to visually superimpose life-sized IKEA furniture into their home prior to purchasing, allowing them to visualize how different items would look and fit within their home. 

*click on link for more information on each

APPENDIX B: IMAGES OF RESTAURANT IN CHAPTER 3









APPENDIX C: DESSERT MENU OPTIONS IN CHAPTER 3



OLD COMPTON
BRASSERIE

Desserts

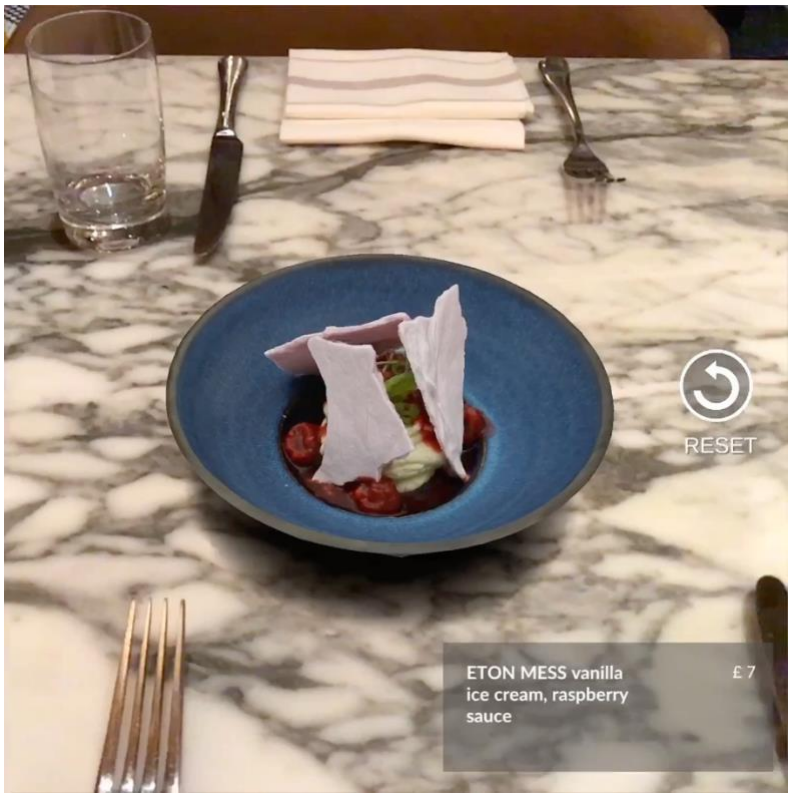
CREME BRULEE 7
STICKY TOFFEE PUDDING *vanilla ice cream* 7
STRAWBERRY TRIFLE 7
BERRY PAVLOVA *white chocolate sauce (to share)* 10
BELGIAN CHOCOLATE TRUFFLE CAKE *mango sorbet (pb)* 7
ETON MESS *vanilla ice cream, raspberry sauce* 7

APPENDIX D: PRESENTATION FORMAT MANIPULATION IN CHAPTER 3

Control Condition



AR Condition



https://www.youtube.com/watch?v=0htkKJ3ovsA&feature=youtu.be

APPENDIX E: COMPLETE LIST OF MEASURES CHAPTER 3

1. *How Desirable Did You Find Each Dessert You Viewed? [7 Point Scale, 1=Very Undesirable, 7=Very Desirable]*
    A. *Crème Brûlée*
    B. *Stucky Toffee Pudding*
    C. *Strawberry Trifle*
    D. *Berry Pavlova*
    E. *Belgian Chocolate Truffle Cake*
    F. *Eton Mess*

2. *Did you order a dessert? [Yes, No]*

3. *If no, why did you not order dessert? [open response]*

4. *If yes, which dessert did you order? [open response]*

5. *Why did you choose the dessert you did? [open response]*

6. *Were you planning to get dessert even before seeing the menu? [Yes, No]*

7. *How familiar with Augmented Reality technology are you? [7 Point Scale, 1=Very Unfamiliar, 7=Very Familiar]*

APPENDIX F: DESSERT OPTIONS IN CHAPTER 4

Treacle Tart



Summer Berries



Brownie



APPENDIX G: PRESENTATION FORMAT MANIPULATION IN CHAPTER 4

Control Condition



https://www.youtube.com/watch?v=20LOf28zh9Y&feature=youtu.be

AR Condition



https://www.youtube.com/watch?v=EX3APBZdnXg&feature=youtu.be

APPENDIX H: COMPLETE LIST OF MEASURES CHAPTER 4

1. *Dessert Selected: Summer Berries OR Treacle Tart OR Chocolate Brownie*

2. *Please answer the following BEFORE RECEIVING YOUR CHOSEN DESSERT: [7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
    a. *I am craving the dessert I chose.*
    b. *When viewing the dessert, I could imagine myself eating it.*
    c. *I think I will enjoy the dessert I chose.*
    d. *I feel confident the dessert I chose will taste good.*

3. *Please answer the following AFTER EATING YOUR CHOSEN DESSERT: [7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
    a. *I enjoyed the dessert.*
    b. *I am happy I chose the dessert I did*
    c. *The dessert looked the way it was pictured.*
    d. *The dessert tasted the way I imagined it would.*

IV	**Measure**	**Mean**		***F***	***p***	η_p^2
		Control	**AR**	**(1, 127)**		
Pre-Consumption						
Condition	"I am craving the dessert I chose"	4.90	5.46	8.402	.004	.062
Condition	"I think I will enjoy the dessert I chose"	5.93	5.94	.004	.950	.000
Condition	"I feel confident the dessert I chose will taste good"	5.66	5.94	2.980	.087	.023
Condition	"When viewing the dessert, I could imagine myself eating it"	5.49	5.90	5.189	.024	.039
Post-Consumption						
Condition	"I enjoyed the dessert"	5.59	6.03	4.024	.047	.031
Condition	"I am happy I chose the dessert I did"	5.58	6.08	3.985	.048	.030
Condition	"The dessert looked the way it was pictured"	5.78	6.24	3.985	.048	.030
Condition	"The dessert tasted the way I imagined it would"	4.75	5.68	12.632	.001	.090

APPENDIX I: LAMB SHAWARMA PRETEST RESULTS CHAPTER 5

Fifty-one participants (41% Female, 59% Male, 0% nonbinary/other; M_{Age} = 41.90, SD = 12.35) recruited from Amazon Mechanical Turk participated in this pretest in exchange for monetary compensation. All participants viewed a static 2D picture of the Lamb Shawarma pictured in Appendix F and were asked to rate how indulgent they perceived the Lamb Shawarma to be on three bipolar items (1 = Unhealthy/High in Calories/Bad for You and 7 = Healthy/Low in Calories/Good for you; α = .90). Analysis results indicated that the Lamb Shawarma (M = 3.21, SD = .96) was considered to be neutral on this scale (neither indulgent nor healthy), as the mean was not significantly different from the mid-point ($t(50) = 1.554$, $p = .13$).

