Impact of Manipulative Design Patterns in Augmented Reality on Consumer Buying Behaviours

A Thesis Submitted for the Degree of Master of Computer Science

K. Gunawardana

University of Colombo School of Computing

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DECLARATION

I hereby declare that the thesis is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in the thesis. This thesis has also not been submitted for any degree in any university previously.

Student Name: K. Gunawardana

Registration Number: 2019/MCS/034

Index Number: 19440342

KumuduGunawardana   30/09/2024

Signature of the Student & Date

This is to certify that this thesis is based on the work of Mr. /Ms. _____K. Gunawardana_____ under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

Certified by,

Supervisor Name: Dr. Kasun Karunanayaka

_____ 30/09/2024

Signature of the Supervisor & Date

I would like to dedicate this thesis to my parents who are my biggest pillars of strength

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ABSTRACT

The increasing popularity of immersive technologies such as Augmented Reality, Virtual Reality have started to affect and shape the daily life of individuals across all age categories. The investment of time, resources and money from leading technology companies, suggest that immersive technologies would become the next big technology trend in the world. Due to its prognosticated capabilities and potential, the business world also has taken a keen interest on using technologies such as augmented reality when creating strategies for marketing and advertising.

The inherent nature of marketing and advertising to persuade a customer or a potential customer to make a buying decision could be complemented from nature of immersive technology applications, while the dark design patterns or manipulative design patterns in augmented reality application design could lead the persuasive approach to a manipulative approach. How such manipulations might impact a consumer's behaviours is an interesting research topic with both academic and practical benefits.

Thereby, this research "Impact of manipulative design patterns in augmented reality on consumer behaviours" would first attempt to understand what dark design patterns could be used in an augmented reality-based application and then how those dark design patterns could influence consumer decision making. Once the possible dark design patterns are identified, effectiveness of the identified dark patterns would be evaluated using a suitable augmented reality system. The effectiveness would be measured using a controlled experiment, in which a selected set of participants would get involved. Through the analysis of the experiment's data, this research would determine whether dark design patterns in augmented reality could impact a consumer's buying behaviours.

Keywords: Augmented reality, Human computer interaction, Image processing

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LIST OF ABBREVIATIONS

UI   User Interface

AR   Augmented Reality

VR   Virtual Reality

MR   Mixed Reality

XR   Extended Reality

HCI   Human Computer Interactions

SET   Sensory Enabling Technologies

IDE   Integrated Development Environment

CHAPTER 1

INTRODUCTION

The technology advancements in the fields of computer science, electronics, and communication in the past few decades have now created a world where the digital presence of human beings is the norm. The tendency to live in a virtual world simultaneous to the real world is trending among both youngsters and adults, not only in their personal life but also in work life. The accessibility, availability, and affordability of advanced diversified digital devices such as smartphones, high-tech lenses have widened the audience for technologies like Augmented Reality (AR).

Even though AR technologies are comparatively at an infant stage, with great potential for further development, nevertheless, they have achieved commendable results in generating 2D/3D virtual objects, and annotations that blend with the users' surroundings. Therefore, it has already become quite popular among the general public through gaming and entertainment applications due to its immersive, pervasive, and realistic feel.

The emerging popularity of AR applications captured the attention of not only the technology community but also others such as sales and marketing circles, since it has paved way for a new marketing and advertising channel which is more interactive and arguably more powerful than traditional channels. As a matter of fact, even a decade, ago back in 2014, IKEA the Swedish multinational conglomerate specialized in ready to assemble furniture, incorporated AR in their online product catalogue offering potential customers the opportunity to experience the product at their home before actually purchasing it[1]. This virtual furnishing capability of the online product catalogue was a tremendous success, which resulted in the company launching their AR enabled mobile app "IKEA Place". Additionally, according to a survey done by Deloitte in 2017 almost 90% of companies with annual revenue between $100 million to $1 billion are already leveraging AR or VR technology for their marketing and advertising strategies (Feng and Mueller, 2019).

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[1] IKEA AR catalogue https://www.bbc.com/news/business-28399343

The enthusiasm for AR technologies and applications in the sales, marketing and advertising domains further intensified with the launch of platforms like Metaverse[2] by Meta, which promotes themselves as the successor to mobile internet that enables users to interact with each other through a sophisticated virtual world where they can connect, learn, shop, work and play. The company Meta has announced the results of a survey that establishes, that adding AR to marketing and advertising campaigns drives awareness at a lower cost, accompanied by success stories of beauty care brand Avon and car brand Mini[3]. The technology giant advocates for AR embedded marketing and advertising, as they expect to reach one billion users on the Metaverse by the next decade, fueling and accelerating the growth of AR technologies. The anticipated increase in the number of people using or rather living in a virtual world like Metaverse, has encouraged research to be carried out with different scientific perspectives. One such new area of interest is, manipulative design patterns or dark design patterns in AR.

Figure 1: IKEA AR catalogue

2 Metaverse https://about.meta.com/what-is-the-metaverse/

3 AR Ad survey https://web.facebook.com/business/news/insights/groundbreaking-ar-ad-study-quantifies-the-value-of-immersive-creative?_rdc=1&_rdr

1.1 Problem Domain

A dark design pattern in the context of user experience is one that system designers use to exploit the users to behave in ways that may not be in the best interest of themselves but the system(Conti and Sobiesk, 2010). In traditional systems like mobile apps, the dark design patterns were limited to user interface (UI) related manipulations such as misleading information, hidden information etc., where as in the AR landscape, applying dark design patterns is not limited only to the UI.

Prior to diving into the world of AR and how it has created possibilities for new means of sales, marketing, and advertising it would be beneficial to have a clear understanding of what AR is and how it is used in today's world. Augmented Reality as the name implies, augments or enhances some parts of the physical surroundings the user actually lives in, through the use of digital displays and computer graphics. The most common AR technology as of today is AR smartphone apps, where the phone's camera is used to overlay digital objects on to a streaming video feed. The objects generated using the AR technology would be attached to the real-world objects in a manner that makes it appear real. In addition to smartphone apps, another AR device is the AR headset, which the user can wear similar to a Virtual Reality (VR) headset and view physical world around him with additional digital objects. However, it should be noted that, although popular in fiction, the AR headset is not yet used widely by the general population (Mhaidli and Schaub, 2021).

The exposure of Manipulative Designs in AR by (Wang et al., 2023) raises some important research questions, of which one is, whether manipulative designs in AR can be used to influence consumer behaviours and their purchasing decisions, via the UI design or via a combination of design models, for example UI, and audio feedback.

In the conventional sales and marketing platforms, there are primarily two broad approaches to influence consumer buying behaviours which are persuasion and manipulation (Beauchamp and Public Interest Enterprises, Inc., 1984). Persuasion is when an advertisement provides information about a certain product in a manner that guides the consumer to make a rationale buying decision. Hence, utilizing persuasion in marketing strategies is considered to be

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acceptable. However, an advertisement that directs a consumer to purchase a product involuntarily or against their best interest is identified as manipulative marketing and is ethically problematic.

In the age of digital presence and Metaverse, where human networking and connections are built and maintained predominantly through a diverse virtual world, influences on consumer behaviours would change drastically (Feng and Mueller, 2019). Marketing strategies used in the past would be reformed in order to exploit the limitless opportunities provided by the ever advancing digital technologies (Mhaidli and Schaub, 2021).

1.2 Motivation

Although AR has been a topic in the computer science and technology world for decades, it became mainstream and trending during the last couple of years due to the advancements in supporting hardware and software technologies, along with the increased accessibility through widespread adaptation to smartphones. The immense potential of AR with its popularity has caught the attention of the business world, who now have started to create their marketing and advertising campaign strategies towards AR.