APPENDIX J: PRESENTATION FORMAT OF LAMB SHAWARMA IN CHAPTER 5

Control Condition



https://www.youtube.com/watch?v=hoLIYWZ9eOM&feature=youtu.be

AR Condition



https://www.youtube.com/watch?v=bl058tnCUu4&feature=youtu.be

APPENDIX K: COVID-19 GUIDELINES CHAPTER 5

To ensure the health and safety of individuals who voluntarily agreed to participate in this Study, we followed strict COVID-19 guidelines set forth by both the Government and University. COVID-19 compliance guidelines are found below:

1. All participants were required to scan an ID card to access the building as part of a Track and Trace initiative. This also required participants to have their temperature checked prior to accessing the building to ensure they did not have a fever. Although participant identities were known for purposes of Track and Trace, their identity was not linked to their responses in this study in any way.
2. All participants were required to wear a face mask for the entire time they were in the building (this includes while waiting to begin the study, while completing the study, and after the study had ended).
3. In order to ensure 2 meters/6 feet between participants, a lecture theatre with a normal capacity of 84 people was converted into a Laboratory, with a maximum of 20 participants. Participants were spread throughout the room with seats blocked off to ensure proper distancing. See photo below representing the room setup.
4. Between each session all hard surfaces (door handles, desks, iPads, etc.) were professional cleaned. Hand sanitizer was also provided to participants before and after the session if they wished to use it.



APPENDIX L: COMPLETE LIST OF MEASURES CHAPTER 5

- **Desire** *[see individual item for scale]*
  - *How desirable did you find the Lamb Shawarma to be? [7 Point Scale, 1=Extremely Undesirable, 7=Extremely Desirable]*
  - *How strong is your urge to eat this Lamb Shawarma? [7 Point Scale, 1=Extremely Weak, 7=Extremely Strong]*
  - *How strong are your cravings for this Lamb Shawarma? [7 Point Scale, 1=Extremely Weak, 7=Extremely Strong]*

- **Purchase Likelihood** *[7 Point Scale, 1=Extremely Unlikely, 7=Extremely Likely]*
  - *After viewing the Lamb Shawarma, how likely would you be to order it if it was offered on a menu?*

- **Mental Simulation** *[7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
  - *I could imagine myself eating the Lamb Shawarma displayed.*
  - *I could see myself eating the Lamb Shawarma displayed.*
  - *I thought about myself eating the Lamb Shawarma displayed.*
  - *The thought of myself eating the Lamb Shawarma felt real.*
  - *The thought of myself eating the Lamb Shawarma was very clear.*
  - *The thought of myself eating the Lamb Shawarma was very vivid.*

- **Presence** *[see individual item for scale]*
  - *The Lamb Shawarma felt like it was on the table in front of me. [7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
  - *I momentarily forgot the Lamb Shawarma was not real. [7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
  - *I perceived the Lamb Shawarma to be located: [5 Point Scale, 1=Entirely on my iPad, 5=Entirely on the table in front of me]*

- **Attention to Background** *[7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree; reverse coded]*
  - *I paid more attention to the Lamb Shawarma than I did the background behind it.*

- **Enjoyment of the Experience** *[7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
  - *I enjoyed viewing this food item.*
  - *It was fun to view this food item.*

- **Personal Relevance** *[7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
  - *This is a type of dish I might order when at a restaurant.*
  - *This is similar to other foods I eat.*

- **Fluency** *[7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
  - *It was easy for me to evaluate this food item.*
  - *It was difficult for me to evaluate this food item. [reverse coded]*

- **Psychological Ownership** *[7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
    - *I felt like I had already ordered the Lamb Shawarma.*
    - *I felt like the Lamb Shawarma was already mine.*

- **Spatial Distance** *[see individual item for scale]*
    - *How close do you think the restaurant offering the Lamb Shawarma is located? [7 Point Scale, 1=Very Far, 7=Very Close]*
    - *How many miles away do you think the restaurant offering this Lamb Shawarma is located? [open response]*

- **Temporal Distance** *[see individual item for scale]*
    - *How quickly do you think the restaurant could deliver this Lamb Shawarma to you? [7 Point Scale, 1=Very Slow, 7=Very Fast]*
    - *How many minutes do you think it would take the restaurant to deliver this Lamb Shawarma to you? [open response]*

- **Realism** *[7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
    - *This Lamb Shawarma looks realistic.*
    - *This Lamb Shawarma looks real.*
    - *This Lamb Shawarma looks believable.*
    - *This Lamb Shawarma looks natural.*

- **Mood** *[7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
    - *I am in a good mood right now.*
    - *I am in a bad mood right now. [reverse coded]*

- **AR Familiarity** *[7 Point Scale, 1=Very Unfamiliar, 7=Very Familiar]*
    - *How familiar are you with Augmented Reality technology?*

- **Willingness to Pay** *[Open Response]*
    - *How much would you be willing to pay (in Pound sterling) to have this Lamb Shawarma right now?*

- **Attempted Touch** *[7 Point Scale, 1=Strongly Disagree, 7=Strongly Agree]*
    - *I felt like I wanted to reach out and touch the Lamb Shawarma.*
    - *I reached out to try to touch the Lamb Shawarma.*

*In addition, we include measures for PPE (to ensure PPE compliance as part of COVID-19 regulations) and a Tech Check (to account for any technology glitches experienced while using the iPad).