When conducting a background study on AR and its related topics, the dark design pattern aspect caught my attention as it directed me to explore a feature of AR that has thus far captured modest attention yet can have significant effects on the well-being of the society and individuals. The recent hype in AR marketing and advertising by corporate and technology giants encouraged me further, to conduct a research that investigates and evaluates manipulative designs in AR and how such manipulations can impact consumer behavior and decision making. Although AR based marketing and advertising has not come to its full potential, I believe it would be advantageous for the general public to have some knowledge on the possible tricks in AR based advertising and marketing before it becomes the norm.

1.3 Research Objectives, Questions and Contributions

Exploring and evaluating dark design patterns in interface design especially with regards to the traditional computer systems such as websites, mobile applications is a popular research area in Human Computer Interaction (HCI) domain to this day. Similarly, computer scientists and researchers have taken continuous interest in the domain of AR and therefore, many studies have been carried out around the topic as well. With the emerging popularity of platforms like metaverse, investigating and exploring around immersive technologies in the present time would shed light on future opportunities and challenges that both the computer science community and the general public may face. Exploring and evaluating how the design of an AR system can affect a user's decision-making process is therefore, a recently developed computer science problem around which academic research can be constructed.

Hence, this research would focus on identifying, analysing, implementing and evaluating manipulative AR design patterns that can be used for marketing and advertising using AR tools and technologies in order to influence consumer decision making.

1.3.1 Research Objectives

1. Identify and understand manipulative design patterns that can be used in AR application design to impact consumer buying behaviours
2. Conduct a comparison between an AR based marketing/advertising solution and a traditional digital solution.
3. Determining the impact of manipulative/dark design patterns of AR on consumer buying behaviours

1.3.2 Research Questions

1. What are the manipulative design patterns in AR?
2. What design patterns could be used to manipulate consumer buying behaviours?
3. How to develop a manipulative AR prototype that can impact consumer buying behaviours?
4. How to evaluate the proposed prototype?

1.3.3 Research Contributions

Even though research have been done related to dark design patterns in AR, those were mainly focusing on the users' privacy and security aspects (Wang et al., 2023), whereas this research is aiming to identify and implement design patterns that can manipulate consumer behaviour, thus adding a fresh perspective to a growing research area. The existing research which combine AR with marketing/advertising, have predominantly used scenario construction-based methods (Mhaidli and Schaub, 2021) while this research aims to develop a prototype to compare the effects of AR marketing with traditional marketing, which is a novel idea. Furthermore, the research would have the potential to identify and predict how consumer decision making can be influenced through the use of no only AR but also more advance concepts like Extended Reality (XR) and would also provide a basis to conduct future research in AR, Virtual Reality (VR) and XR domains.

Although a relatively new approach, AR embedded marketing and advertising has seen success in industries like retail where potential customers can virtually try clothing, cosmetics or even visualize furniture (Heller et al., 2019). The food and beverages industry has also entered the AR marketing landscape to seize the limitless opportunities provided by the technology. Back in 2018 renown cereal brand Kellogg's and popular chocolate brand Cadbury had launched AR embedded packaging with the support of blippar[4] which is a pioneer company in AR technologies (Konopelko, 2019). In addition to the AR marketing campaigns with packaging, researchers have taken interest in investigating how AR/MR technologies can impact food science and food industry (J.K. Chai et al., 2022).

Since the marketers as well the researchers have recently taken keen interest in applying AR to food and beverage industry, this research would select it as the target product group to apply the dark design patterns of AR and evaluate its impact on consumer decision making. Thereby, while the food industry utilizes AR in their marketing and advertising, this research would focus

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4 blippar https://www.blippar.com/

on highlighting possible manipulations consumers would face, thus contributing to the social and economic welfare of the general public.
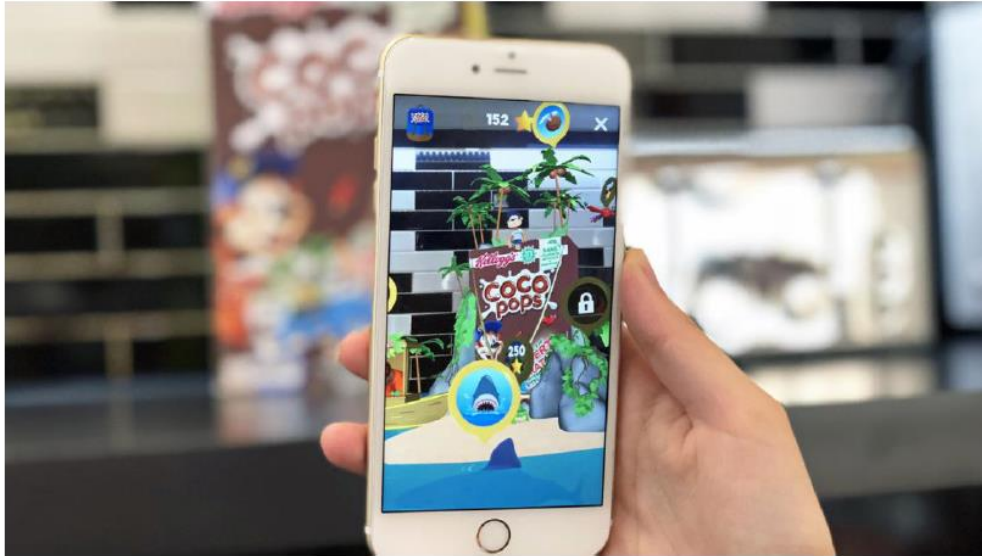
Figure 2: Kellogg's AR packaging

1.4 Scope

The research would initially focus on identifying, and understanding the manipulative design patterns in AR which can be used to impact consumer behavior for food and beverages industry. The extensive research carried out in the HCI domain had mainly focused on dark design patterns in interface design with related to digital platforms such as websites and mobile applications. Since AR based applications and equipment, have barely captured the general populations' attention, not many work have been done with respect to dark patterns in AR, hence identifying one or more dark patterns/manipulative designs in AR would be the first stage of the research. Exploring on the selected product category which is the food and beverages is also necessary for the purpose of deciding which AR dark design patterns could be used to manipulate potential consumers.

Once the dark patterns in AR design that can be incorporated in food and beverage advertising and marketing are identified, those patterns need to be evaluated to establish its effectiveness on influencing consumers. Therefore, an appropriate mobile application prototype would be

developed incorporating one or more manipulative patterns identified in stage one. The mobile application would be a simple prototype with minimum functionalities and capabilities since the objective of it is to assess how manipulative designs influence consumer behaviour and decision making, rather than to use as a real-world mobile application. A selected group of participants which is no more than 30 people would be invited to make a comparison between the AR prototype mobile application and the traditional mobile application in order to determine the impacts of manipulative AR design on consumer decision making.

However, it should be noted that, even though, AR promises to delivery limitless capabilities, the technology is in its initial stages with a lot of room for further improvement. This would therefore become a limitation to this research as there are technical constraints when it comes to implementing the identified design patterns. Furthermore, the cost and resource constraints the research may face would also become a limitation in the next stages of the research.

CHAPTER 2

LITERATURE REVIEW

The research, "Impact of manipulative design patterns in Augmented Reality on consumer buying behaviours", as the name suggests, collaborates with number of research disciplines. Therefore, it is important to clearly identify these disciplines and have a comprehensive understanding of their independent characteristics, as well as how they combine with one another, to accomplish the objectives of this research. A thorough analysis on the broader topics of "AR technology ", "User Experience (UX) and interaction design", "Digital marketing and advertising", "Applications of AR in marketing and advertising", "Psychology and consumer behaviour" and "Human-food interaction" was carried out by studying and evaluating relevant prior research materials and industry sources in order to gain the necessary domain knowledge and insights. The following chapter explores the significance, contribution and identified research gaps in the work of the above-mentioned broader topics, under four main categories.

1. Dark patterns in UI/UX and interaction design
2. VR/AR/XR in marketing and advertising
3. Psychology, cognitive biases and consumer behaviour
4. Human-food interaction

The diagram in Figure 1 depicts the research materials primarily referred in this chapter under the four categories mentioned above.
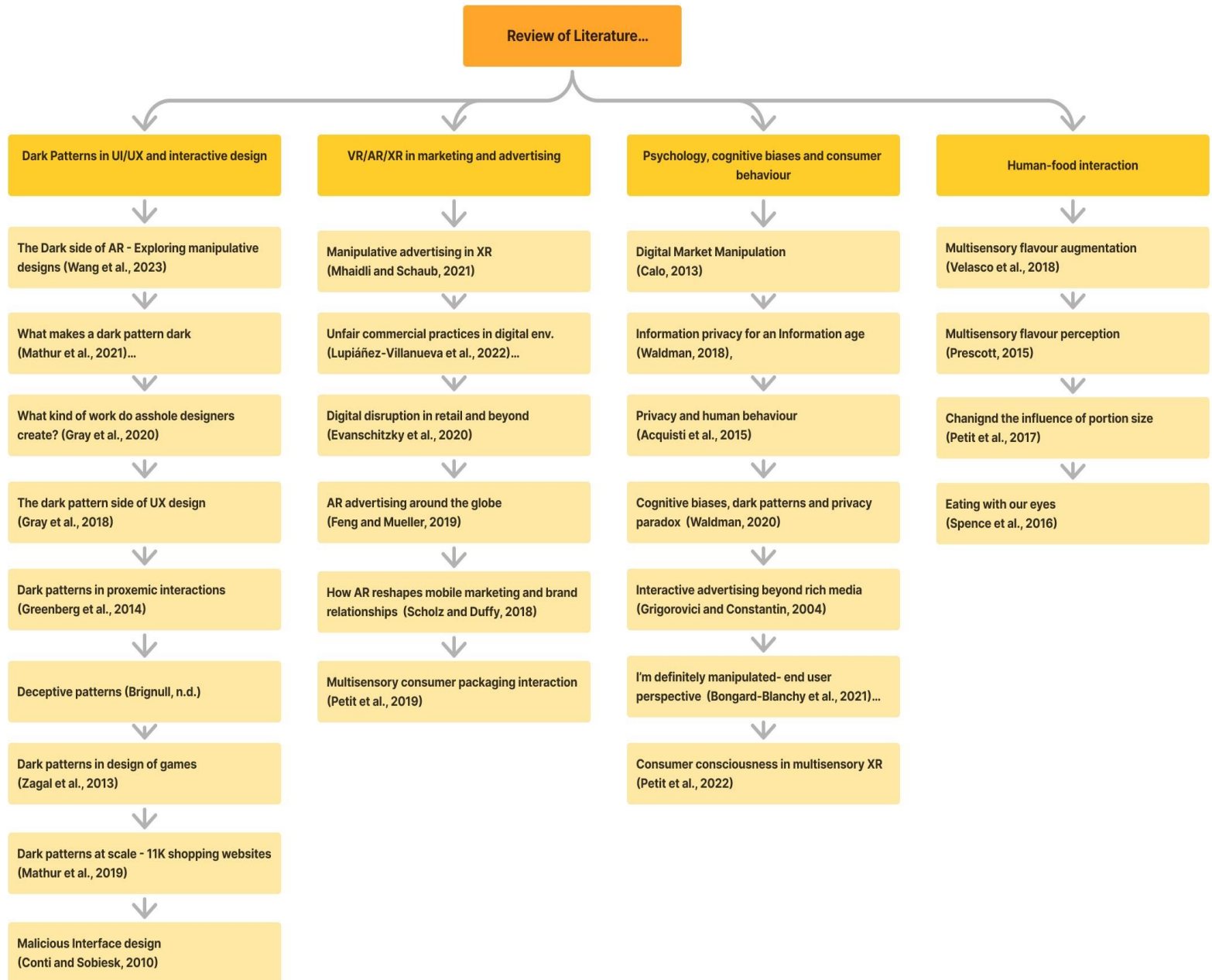
Figure 3: Literature review taxonomy

2.1 Dark patterns in UI/UX and interaction design

There are a number of widely accepted definitions for "dark patterns" in the HCI community among which the very first one is "a user interface that has been carefully crafted to trick users into doing things...they are not mistakes, they are carefully crafted with a solid understanding of

human psychology, and they do not have the user's interests in mind"(Brignull, n.d.). Brignull's initial work back in 2010, disclosed 12 dark patterns which included the below (Gray et al., 2018);

- Bait and switch – set out to do one thing but a different, undesirable thing happens instead

- Forced continuity – when the free trial ends, your credit card is charged without any warnings

- Disguised ad – adverts that are disguised as other kind of content to get you click on them

- Friend spam – products asks for your email or social media permissions under the pretence it will be used for a desirable outcome but then spams all your contacts in a messaging claiming to be you

- Hidden costs - you discover that unexpected charges have appeared at the last step of the checkout process

- Misdirection – the design purposefully focuses your attention one thing to distract you from another

- Price comparison prevention – The retailer makes it hard for you to compare the price of an item with another item, so you cannot make an informed decision

- Privacy Zuckering – You are tricked into publicly sharing more information about yourself than you intend to

- Roach Motel – The design makes it very easy for you to get into a certain situation but makes it hard to get out of it

- Sneak into Basket – you attempt to purchase something but somewhere in the purchasing journey the site sneaks an additional item into your basket

- Trick questions – a question when glanced upon quickly appears to ask one thing but if read carefully asks something entirely different

Along with Brignull's introduction of the term dark patterns, academic research avenues of HCI and UX expanded encouraging researchers to explore and describe dark patterns. This led to extensive literature on the dark patterns subject that defines what actually is meant by a dark pattern and how a dark pattern can impact a user. Contrary to defining dark patters as "tricks"

(Brignull, n.d.) , some have defined dark patterns with its main features, for example, "design choices that benefit an online service by coercing, steering or deceiving users into making decisions that, if fully informed and capable of selecting alternatives, they would not make" (Mathur et al., 2019) or "designers explicitly assert control over the user's experience, implementing obnoxious, coercive, or deceitful behaviors that are almost solely in the shareholder's best interest" (Gray et al., 2020).

Although the term "dark patterns" was not used, there have been research prior to Brignull that examined interface design in order to identify ill-intended interfaces that do not follow the best practices of design. One such is (Conti and Sobiesk, 2010) where 11 categories of malicious interface design were identified.

- Coercion – Threatening or mandating the user's compliance
- Confusion – Asking the user questions or providing information that they do not understand
- Distraction - Attracting the user's attention away from their current task by exploiting perception, particularly pre-attentive processing
- Exploiting Errors - Taking advantage of user errors to facilitate the interface designer's goals
- Forced Work - Deliberately increasing work for the user
- Interruption - Interrupting the user's task flow
- Manipulating Navigation - Creating information architectures and navigation mechanisms that guide the user toward interface designer task accomplishment.
- Obfuscation - Hiding desired information and interface elements
- Restricting Functionality - Limiting or omitting controls that would facilitate user task accomplishment
- Shock - Presenting disturbing content to the user
- Trick - Misleading the user or other attempts at deception

When considering user interface design, a commonly referred principle is persuasive design, in which design is accepted as an inherently persuasive act where designers create intentional

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change in the world that either directly or indirectly induce behavioural or social change (Redström, 2006). In (Fogg, 2002), the shaping of behavior is proposed to be achieved through 7 strategies; reduction, tunneling, tailoring, suggestion, self-monitoring, surveillance, and conditioning while maintaining the ethical standards of the society. Due to the behaviour changing aspect of dark patterns, it is believed that UX dark patterns may have its roots in persuasive design technologies by twisting its original purpose and ethical stand point. However, when defining the below five main dark patterns strategies, to better capture the developments in UX design space (Gray et al., 2018), didn't frame the strategies solely on persuasive technologies but rather acknowledged its influence on dark patterns.