APPENDIX M: CHAPTER 6 FOOD DESIRABILITY PRETEST

Fifty participants (44% Female, 54% Male, 2% nonbinary/other; M_{Age} = 39.22, SD = 10.94) recruited from Amazon Mechanical Turk participated in this pretest in exchange for monetary compensation. All participants viewed a static 2D picture of the seven different food items (Waffle Fries, Parmesan Fries, Raw Kale Salad, Chocolate Cake, Fermented Trout, Stewed Eggplant, Fruit and Caramel Crepes) and were asked to rate how desirable they perceived each item to be on three bipolar items (1 = Undesirable and 7 = Desirable). Analysis results indicated that the Parmesan Fries (M = 6.18, SD = 1.26) were considered to be the most desirable food item as the mean was significantly higher from the mid-point ($t(49) = 12.27$, $p < .001$), while the Fermented Trout (M = 2.52, SD = 1.78) was considered to be the least desirable food item as the mean was significantly lower than the mid-point ($t(49) = -5.89$, $p < .001$). Means and standard deviations for the desirability of all 7 items measured are listed below:

Item	**Mean**	**Standard Deviation**
Waffle Fries	6.12	1.14
Parmesan Fries	6.18	1.26
Raw Kale Salad	3.90	1.96
Chocolate Cake	6.18	1.57
Fermented Trout	2.52	1.78
Stewed Eggplant	3.16	1.90
Fruit and Caramel Crepe	5.94	1.41

APPENDIX N: CHAPTER 6 STIMULI

Desirable: Parmesan Fries



Undesirable: Fermented Trout



APPENDIX O: CHAPTER 6 ANALYSIS OF AR PRESENTATION ON PRODUCT ATTITUDE WITH ALL PARTICIPANTS INCLUDED

When including the participant who failed the suspicion probe and the outlier, 2x2 ANOVA revealed a marginally significant main effect of presentation format ($F(1, 169) = 2.97$, $M_{Control} = 3.76$, $M_{AR} = 4.16$; $p = .09$, $\eta_p^2 = .02$) on product attitude and a significant main effect of food item ($F(1, 169) = 88.66$, $M_{Undesirable} = 2.88$, $M_{Desirable} = 5.00$; $p < .001$, $\eta_p^2 = .34$) on overall product attitude. The interactive effect was not significant ($F(3, 169) = .13$, $p = .72$, $\eta_p^2 = .001$).

APPENDIX P: CHAPTER 7 EXCLUDED AR STUDY

Results from the Chapters 3 – 4 using field experiments highlighted the effect of AR presentation on the desirability, purchase likelihood, and post-consumption evaluation of foods, and suggested that mental simulation plays a key role in this process. This study replicates the effect of AR presentation on desirability in a controlled lab environment, and also tests whether the presence of nutritional information attenuates the positive AR effect on desirability.

Importantly, the controlled laboratory setting gave us the opportunity to collect multi-item scale measures, more definitively demonstrate the mediational role of mental simulation, and attempt to rule out alternative mechanisms. Specifically, one might argue that the effects found in previous studies were driven by an increased realistic depiction of the food items or by a positive mood state induced in the AR presentation condition. The former explanation seems especially unlikely given that the food depictions in Chapter 4 were identical across conditions (including scale, resolution, and dimensionality). However, we measured both visual realism and mood to explicitly test their potential explanatory power. Finally, while Chapters 3 and 4 focused exclusively on indulgent food items (i.e., caloric desserts), the current study allowed us to extend this investigation to non-indulgent food categories.

Pretest

One hundred participants (41% Female, 59% Male, 0% Nonbinary/Other; M_{Age} = 37.95, SD = 13.04) recruited from Amazon Mechanical Turk participated in this pretest in exchange for monetary compensation. All participants viewed the three food items pictured below (french fries, an arugula salad, and a fruit platter) in a randomized order, and were asked to rate how indulgent each food was on three bipolar items (1 =

Unhealthy/High in Calories/Bad for You and 7 = Healthy/Low in Calories/Good for You; all reverse-coded; $\alpha_{FrenchFries}$ = .88, $\alpha_{ArugulaSalad}$ = .70, $\alpha_{FruitPlatter}$ = .75). Analysis results indicated that the arugula salad (M = 1.64, SD = .72) and fruit platter (M = 1.79, SD = .77) were considered to be non-indulgent food items (with means significantly below the mid-point, $t(99) = -32.66$, $p < .001$; and $t(99) = -28.57$, $p < .001$; respectively), while the french fries (M = 5.70, SD = 1.44) were considered to be indulgent (with a mean significantly above the mid-point indulgence score, $t(99) = 11.85$, $p < .001$).

Fruit Salad



French Fries



Arugula Salad



Design and Procedure

Two hundred and five members of a community-based subject-pool (59% Female, 41% Male, 0% Nonbinary/Other; M_{age} = 31.09, SD = 14.65) participated in this experiment in exchange for monetary compensation. We used a 2 (presentation format: control versus AR) x 2 (nutritional information: absent versus present) between-subjects design. As a cover story, participants were told that a new local restaurant was soliciting feedback regarding potential food dishes to offer on their menu. Participants were then shown one of three foods on an iPad: french fries, an arugula salad, or a fruit platter. Pretest results reported above suggested that while the french fries were considered to be indulgent, the arugula salad and fruit platter were considered to be non-indulgent. Presentation format was manipulated in the same manner as in Chapter 4. Thus, once again, the renderings of each of the three food items were identical in scale, resolution, and dimensionality across the two presentation format conditions, with the only difference being whether the food was featured against a static background (control) or was visually superimposed onto participants' environments in real-time (AR condition).

To manipulate the presence of nutritional information, half the participants were presented with the pictured food's nutritional label as they viewed the food (this information was displayed on a separate computer screen, not on the iPad they used to view the foods). The nutrition label included information regarding the calories, fat content, sodium, protein, and other dietary facts for the pictured food item, pictured below.