- Nagging – redirection of expected functionality that persists beyond one or more interactions
- Obstruction – making a process more difficult than it needs to be with the intent of dissuading certain action(s)
- Sneaking – attempting to hide, disguise or delay the divulging of information that is relevant to the user
- Interface interference – manipulation of the user interface that privileges certain actions over others
- Forced action – requiring the user to perform a certain action to access (or continue access) certain functionality

The new classification proposed by (Gray et al., 2018) also included sub categories that further interpreted the category. For example, the Interface interference dark pattern includes "toying with emotions" as a sub category which addresses "the use of language, style, colour or other similar emotion in order to persuade the user into a particular action".

The higher-level attributes that compose a dark pattern in design have also been used as a basis to introduce a taxonomy for dark patterns. (Mathur et al., 2019) have proposed a categorisation that consists of five subcategories to define the dark patterns based on the attribute values of the identified dark patterns;

- Asymmetric - impose unequal burdens on the choices available to the user. The choices that benefit the service are feature prominently while the options that benefit the user are typically tucked away behind

- Covet - push a user toward selecting certain decisions or outcomes, but hide the influence mechanism from the user

- Deceptive - induce false beliefs in users through affirmative misstatements, misleading statements, or omissions

- Information hiding - obscure or delay the presentation of necessary information to users

- Restrictive – reduce or eliminate the choices presented to users

Thus far, the literature discussed have defined dark patterns and its taxonomy on the basis of UI design. Nevertheless, with the advancement of technology and digitization of the world there can be innovative techniques that can impact user experience with a digital system. (Greenberg et al., 2014) brought a new angle to the dark patterns discussion with their research that analyses the dark patterns in proxemic interactions. Proxemic interactions in design has been inspired by Hall's proxemic theory that explains people's understanding and use of interpersonal distances to mediate their social interactions with others (Hall, 1966). In proxemic interactions, the intent is to design systems that will let people exploit a similar 'social' understanding of their proxemic relations with their nearby digital devices to facilitate more seamless and natural interactions (Greenberg et al., 2011). Given below are some of the dark patterns identified in (Greenberg et al., 2014) that exploits proxemic interactions of the user;

- The Captive Audience - The person enters a particular area to pursue an activity that takes a given time, and that does not involve the system. The system senses the person at that location, and begins an unsolicited (and potentially undesired) action based on the fact that the person is now captive.

- The Attention Grabber - The person happens to pass by the field of view of a strategically located system. The system takes deliberate action to attract and keep that person's attention.

- Disguised Data Collection - Information gathered to provide a certain service is abused to build a rich user profile, without the consent of users.
- The Social Network of Proxemic Contacts - The system tracks your proxemic relations with others and constructs a social network on the assumption that you are somehow socially related, when there is no relationship

By analysing the existing key definitions and concepts of dark patterns literature, the research "What makes a dark pattern… Dark" (Mathur et al., 2021) has proposed a conceptual foundation based on the normative perspectives derived from the scholarships of psychology, economics, ethics, philosophy and law. The study had performed an in-depth comparison among the dark pattern definitions, types and attributes from prior work, in order to summarise and propose a broader set of categorisations. The many definitions for dark patterns in UI/UX design from literature which are derived from a descriptive perspective have been taken under four facets, which are;

- Characteristics of the user interface – Coercive, Obnoxious, Malicious, Trickery
- Mechanisms of effects on user – Manipulate user, Exploit user, Confuse user, Attack user
- Role of user interface designer – Abuser of designer knowledge, Designer intent
- Benefits and harms – Benefit to service, Harm to user

Additionally, the attributes aspect of dark patterns is separately considered in (Mathur et al., 2021) to propose another summarization of dark pattern interfaces based on how they modify the user's choice architecture.

- Modifying the decision space – Asymmetric, Restrictive, Covert, Disparate treatment
- Manipulating the information flow - Deceptive, Information hiding

Taking a step further from defining dark patterns based on its attributes, (Mathur et al., 2021) have explored why the HCI researchers, practitioners and users be concerned about dark patterns, and have suggested four normative considerations to define a dark pattern.

- Individual welfare – a dark pattern is any interface that modifies the choice architecture to benefit the designer at the expense of the user's welfare

- Collective welfare - a dark pattern is any interface that modifies the choice architecture to benefit the designer at the expense of collective welfare
- Regulatory Objectives - a dark pattern is any interface that modifies the choice architecture to interfere with or undermine specific regulatory objectives
- Individual Autonomy - a dark pattern is a user interface that undermines individual decision-making

When thoroughly analysing the prior work related to dark patterns in interface design, it is clear that although there are different definitions, researchers have a common agreement that dark patterns are intentional designs to evoke a given behavior from the user ((Zagal et al., 2013), (Gray et al., 2020), (Mathur et al., 2021)). Therefore, it would be important to have at least a general understanding on the basic psychological principles underlying when manipulating a user or rather a consumer with regards to this research.

With the introduction of immersive technologies and those becoming popular among the general public, the dark patterns research avenue has further expanded. (Wang et al., 2023) have identified dark patterns in AR that can be used to manipulated the users in future when AR applications become mainstream. The discussion around dark side of augmented reality is what inspired to conduct this research, "Impact of manipulative design patterns in Augmented Reality on consumer buying behaviours. Below are the four main themes of dark patterns identified by (Wang et al., 2023);

- Obstruction-forced actions - where the user is forced to execute a particular action. For example, window pop ups which would guide the user to behave in a particular way.
- Interface interference - where the interface is designed in a way to trick the user to agree for something without much attention to it. For example, consent for cookies or a highlighted agree button.
- Safety - by the nature of AR applications, they are pervasive, mobile and realistic which results in introducing safety risks for the user.
- Associative dark patterns - where emotions are exploited to influence a user's purchase decisions

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2.1.1 Summary of dark patterns in UI/UX and interactive design

Research	Dark pattern theme	Identified dark patterns
Deceptive Patterns (Brignull, n.d.)	Carefully crafted interfaces to trick users	Bait and switch Forced continuity Disguised ad Friend spam Hidden costs Misdirection Price comparison prevention Privacy Zuckering Roach Motel Sneak into Basket Trick questions
Malicious interface design: exploiting the user (Conti and Sobiesk, 2010)	Ill-intended interfaces that do not follow the best practices of design	Coercion Confusion Distraction Exploiting Errors Forced Work Interruption Manipulating Navigation Obfuscation Restricting Functionality Shock Trick
The dark (patterns) side of UX design (Gray et al., 2018)	Unethically twisting the original purpose of persuasive design techniques	Nagging Obstruction Sneaking Interface interference Forced action
Dark Patterns at Scale: Findings from a Crawl of 11K Shopping Websites (Mathur et al., 2019)	Categorising dark patterns based on attribute values	Asymmetric Covet Deceptive Information hiding Restrictive
Dark patterns in proxemic interactions: a critical perspective (Greenberg et al., 2014)	Exploiting proxemic interactions	The Captive Audience The Attention Grabber Disguised Data The Social Network of Proxemic Contacts

What makes a dark pattern… Dark (Mathur et al., 2021)	Categorising the existing key definitions derived from a descriptive perspective	Characteristics of the user interface Mechanisms of effects on user Role of user interface designer Benefits and harms
	Modifications to the user's choice architecture	Modifying the decision space Manipulating the information flow
	Normative considerations	Individual welfare Collective welfare Regulatory Objectives Individual Autonomy
The Dark Side of Augmented Reality: Exploring Manipulative Designs in AR (Wang et al., 2023)	Dark patterns in AR	Obstruction-forced actions Interface interference Safety Associative dark patterns

Table 1: Summary of dark patterns

2.2 VR/AR/XR in marketing and advertising

Before diving in to the ever-evolving world of digital marketing and advertising, it would be important to have a general understanding on marketing and advertising is. In the conventional sales and marketing platforms, there are primarily two broad approaches to influence consumer buying behaviours which are persuasion and manipulation (Beauchamp and Public Interest Enterprises, Inc., 1984). Persuasion is when an advertisement provides information about a certain product in a manner that guides the consumer to make a rationale buying decision. Hence, utilizing persuasion in marketing strategies is considered to be acceptable. However, an advertisement that directs a consumer to purchase a product involuntarily or against their best interest is identified as manipulative marketing and is ethically problematic. (Danciu, 2014), states that advertisements can have features that are informative, persuasive and manipulative. Informative features are factual features of the product while persuasive features are logical arguments whereas manipulative features are those that encourage customers to buy a product but without having any logical reasoning.