French Fries



Nutrition Facts

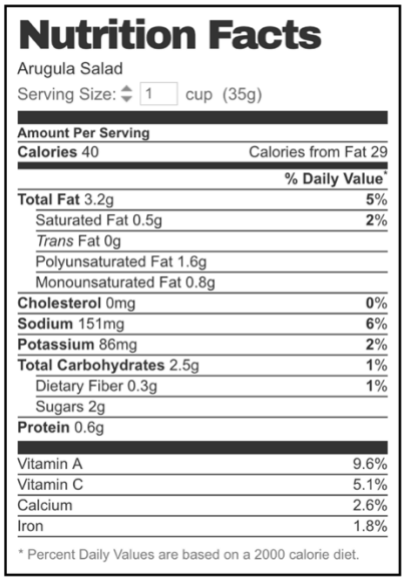
Parmesan Fries

Serving Size: 1 order (142g)

Amount Per Serving	
Calories 501	Calories from Fat 270
	% Daily Value*
Total Fat 30g	**46%**
Saturated Fat 6g	**30%**
Trans Fat 0.2g	
Polyunsaturated Fat 7.5g	
Monounsaturated Fat 15g	
Cholesterol 11mg	**4%**
Sodium 479mg	**20%**
Potassium 715mg	**20%**
Total Carbohydrates 50g	**17%**
Dietary Fiber 4.5g	**18%**
Sugars 0.4g	
Protein 7.7g	
Vitamin A	6.9%
Vitamin C	15%
Calcium	10%
Iron	6.8%

* Percent Daily Values are based on a 2000 calorie diet.

Arugula Salad



Nutrition Facts

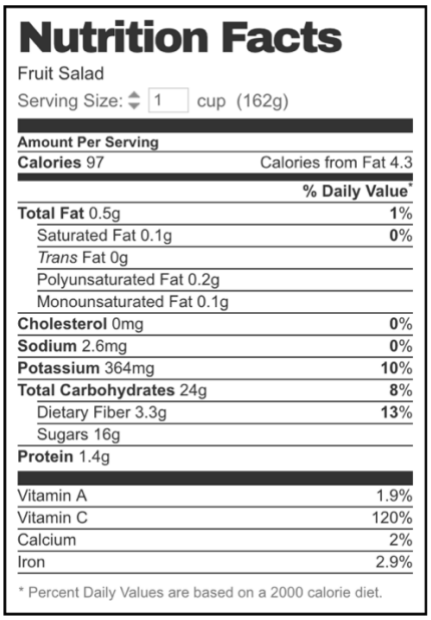
Arugula Salad

Serving Size: 1 cup (35g)

Amount Per Serving	
Calories 40	Calories from Fat 29
	% Daily Value*
Total Fat 3.2g	**5%**
Saturated Fat 0.5g	**2%**
Trans Fat 0g	
Polyunsaturated Fat 1.6g	
Monounsaturated Fat 0.8g	
Cholesterol 0mg	**0%**
Sodium 151mg	**6%**
Potassium 86mg	**2%**
Total Carbohydrates 2.5g	**1%**
Dietary Fiber 0.3g	**1%**
Sugars 2g	
Protein 0.6g	
Vitamin A	9.6%
Vitamin C	5.1%
Calcium	2.6%
Iron	1.8%

* Percent Daily Values are based on a 2000 calorie diet.

Fruit Salad



Nutrition Facts

Fruit Salad

Serving Size: 1 cup (162g)

Amount Per Serving	
Calories 97	Calories from Fat 4.3
	% Daily Value*
Total Fat 0.5g	**1%**
Saturated Fat 0.1g	**0%**
Trans Fat 0g	
Polyunsaturated Fat 0.2g	
Monounsaturated Fat 0.1g	
Cholesterol 0mg	**0%**
Sodium 2.6mg	**0%**
Potassium 364mg	**10%**
Total Carbohydrates 24g	**8%**
Dietary Fiber 3.3g	**13%**
Sugars 16g	
Protein 1.4g	
Vitamin A	1.9%
Vitamin C	120%
Calcium	2%
Iron	2.9%

* Percent Daily Values are based on a 2000 calorie diet.

After viewing the food, participants indicated the overall desirability of the food (on four 7-point bipolar items: Undesirable - Desirable, Dislike - Like, Unfavorable - Favorable, Negative - Positive; and one semantic differential item, "How strong are your cravings for this food?" Extremely weak - Extremely strong; α = .93), mental simulation (on four 5-point Likert items adapted from Hildebrand et al. 2019: "I could imagine myself eating the dish displayed", "I could see myself eating the dish displayed", "The thought of eating the dish was very clear", and "The thought of eating the dish was very vivid"; α = .82) and realism (on four 7-point Likert scaled items: "This dish looks realistic", "The dish looks real," "This dish looks believable", and "The dish looks natural"; α = .91). Finally, participants indicated their mood (on six 7-point Likert items: "I am in a good mood right now," "I am in a cheerful mood right now," "I am happy right now," "I am in a bad mood right now," "I am in a sad mood right now," and "I am unhappy right now," [the last three items reverse-coded]; α = .94), gender, and age.

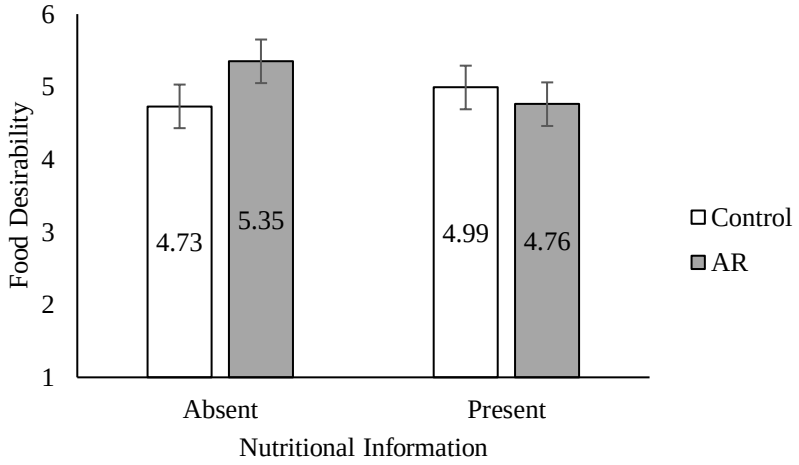
Results and Discussion

Desirability. ANOVA results demonstrated that the presentation format did not significantly interact with the food category to influence any of the dependent variables (all *p*'s > .70). Accordingly, we collapsed the data across food categories, and treat food category as a covariate with two dummy variables in the subsequent analyses.

ANCOVA results revealed a significant interaction between presentation format and nutritional information on desirability of the food ($F(1, 199) = 4.82$, $p = .03$, $\eta_p^2 = .02$). An analysis of contrasts revealed that when nutritional information was absent (as was the case in Chapters 3 and 4), AR presentation has a significant positive effect on desirability ($M_{Control} = 4.73$ versus $M_{AR} = 5.35$; $F(1, 199) = 7.29$, $p < .01$, $\eta_p^2 = .04$), consistent with

results in both chapters. However, when nutritional information was present, the simple effect of presentation format was no longer significant ($M_{Control}$ = 4.99 versus M_{AR} = 4.76; $F(1, 199) = .76$, $p = .38$).

INTERACTIVE EFFECT OF AR PRESENTATION AND NUTRITIONAL INFORMATION ON FOOD DESIRABILITY



Mental simulation. An ANCOVA demonstrated a main effect of AR presentation on the degree to which participants engaged in mental simulation ($M_{Control}$ = 3.42 versus M_{AR} = 3.73; $F(1, 199) = 4.78$, $p = .03$, $\eta_p^2 = .02$). Neither the main effect of nutritional information nor its interaction with presentation format were significant (both p's > .55).

To assess whether mental simulation could explain effect of presentation format on desirability in the absence of nutritional information, we ran a moderated mediation analysis (model 8, Hayes 2013) with 10,000 resamples. Results showed that when nutritional information was absent, the indirect effect of AR presentation format on desirability through mental stimulation was significant (indirect effect = .2668, 95% CI: .0455 to .5219), consistent with results in Chapter 4. However, this indirect effect was not

significant in the presence of nutritional information (indirect effect = .2130, 95% CI: -.1882 to .6361).

Alternative mechanisms: Visual realism and mood. ANOVA results did not produce significant effects of presentation format, nutritional information, or their interaction on visual realism and mood (all *p*'s > .10) suggesting these are unlikely to be alternative mediating variables. In addition, the results reported above continue to hold when including these variables as covariates. Specifically, ANCOVA results continued to demonstrate a significant presentation format x nutritional information interaction on desirability of the food ($F(1, 197) = 6.30$, $p = .01$, $\eta_p^2 = .03$). An analysis of contrasts confirmed that when nutritional information was absent, AR presentation has a significantly positive effect on desirability ($M_{Control} = 4.73$ versus $M_{AR} = 5.35$; $F(1, 197) = 6.15$, $p = .01$, $\eta_p^2 = .03$), consistent with the results in Chapters 3 and 4. However, when nutritional information was present, this effect was no longer significant ($M_{Control} = 4.99$ versus $M_{AR} = 4.76$; $F(1, 197) = 1.89$, $p = .17$).

To assess whether mental simulation would continue to explain effect of presentation format on desirability in the absence of nutritional information, we again ran a moderated mediation analyses (model 8, Hayes 2013) with 10,000 resamples. Results demonstrated that when nutritional information was absent, the indirect effect of mental simulation on desirability was significant (indirect effect = .2115, 95% CI: .0269 to .4269), consistent with the results in Chapter 4. This indirect effect was not significant in the presence of nutritional information (indirect effect = .0536, 95% CI: -.3163 to .4100).

To summarize, this study replicated the major findings from the field experiments in Chapters 3 and 4 in a controlled lab setting and with more extensive measures of key variables. This study also demonstrated that the positive effect of AR presentation is not limited to indulgent foods, but also applies to non-indulgent categories. Notably, we

establish an important boundary condition for the effects of AR presentation on food. While AR presentation increases the mental simulation of consuming a pictured food, such simulation only converts into increased desirability in the absence of more utilitarian attribute information (e.g., nutritional information). Finally, this study provided more conclusive support for the mediational role of mental simulation, while ruling out alternative explanations surrounding visual realism or mood.

However, upon further consideration and with the guidance from the editorial team at the Journal of Marketing, we recognize that the findings reported here are potentially confounded as the nutritional information depicted was viewed on a different device (the desktop computer where the Qualtrics survey was administered) from the device used to depict the food item (the iPad). Although at the time the experiment was run the technology was *not* capable of displaying both the digital food item *and* nutrition information simultaneously, we are unable to definitively claim that the observed effect from viewing the nutrition information is in fact a direct result from the information presented, or instead could simply be driven by re-directed attention irrespective of what the attention was directed to.

Further, the finding that increased mental simulation improves desirability (i.e., the second path of the proposed theorizing), has already been well-established in extant literature. However, this research is the first to empirically demonstrate that the real-time superimposition afforded by AR can increase mental simulation (the first path in the model). Accordingly, we decided to focus more on the link between AR and the mediator of mental simulation (vs. a focus on the link between mental simulation and desirability, which has already been well established albeit not in this context), examining what preceding mediators might explain the link between AR presentation and mental simulation to begin with.

CHAPTER 15

APPENDIX: CHAPTERS 8 – 12

APPENDIX A: SPATIAL AUDIO EXAMPLE

For the best experience, please listen with headphones.

Spatial Audio Example

APPENDIX B: CHAPTER 9 STIMULI

For the best experience, please listen with headphones.