Although AR and other immersive technologies are still not the most popular advertising and marketing channel, exponential growth is expected in the near future. From the user perspective, AR is entertaining while from the marketer's perspective, the novelty of AR alone has the potential to increase brand awareness. AR delivers an engaged audience to marketers. Consumers choose to trigger an AR experience, versus passive forms of traditional advertising which don't generate active audience engagement. (Feng and Mueller, 2019). Moreover, when compared to traditional means of marketing and advertising, consumers' find AR campaigns playful, convenient, time saving (Yaoyuneyong et al., 2016). The immersive, persuasive and realistic nature of AR applications provide the potential consumers' the opportunity to experience the product at their own intimate space for example home, improving customer-brand relationship (Scholz and Duffy, 2018).

Even by today, there are many renown companies that have entered the landscape of VR/AR marketing and advertising. (Scholz and Smith, 2016) has described four AR marketing paradigms based on the devices that are involved with the marketing applications.

- Active print/packaging - a smartphone, tablet or computer camera to scan AR-equipped printed material (such as a print ad, product packaging, or a catalogue) in order to access digital content triggered on their mobile device or computer screen.
- Bogus window – users' view is augmented using a device such as a digital screen which may be disguised
- Geo-Layer - space around the user is augmented with digital objects that may or may not be linked to specific geolocations
- Magic mirror - enables consumers to interact with virtual objects and to see themselves as part of the augmentation either through the AR mobile app or AR equipped screen

The human senses play an important role in how a person experience a product be it physically or virtually. The multisensory technologies that are already provided through AR such as visual and audio, and are anticipated features such as haptic interfaces will aid businesses in their marketing and advertising (Evanschitzky et al., 2020). Additionally, (Petit et al., 2019) has

proposed that multisensory technology would be beneficial to consumers' as it provides means to evaluate products and services.

The prodigious potential and the interest in business world to invest in immersive technologies for their marketing and advertising campaigns, researchers have become keen to explore the customer manipulation techniques that can unleashed in AR/VR/XR platforms. The research conducted by (Mhaidli and Schaub, 2021) has explored the existing AR, VR and XR technologies along with predictions for future developments in those technologies to identify possible future marketing and advertising scenarios that the world may have to experience. They state that "new forms of XR advertising could pave the way for new types of manipulative advertising, tricking consumers into buying products they do not want or need, potentially convincing consumers to buy products that are actively detrimental to their health and well-being". Accordingly, below are the identified characteristics of immersive technologies, which can be used to design manipulative AR applications to influence consumers.

- Greater immersivity - feeling as though you are in the ad
- Extreme realism - hard to tell advert from reality
- Previewing products - try products before buying them
- Hyper-personalization - an ad made just for you
- Pervasive advertising - ads are everywhere

(Mhaidli and Schaub, 2021) had further identified five key mechanisms of manipulative advertising in XR, which are enabled through the above identified characteristics of XR. The mechanisms of manipulative advertising are as below;

- Misleading experience marketing
- Inducing artificial emotions in consumers
- Sensing and targeting people when they are vulnerable
- Emotional manipulation through hyper-personalization
- Distortion of reality

2.3 Psychology, cognitive biases and consumer behaviour

Even though, there had been a debate among scholars and commentators, whether individuals have the ability to make rational disclosure decisions online, many researchers had debunked the rational disclosure based arguments supporting the idea that individuals make rational disclosure decisions (Waldman, 2020). It is stated that, dark patterns used in online platforms makes rational decision making difficult to the user due to the cognitive biases, increasing the economic harm (Calo, 2013). With the availability of sophisticated technology, the vulnerabilities of a target individual or group can be amplified in order to steer them to make decisions that do not result in their best interest but the digital system, while falsely believing that they are being rational.

Recent research in the psychology field have identified many cognitive and behavioural barriers to rational decision making of an individual (Acquisti et al., 2015), out of which the most pervasive and relevant ones to the digital world is discussed by (Waldman, 2020) ;

- Anchoring - disproportionate reliance on the information first available when we make decisions
- Framing - the way in which an opportunity is presented to consumers, either as a good thing or a bad thing
- Hyperbolic discounting - the tendency to overweight the immediate consequences of a decision and to underweight those that will occur in the future, makes it difficult for consumers to make rational disclosure decisions.
- Over-choice - the problem of having too many choices, which can overwhelm and paralyze consumers

In addition to these, (Waldman, 2018), had shed light on the construct of "trust" when using online and digital platforms which he argues as a powerful attribute that impacts a user's willingness to share information. "Trust, a resource of social capital between or among two or more parties concerning the expectation that others will behave according to accepted norms, is a powerful predictor of a willingness to share personal information online".

The research carried out by (Grigorovici and Constantin, 2004) had analysed the cognitive load aspect of interactive environments. Cognitive load is associated with the amount of information or tasks an individual is handling at a given time. The researchers have claimed that increased cognitive load of being in an immersive and interactive environment (having to respond to and interact with an ad, perhaps engage in tasks as part of the ad) means that fewer cognitive resources can be spent critically evaluating the ad's message and enacting resistance strategies to counter the ad's message.

An aspect in psychology that directly affects consumer behaviour is the consciousness of the individual, since it is an important attribute in decision making. In the traditional offline environment, sensory inputs such as sight, touch, smell etc. contributes to consciousness of a person. In the world of XR, although still limited in capabilities, Sensory Enabling Technologies (SETs) are now providing mid-air haptics and smell interfaces which marketers can use to stimulate consumer's senses which will influence consumer consciousness thus leading to impacting consumer behaviour (Petit et al., 2022).

The report provided by EU Consumer Programme (Lupiáñez-Villanueva et al., 2022) has evaluated in detail how dark patterns affect the consumer behaviours. The report had established that dark patterns are hidden and subtle therefore difficult spot and thus average consumers' lack awareness about the existence of dark patterns. It further revealed that exposure to dark patterns lead to consumer's making inconsistent decisions, corroborating to the fact that consumers could be manipulated through UX design. Moreover, the experiments done for the study has established that the vulnerability and education level of the consumers affect the ability to make consistent choices when exposed to dark patterns. However, it has also been recognized that even though some participants in a study were able to identify dark patterns in interface design and the likelihood of manipulation through those patterns, they were unable to resist the impulse to purchase that particular item (Bongard-Blanchy et al., 2021).

2.4 Human-food interaction

Since the research aims to evaluate the impact of manipulative design patterns on consumer behaviours via the food industry, it is important to have insights to not only the food industry and its existing approaches to incorporate AR, but also how the human mind works with regards to consuming food.