No Audio Condition

Standard Audio Condition

Spatial Audio Condition

APPENDIX C: CHAPTERS 9, 10, AND 11 MATERIALS

Samsung S21 Mobile Phone



DT770M Over-ear Headphones



APPENDIX D: CHAPTER 9 MEASURES

Familiarity

- *I am familiar with Perrier water [7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

Previously eaten

- *I have drank Perrier water before [Choice: Yes, No, Unsure]*

Desire *[see individual item for scale]*

- *How strong is your urge to drink this Perrier water [7 Point Scale, 1=Extremely Weak, 7=Extremely Strong]*
- *How strong are your cravings for this Perrier water [7 Point Scale, 1=Extremely Weak, 7=Extremely Strong]*
- *How desirable did you find the Perrier water to be? [7 Point Scale, 1=Extremely Undesirable, 7=Extremely Desirable]*

Purchase *[7 Point Scale, 1=Extremely Unlikely, 7=Extremely Likely]*

- *After viewing the Perrier water, how likely would you be to purchase it if it was offered at a store?*
- *How likely would you be to purchase this Perrier water if it was offered to you right now?*

Perceived Taste *[7 Point Scale, 1=Far Below Average, 7=Far Above Average]*

- *Please evaluate the Perrier water you just viewed on the following dimensions:*
  - *Delicious*
  - *Satisfying*
  - *Thirst Quenching*

WTP *[Sliding Scale from 0 to 5]*

- *How much would you be willing to pay for this 330ml bottle of Perrier water (in Pound Sterling £)?*

Brand Liking *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I like the brand Perrier*
- *I think positively of the brand Perrier*

Brand Modernity *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I view Perrier as a modern brand*
- *I view Perrier as a traditional brand (reverse coded)*
- *I view Perrier as an outdated brand (reverse coded)*
- *I view Perrier as an innovative brand*

Presence *[see individual item for scale]*

- *The Perrier bottle felt like it was on the table in front of me [7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*
- *I momentarily forgot the Perrier bottle was not real [7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*
- *I perceived the bottle of Perrier water to be located [7 Point Scale, 1=Entirely on the Mobile Phone, 7=Entirely on the Table in front of me]*

Realism *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *The bottle of Perrier water looked real*
- *The experience of opening the bottle of Perrier water felt real*

Mental Simulation *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I could imagine myself drinking the Perrier water*
- *I could see myself drinking the Perrier water*
- *I thought about myself drinking the Perrier water*

- *The thought of myself drinking the Perrier water felt real*
- *The thought of myself drinking the Perrier water was very clear*
- *The thought of myself drinking the Perrier water was very vivid.*

Enjoyment of the Experience *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I enjoyed viewing this Perrier water*
- *It was fun to view this Perrier water*

Personal Relevance *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *This is a type of drink I might purchase when at a shop*
- *This is similar to other beverages I drink*

Movement *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I felt drawn to the bottle of Perrier water by the way it looked*
- *I felt drawn to the bottle of Perrier water by the way it sounded*
- *I moved the phone closer to the bottle of Perrier because of the way it looked*
- *I moved the phone closer to the bottle of Perrier because of the way it sounded*

Sensory Measures

- *Please indicate the extent to which you engaged each of the following senses while evaluating the Perrier bottle [5 Point Scale, 1=Not at All, 5=The Entire Time]*
    - *Sight*
    - *Sound*
    - *Smell*
    - *Taste*
    - *Touch*
- *On a scale from 1 (not at all important) to 10 (the most important), please indicate the importance each sense played in your evaluation of the Perrier bottle:*
    - *Sight*
    - *Sound*
    - *Smell*
    - *Touch*
    - *Taste*

Tech Check *[Choice: Yes, No, Unsure]*

- *The bottle appeared to get larger as I moved the phone closer*
- *I heard sounds while viewing the bottle of Perrier water*

Audio Measures *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *As I approached the bottle the sound became louder*
- *The sound the bottle of Perrier water made seemed real*
- *The sound coming from the bottle of Perrier water made the experience feel more real*

Novelty *[7 Point Scale, 1=Very Unfamiliar, 7=Very Familiar]*

- *How familiar are you with Augmented Reality technology?*
- *How familiar are you with Spatial Audio?*

Demographics

- *What is your Gender [Choice: Male, Female, Non-binary/other, Prefer not to say]*
- *What is your age*

APPENDIX E: CHAPTER 9 DESIRABILITY AND PURCHASE LIKELIHOOD RESULTS

Desirability

ANOVA results revealed a significant main effect of audio format on product desirability ($F(2, 136) = 3.81$; $M_{NoAudio} = 3.91$; $M_{StandardAudio} = 3.64$; $M_{SpatialAudio} = 4.44$; $p = .02$, $\eta_p^2 = .05$). An analysis of contrasts revealed that participants in the spatial audio condition ($M_{SpatialAudio} = 4.44$) reported significantly higher desirability compared to the standard audio condition ($M_{StandardAudio} = 3.64$; $p < .01$) and marginally significantly higher desirability compared to the no audio condition ($M_{NoAudio} = 3.91$; $p = .07$). Interestingly, there was no significant difference between the no audio and standard audio conditions ($p = .32$).

Purchase Likelihood

ANOVA results revealed a significant main effect of audio format on purchase likelihood ($F(2, 136) = 3.18$; $M_{NoAudio} = 4.25$; $M_{StandardAudio} = 3.71$; $M_{SpatialAudio} = 4.57$; $p = .05$, $\eta_p^2 = .05$). An analysis of contrasts revealed that participants in the spatial audio condition ($M_{SpatialAudio} = 4.57$) reported significantly higher purchase likelihood compared to the standard audio condition ($M_{StandardAudio} = 3.71$; $p = .01$), but not significantly different purchase likelihood compared to the no audio condition ($M_{NoAudio} = 4.25$; $p = .35$). Interestingly, there was a marginally significant increase in purchase likelihood in the no audio condition compared to the standard audio condition ($p = .09$).

APPENDIX F: RULING OUT NOVELTY

Chapter 9: Spatial Audio Familiarity on Product Attitude

Spatial Audio familiarity did not differ across the three audio presentation format conditions ($M_{NoAudio}$ = 3.25, $M_{StandardAudio}$ = 3.38, $M_{SpatialAudio}$ = 3.91; $F(2, 136) = 1.80$, $p = .21$). Importantly, neither the main effect of spatial audio familiarity ($p = .54$) nor the interaction between audio format and spatial audio familiarity ($p = .13$) were significant predictors of product attitude.