In the research (Velasco et al., 2018), the researches elaborate on the idea that flavour is a multisensory construct that involves taste, or gustation, olfaction etc., and thereby, all the sense can influence a person's food experience. Flavour augmentation can be impacted through core intrinsic elements such as taste, smell, touch etc., or extrinsic elements such as colour, shape, atmospheric sound etc., all of which influence the overall experience with flavour (Prescott, 2015). The researchers (Velasco et al., 2018) have put forward the argument that meaningful collaboration of multisensory science and digital technology would be capable of augmenting flavour perceptions, hence resulting in impacting food consumption. They have suggested four methods to impact flavour perception and augmentation which are;

- Visual augmentation
- Auditory augmentation
- Tactile/Haptic augmentation
- Multiple extrinsic elements for flavour augmentation

Additionally, (Petit et al., 2017) states that visualizing attractive food has a tendency to trigger previous positive encounters with such food items and this may simulate scenarios of eating the particular food, which could result in the purchase of this food item. It has been established decades back that pervasive visual exposure to food increase consumers' desire to eat both among children and adults (Borzekowski and Robinson, 2001). Thereby, out of all the sensory channels, the vision is the sense that provides the most effective means of foraging and predicting which foods are safe and nutritious to consume (Spence et al., 2016).

Although, the existing multisensory technologies may not have capabilities to implement augmentation for all the categories identified above, it could give researchers of various fields, inspiration to undertake research that could develop technology to support such augmentations.

2.5 Research gap

The comprehensive literature review conducted helped to extracted knowledge and insights on key academic disciplines that are relevant for the research, "Impact of manipulative design patterns in Augmented Reality on consumer buying behaviours". The knowledge gathered from this literature survey would have significant contributions to identifying manipulative design patterns in AR that can affect consumer decision making related to food industry.

Furthermore, through the analysis of relevant interdisciplinary literature, it was identified that although work has been commenced to recognize the role of AR, MR and XR in the business world and to identify dark design patterns in AR, those are still in preliminary stages with ample opportunities for further studies. Moreover, the previous researches have been conducted to understand the possible relationship between AR and marketing/advertising, it has been done mainly via scenario construction(Mhaidli and Schaub, 2021), (Wang et al., 2023). Conducting a research on how design patterns in AR can be used to manipulative marketing/advertising through the use of an experimental AR prototype is a novel idea.

The evolving capabilities of AR and related technologies offers a landscape for marketers to exploit and manipulated consumers in subtler yet advanced manner which was not seen in mainstream traditional and digital marketing strategies. Therefore, this research would have the potential to identify and predict how our decision making can be influenced through the use of not only AR but also through more advanced concepts like XR and would also provide a basis to conduct future researches in AR, VR and XR domains.

CHAPTER 3

METHODOLOGY

This research, as discussed in detail in the previous chapter, is stretched through multiple academic domains and research disciplines. Therefore, the research methodology has to be conscientiously chosen and designed in order to successfully integrate the study among these domains. This chapter provides a comprehensive outline of how the research "Impact of Augmented Reality in consumer buying behaviours" would be conducted.

3.1 Research Philosophy

The research would be carried out with the aim of attaining a comprehensive and holistic understanding on how dark design patterns can impact the decision-making process of a consumer. The complex and dynamic nature of the multiple domains involved in this research, such as AR, human cognition, human behavior demands a practical and a flexible approach. Therefore, pragmatism research philosophy is chosen as the most suitable philosophy to base the beliefs, assumptions and principals when proceeding with this research. Pragmatism would integrate both quantitative and qualitative research methods thus contributing to a flexible approach.

Furthermore, synthesising both quantitative and qualitative types of data would support investigating the topic from different standpoints which would be essential to properly analyse the complexities in human interactions with AR technology. The pragmatist philosophy is therefore in line with the cross-disciplinary nature of this research that encompasses facets of technology, psychology, design and consumer behaviour. Hence adapting pragmatism would provide practical insights that can be used to design the AR prototype.

3.2 Research Design

In order to achieve the objectives of the research which is to identify dark/manipulative design patterns that can be incorporated to AR mobile applications for the food and beverage industry and to evaluate their effectiveness on consumers, the research should be designed in a manner that could capture both qualitative and quantitative aspects of the variables available. A thorough review of existing literature related to dark design patterns in traditional digital systems and immersive systems is a necessity in this study, since the preliminary step is to identifying applicable dark design patterns. Thereby the research has been started with a qualitative study and then would be followed by a combination of quantitative and qualitative studies to measure the impact of the identified dark patterns. Therefore, the mixed-method design approach was selected as it would allow a comprehensive understanding of user experience and perceptions while granting the collection and analysis of numerical data to evaluate the effectiveness.

In this research, the mixed-method research design would be supplemented with experimental design approach since the adaptation of experimental approach would provide systematic procedures to assess the effectiveness of the identified dark patterns. A study group of appropriate size would be decided and within subject design, where a participant is exposed to all of the experimental designs, thus, would evaluate all the implemented dark design patterns. The diagram in figure 4 depicts the within subject research design.
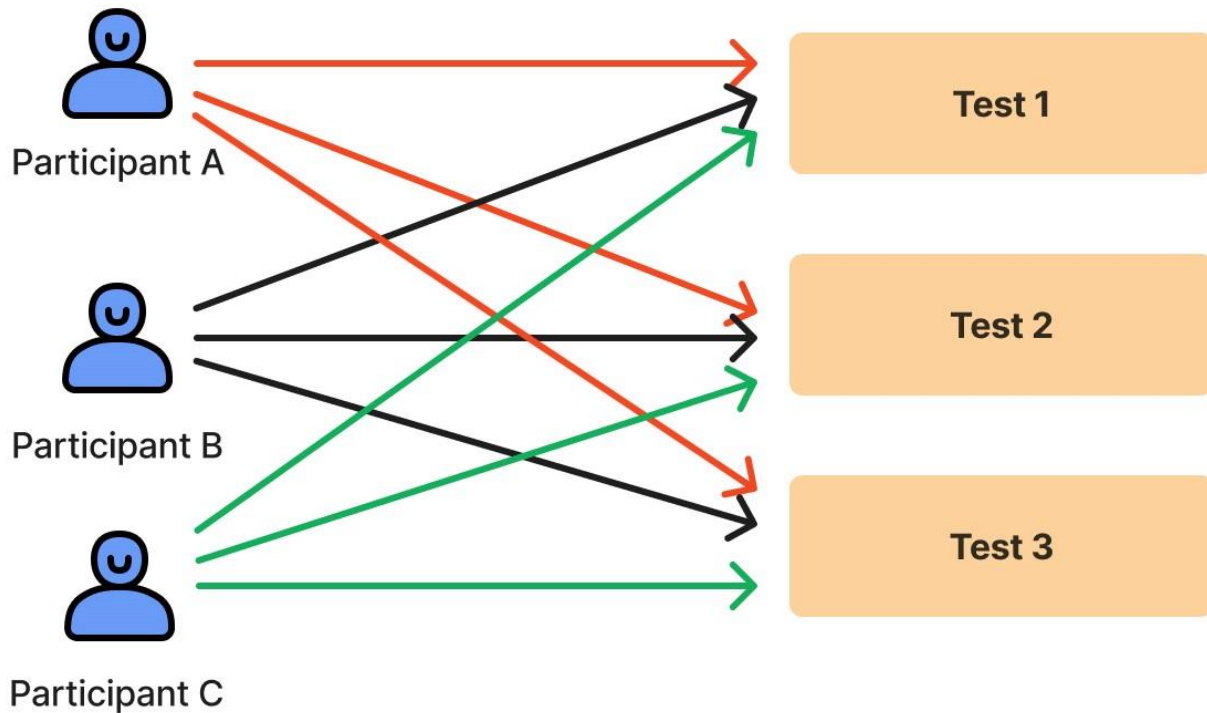
Figure 4: Within Subject Design

3.3 Proposed Solution Design and Implementation Details

3.3.1 Proposed Solution Design

The impact of dark/manipulative design patterns in AR on consumer behaviour would be examined via implementing a prototype mobile application that displays a menu containing food and beverages. This mobile application would be a simple prototype that allows the user to view the selected menu item, to which the AR capabilities along with the identified dark patterns would be applied. However, it should be noted that this prototype is developed with sole purpose of evaluating how dark patterns in AR would impact a consumer's decision making. Therefore, the mobile application would only provide a limited set of menu items to select from, which would be a minimum of 3 items. Furthermore, the prototype would have the functional capabilities to view the selected menu item and to indicate the willingness to purchase it. Since the objective of this research is to explore how manipulative design in AR impacts consumer buying behaviours, the prototype would not be connected to a backend server, hence the

tester/consumer would not be able to place an actual order. It should also be noted that, although the prototype mobile application has limited functionalities, it would be encompassing the adequate level of functionality to act as the central component of the experiment, providing a tangible interface for participants to engage with, thus enabling the collection of empirical evidence.