Chapter 10: Spatial Audio Familiarity on Product Attitude

Spatial Audio familiarity did not differ across the two audio presentation format conditions ($M_{StandardAudio}$ = 3.92, $M_{SpatialLite}$ = 3.95; $F(1, 172) = .01$, $p = .91$). Importantly, neither the main effect of spatial audio familiarity ($p = .53$) nor the interaction between audio format and spatial audio familiarity ($p = .88$) were significant predictors of product attitude.

Chapter 11: Spatial Audio Familiarity on Product Attitude

Once again, neither the main effect of spatial audio familiarity ($p = .32$) nor the interaction between audio format and spatial audio familiarity ($p = .68$) were significant predictors of product attitude.

APPENDIX G: CHAPTER 10 STIMULI

For the best experience, please listen with headphones.

Product-Relevant Sound – Standard Audio

Product-Relevant Sound – Spatial Lite

Product-Irrelevant Sound – Standard Audio

Product-Irrelevant Sound – Spatial Lite

APPENDIX H: CHAPTER 10 MEASURES

Product Familiarity Questions *[see individual item for scale]*

- *I am familiar with Pringles [7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*
- *I enjoy eating snack food items [7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*
- *I have eaten Pringles before [Choice: Yes, No, Unsure]*
- *I have a dietary restriction that prevents me from eating pringles [Choice: Yes, No, Unsure]*

Product Attitude *[see individual item for scale]*

- *How strong is your urge to eat these Pringles [7 Point Scale, 1=Extremely Weak, 7=Extremely Strong]*
- *How strong are your cravings for these Pringles [7 Point Scale, 1=Extremely Weak, 7=Extremely Strong]*
- *How desirable did you find these Pringles to be? [7 Point Scale, 1=Extremely Undesirable, 7=Extremely Desirable]*
- *After viewing the pringles, how likely would you be to purchase a cannister if it was offered at a store? [7 Point Scale, 1=Extremely Unlikely, 7=Extremely Likely]*

Taste Perception *[7 Point Scale, 1=Far Below Average, 7=Far Above Average]*

- *Please evaluate the Pringles you just viewed on the following dimensions:*
  - *Delicious*
  - *Tasty*

Enjoyment of the Experience *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*
* indicates inclusion in the scale

- *I enjoyed this experience **
- *This experience was fun **
- *This experience was exciting **
- *This experience was engaging **
- *This experience was boring (reverse coded)**
- *The duration of this experience was too long (reverse coded)*
- *This experience was too repetitive (reverse coded) **
- *The duration of this experience was too short*
- *This experience was frustrating (reverse coded) **

Physical Approach *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I felt drawn to the Pringles*
- *I moved the phone closer to the Pringles*

Perceived Physical Closeness *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I felt as though the Pringles chips were within reach*
- *It felt like I could reach out and grab the Pringles chips*
- *It felt as though the Pringles chips were in my immediate vicinity*

Immersion *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *This experience felt so authentic that it made me think that the virtual Pringles existed for real*
- *I felt that what I was experiencing was something real, instead of a fictional experience*

- *I was so involved in the experience, that in some cases I wanted to interact with the virtual Pringles directly*
- *I was so involved that I felt my actions could affect the experience*
- *I didn't' have any irrelevant thoughts or external distractions during the experience*
- *The experience became the unique and only thought occupying my mind*
- *I lost track of time, as if everything just stopped, and the only thing that I could think about was the experience.*

Realism *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *The can of Pringles looked real*
- *The Pringles chips looked real*
- *The 'pop' the Pringles can made when tapped sounded real*
- *The 'crunch' the Pringles chips made when tapped sounded real*

Audio Measures *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I enjoyed the audio in this experience*
- *As I approached the Pringles can and chips, the volume increased*
- *The audio in this experience seemed relevant to Pringles*

Mood *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I was very hungry when arriving to participate today*
- *I am currently on a diet*
- *I am in a good mood right now*
- *I am in a bad mood right now*

Novelty *[7 Point Scale, 1=Very Unfamiliar, 7=Very Familiar]*

- *How familiar are you with Augmented Reality technology?*
- *How familiar are you with Spatial Audio?*

Demographics

- *What is your gender? [Choice: Male, Female, Non-binary/other, Prefer not to say]*
- *What is your age*
- *Do you identify as having a disability (auditory, visual, other) that impacted your ability to complete either activity in this study? If yes, please briefly describe below. [Choice: Yes, No, Prefer not to say]*

APPENDIX I: CHAPTER 10 PRODUCT RELEVANT/IRRELEVANT SOUND RESULTS

Immersion

A 2x2 ANOVA did not reveal a significant main effect of product sound relevance ($F(1, 170) = 1.86$, $M_{NonProductAudio} = 3.61$, $M_{ProductAudio} = 3.89$; $p = .17$, $\eta_p^2 = .01$) or interactive effect between audio format and product sound relevance ($F(3, 170) = .17$, $M_{Control/NonProduct} = 3.40$, $M_{Control/Product} = 3.61$, $M_{Spatial/NonProduct} = 3.81$, $M_{Spatial/Product} = 4.17$; $p = .71$, $\eta_p^2 < .01$), on immersion.

Enjoyment of the Experience

A 2x2 ANOVA did not reveal a significant main effect of product sound relevance ($F(1, 170) = 1.56$, $M_{NonProductAudio} = 4.64$, $M_{ProductAudio} = 4.92$; $p = .21$, $\eta_p^2 = .01$) or interactive effect between audio format and product sound relevance ($F(3, 170) = .009$, $M_{Control/NonProduct} = 4.41$, $M_{Control/Product} = 4.71$, $M_{Spatial/NonProduct} = 4.87$, $M_{Spatial/Product} = 5.13$; $p = .92$, $\eta_p^2 < .001$), on enjoyment of the experience.