Following the thorough analysis and careful consideration of the dark design patterns and themes identified in existing literature, three broad dark patterns were identified to be used in the experimental phase of this research. These identified patterns listed below are discussed in detail with regards to their suitability in a mobile application for a food menu.

1. Sneaking or Information hiding
2. Interface interference
3. Associative dark patterns

Sneaking or Information hiding

In the research "The Dark (Patterns) Side of UX Design" (Gray et al., 2018), "sneaking" is defined as an attempt to hide or disguise information that is relevant to the users, while Mathur et al., 2019, identifies obscure or delay the presentation of necessary information to users as "Information hiding". Both these terms loosely describe the same dark pattern which is found in traditional digital systems that could also be used as a manipulative design in AR based mobile application.

In the context of a food menu, ingredients of a particular food item are a useful information to the user/consumer when making their purchase decision. With the current trends that promotes healthy life style, nutritious and healthy diets, consumers may be prefer to buy food that are healthy and nutritious. A manipulative design pattern could exploit this preference of a consumer, by hiding the ingredients that are not necessarily healthy and highlighting the ingredients that are healthy. It may be an instance where the food item contains few healthy ingredients while the main ingredients are unhealthy. In the AR mobile menu app, this food item can be implied as healthy and nutritious by designing the interface in a manner that highlights the healthy ingredients and minimizing the attention to unhealthy ingredients.

Interface Interference

This is another dark pattern identified by Gray et al., 2018 which was expanded to sub categories, aesthetic manipulation and toying with emotions. According to the definition in "The Dark (Patterns) Side of UX Design", interface interference is manipulation of the user interface that privileges certain actions over others. In order to privilege or promote a certain action, the interface could use its aesthetic appeal through colour, style etc. or influence the user's emotions.

As stated by Borzekowski and Robinson, 2001, visual representation of food has the biggest impact on a person's desire to consume food, hence, interface interference exhibit substantial potential to be used in this research. When applying the dark pattern to an AR based mobile application food menu, the manipulation would happen through the use of colours, styles etc. For example, when viewing the food item through augmented reality, the colours of the food item may be enhanced to trigger the consumer's hunger. The AR version of the food could also be different to the actual food and the AR version may be more appealing to the consumer. Thereby, the model displayed in the AR mobile application would incorporate interface interference designs to manipulate the consumer.

Associative Dark Patterns

Associative dark patterns were added to the dark design patterns terminology through the research "The Dark Side of Augmented Reality: Exploring Manipulative Designs in AR" (Wang et al., 2023). They described this dark pattern not as directly manipulating the user interface but rather exploiting emotions of a user to influence her purchase decisions. Emotional manipulation could be achieved through sensory input manipulation and even though, an immersive technology like AR is assumed to implement smell interfaces etc. in the future (Petit et al., 2022), in the current technology landscape such advance sensory technologies cannot be used in this research. The only possible sensory input that can be exploited for manipulation of emotions for this research is the auditory input.

Since flavour was established as a multi-sensory construct (Velasco et al., 2018) and it has been stated that flavour could be enhanced through auditory augmentation (Prescott, 2015), through

the incorporation of auditory input, an associative dark pattern could be designed for the AR based mobile food menu application. In this context, manipulation would be done by embedding sounds that are connected to the food item selected by the consumer. For example, if the tester/consumer selected a crispy food item, a crunchy sound would be played in the background when that item is viewed, or sounds and music could be played to create an impression of certain background to the tester/consumer with the aim of emotionally manipulating the him/her.

Subsequent to the identification of dark/manipulative design patterns in AR, attention would be given to designing the suitable "food menu" mobile application prototype. As stated in the beginning of the chapter, the prototype would be providing minimum adequate functionalities required to perform the analysis on identified dark design patterns. The main menu interface would be a simple mobile interface that displays the available three food items, on which the tester could click and load the individual food item interface. Figure 5 depicts a sample design for the main menu interface of the prototype application.
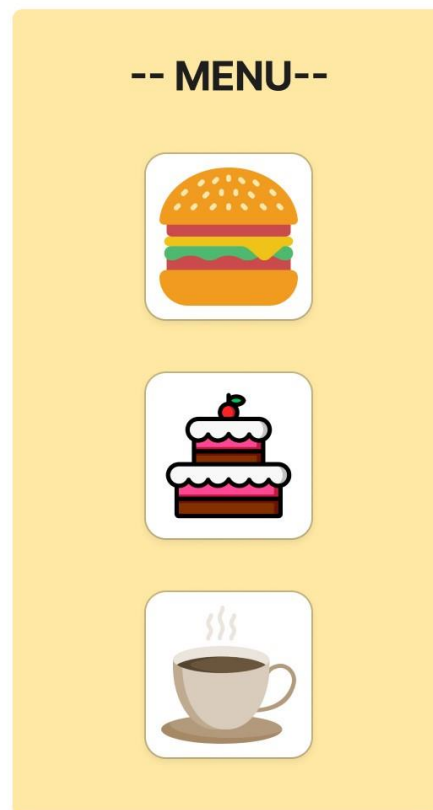
Figure 5: Main menu interface sample design

The second interface or the food item interface would be the one which incorporates one of the following dark design patterns, sneaking/information hiding, interface interference or associative dark patterns. Thereby, each food item interface would be presenting a different experimental scenario out of the three scenarios. Additionally, each food item interface would facilitate an option to go back to main menu interface and an option to indicate whether the consumer is interested to purchase the food item.

3.3.2 Implementation Details

To develop the proposed mobile application prototype below mentioned platforms, libraries, languages and software would be used.

Unity

To implement the prototype AR mobile application several Integrated Development Environments (IDE), game engines and software development kits were considered, which are namely; Android studio, Unity, Vuforia and Flutter. Out of these Unity was selected as the most suitable software to use due to its popularity as programming environment for AR, its versatility as AR platform, the available community support. Selecting the best available AR development environment is essential to the

Although separate plugins are needed to develop for apple Devices (IOS) and Android Devices, the code is almost the same with minimum changes to project settings which are easy to configure.

Unity's AR foundation package that includes the XR camera, AR session, simulation environment etc. is the main package used for the prototype development.

Apple ARKit XR Plugin

This is the plugin used to support mobile application development for apple devices.

C# and Visual Studio

C# is a powerful, Object Oriented Programming language that is used along with Unity in order to script the movement, positioning etc. of the AR objects. The IDE used to code in C# is visual studio.

xCode

This software is used because the prototype mobile app is developed for IOS devices using a windows laptop and therefore the executable on the mobile device has to be created from xCode.

Paint 3D

Paint 3D is a software provided by Microsoft which is used to create 3D objects that are used in the prototype mobile application.

3.4 Evaluation Method

This section outlines the systematic approach that would be undertaken in the research to collect data, analyse the collected data, evaluate generated information and form conclusions based on the evaluation, under the subsections recruiting participants, experimental design, data collection, Data analysis and evaluation.

Recruiting participants

The experimental stage of the research would start with selecting suitable participants for the study. Conventionally, the study group should comprise of participants from a wide range of demographics with different levels of education backgrounds. However, since this research is using only a mobile application prototype with minimum required functionalities to assess the impact of dark design patterns on consumer buying behaviours, recruiting participants from diverse backgrounds would not be ideal. The selected participants should have some experience with immersive technologies such as VR/AR and should have a clear understanding of the difference between a prototype application and a real-world application, in order for them to actively participate in this experiment and to provide meaningful insights and feedback.