Ancillary Analysis

Auditory Realism. A 2x2 ANOVA reveal a significant main effect of product sound relevance ($F(1, 170) = 133.00$, $M_{NonProductAudio} = 3.22$, $M_{ProductAudio} = 5.71$; $p < .001$, $\eta_p^2 = .44$) on Auditory Realism, but no significant interactive effect between audio format and product sound relevance ($F(3, 170) = .16$, $M_{Control/NonProduct} = 3.14$, $M_{Control/Product} = 5.72$, $M_{Spatial/NonProduct} = 3.30$, $M_{Spatial/Product} = 5.70$; $p = .69$, $\eta_p^2 = .001$).

Mood. A 2x2 ANOVA did not reveal a significant main effect of product sound relevance ($F(1, 170) = 1.73$, $M_{NonProductAudio} = 5.32$, $M_{ProductAudio} = 5.55$; $p = .19$, $\eta_p^2 = .01$) or interactive effect between audio format and product sound relevance ($F(3, 170) = .05$, $M_{Control/NonProduct} = 5.23$, $M_{Control/Product} = 5.51$, $M_{Spatial/NonProduct} = 5.40$, $M_{Spatial/Product} = 5.60$; $p = .83$, $\eta_p^2 < .001$), on mood.

APPENDIX J: CHAPTER 11 STIMULI

For the best experience, please listen with headphones.

Control Condition (standard audio)

Spatial Lite Audio

Full Spatial Audio

APPENDIX K: CHAPTER 11 MEASURES

Product Familiarity Questions *[see individual item for scale]*

- *I am familiar with KitKat [7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*
- *I enjoy eating sweet food items [7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*
- *I have eaten KitKat before [Choice: Yes, No, Unsure]*
- *I have a dietary restriction that prevents me from eating KitKat [Choice: Yes, No, Unsure]*

Product Attitude *[see individual item for scale]*

- *How strong is your urge to eat these KitKat bars [7 Point Scale, 1=Extremely Weak, 7=Extremely Strong]*
- *How strong are your cravings for these KitKat bars [7 Point Scale, 1=Extremely Weak, 7=Extremely Strong]*
- *How desirable did you find these KitKat bars to be? [7 Point Scale, 1=Extremely Undesirable, 7=Extremely Desirable]*
- *After viewing the KitKat bars, how likely would you be to purchase it if it was offered at a store? [7 Point Scale, 1=Extremely Unlikely, 7=Extremely Likely]*

Perceived Taste *[7 Point Scale, 1=Far Below Average, 7=Far Above Average]*

- *Please evaluate the KitKat bars you just viewed on the following dimensions:*
  - *Delicious*
  - *Indulgent*
  - *Crispy*

Brand Liking *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I like the brand KitKat*
- *I think positively of the brand KitKat*

Brand Modernity *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I view KitKat as a modern brand*
- *I view KitKat as a traditional brand (reverse coded)*
- *I view KitKat as an outdated brand (reverse coded)*
- *I view KitKat as an innovative brand*

Enjoyment of the Experience *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

* indicates inclusion in the scale

- *I enjoyed this experience **
- *This experience was fun **
- *This experience was exciting **
- *This experience was engaging **
- *This experience was boring (reverse coded)**
- *The duration of this experience was too long (reverse coded)*
- *This experience was too repetitive (reverse coded) **
- *The duration of this experience was too short*
- *This experience was frustrating (reverse coded) **

Physical Approach *[Choice: Yes, No]*

- *I stood up out of my seat during this experience*
- *I walked around during this experience*
- *I extended my arm, moving the phone closer to the KitKat bars during the experience*

- *I broke the KitKat bars by pushing my phone into them*
- *I broke the KitKat bars by tapping on the phone screen*

Movement *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I felt drawn to the KitKat bars*
- *I moved the phone closer to the KitKat bars*

Perceived Physical Closeness *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *It felt as though the KitKat bars were within reach*
- *It felt like I could reach out and grab the KitKat bars*
- *It felt as though the KitKat bars were in my immediate vicinity*

Immersion *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *This experience felt so authentic that it made me think that the virtual KitKat bars existed for real*
- *I felt that what I was experiencing was something real, instead of a fictional experience*
- *I was so involved in the experience, that in some cases I wanted to interact with the virtual KitKat bars directly*
- *I was so involved that I felt my actions could affect the experience*
- *I didn't' have any irrelevant thoughts or external distractions during the experience*
- *The experience became the unique and only thought occupying my mind*
- *I lost track of time, as if everything just stopped, and the only thing that I could think about was the experience.*

Agency *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *During this experience, I felt like I determined the outcomes*
- *During this experience, I felt like I had the responsibility for finding and breaking the KitKat bars*
- *During this experience, finding and breaking the KitKat bars felt under my control*

Fluency *[7 Point Scale, 1=Very Difficult, 7=Very Easy]*

- *The process of finding all the KitKat bars was:*
- *The process of breaking the KitKat bars was:*

Number of bars found *[Choice: 1, 2, 3, 4, 5, 6+]*

- *Please indicate the number of KitKat bars you found:*

Realism *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *The bars of KitKat chocolate looked real*
- *The crunch the KitKat bars made sounded real*

Audio Measures *[7 Point Scale, 1=Strongly Disagree, 7= Strongly Agree]*

- *I enjoyed the audio in this experience*
- *As I approached the KitKat bars, the volume increased*
- *The audio in this experience directed me where to look to locate the next KitKat bar*
- *The audio in this experience made it easier to locate the next KitKat bar*
- *I felt the audio was all around me during this experience*
- *The audio in this experience was always the same in both ears*

Novelty *[7 Point Scale, 1=Very Unfamiliar, 7=Very Familiar]*

- *How familiar are you with Augmented Reality technology?*
- *How familiar are you with Spatial Audio?*

Demographics

- *What is your Gender [Choice: Male, Female, Non-binary/other, Prefer not to say]*
- *What is your age?*
- *Do you identify as having a disability (auditory, visual, other) that impacted your ability to complete the KitKat experience? If so, please briefly describe below. [Open Response]*

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