Therefore, participants recruited for this study would be in the age category between 20-45 with a higher education background. Since there are three dark patterns to be tested with in a limited time allocation, the participant count would be maintained below 30.

Experimental Design

Since the research is adapting within subject design to evaluate the dark patterns implemented, the selected participants for the study would be testing all three identified dark design patterns, hence providing feedback on all three dark patterns. Although, the research is to explore the impacts of dark patterns in AR UI/UX design, it would be of assistance to the participants in the evaluation process to have some sort of a point of reference to compare the AR prototype with. Therefore, in order to critically evaluate the impact of AR on consumer buying behaviours, for each dark pattern incorporated food item interface, there would be a corresponding traditional mobile application interface provided.

The traditional prototype would have the same main menu interface, nevertheless instead of displaying AR objects, the food item interface would display a 2D image of the food item with a small description. Thus, the experiment would include two prototypes, where each prototype includes three scenarios for the tester/consumer to explore. The traditional mobile application prototype would be called "Prototype 01" and the AR features embedded mobile application prototype would be called "Prototype 02", while the food item interface of prototype 01 would be the "control interface" and the food item interface of the prototype 02 would be the "experimental interface". The diagram in figure 5 depicts this structure of the experimental design.
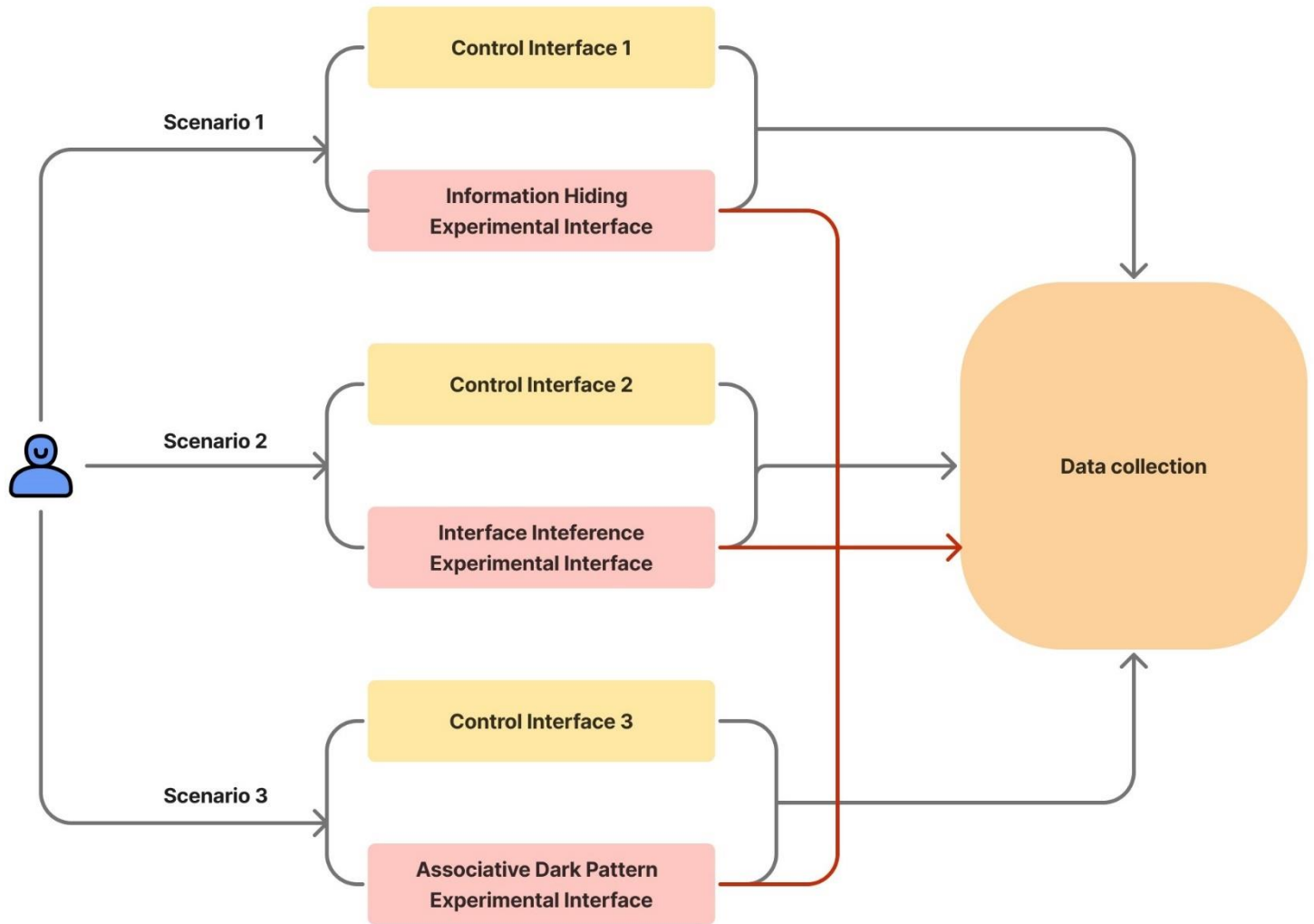
Figure 6: Experimental Design Structure

Data Collection

The research would enter the data collection stage when the participants are testing the prototype and it would continue until they have provided feedback and insights. Therefore, the experiment would collect both qualitative and quantitative data through observations and post-interaction interviews and questionnaires. Designing a befitting questionnaire which could capture the most important insights and feedback would be crucial in order to measure the experimental interface's effectiveness in impacting the buying behaviour. Therefore, other than recording general data such as age, gender the questionnaire should focus on aspects such as which prototype was more engaging with the tester, which was better at visualizing the food

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item, which encouraged the participant to make the purchase decision quickly, whether the participant identified any dark patterns in the experiment interface, and whether awareness of any manipulation techniques impact the decision to purchase the food item etc.

Data Analysis

Since the research would be collecting both qualitative and quantitative data, the data should be analysed by applying both thematic analysis and statistical analysis techniques. Statistical tests such as correlation would be applied on the quantitative data gathered while thematic analysis techniques such as familiarization, coding, theme generation would be applied on qualitative data.

Evaluation

This would be the final stage of the research where the collected and analysed data would be thoroughly evaluated in order to provide comprehensive and practical insights to the research question and the effectiveness of dark/manipulative design patterns in AR on consumer buying behaviour would be determined.

CHAPTER 4

RESULTS AND EVALUATION

This chapter presents the results obtained from the participants who took part in testing the food menu mobile prototypes and systematically evaluates the results using statistical and thematic analysis techniques. The participants have provided quantitative and qualitative feedback, through the meticulously designed questionnaire that captured participants feedback and insights on three broader aspects associated with the research which are;

- General perception of the prototypes
- Awareness of the existence of manipulative designs in AR
- Effectiveness of the design patterns used

The three different scenarios of the prototype applications where each scenario has implemented one of the identified dark/manipulative design patterns, are evaluated as illustrated by figure 5. Firstly, each experimental interface (Prototype 02) is evaluated with the control interface (Prototype 01) separately and then the all three dark design pattern scenarios or the AR interfaces are compared together with the expectation of recognizing which dark patterns would be more effective.

4.1 Overview of participants

The research's prototypes were tested by a total of 25 participants between the ages 20 -50, in which 52% were female and 48% were male. 96% of the total participants stated that they are familiar with the concept of a prototype in the context of software development and have used a mobile application to purchase food before, although, only a 60% of the total population have had some experience with AR prior to participating in this research. Thereby, the above data, indicate that the selected participants have necessary experiences and exposure to explore and evaluate the prototypes designed for this research.

4.2 Quantitative Analysis

4.2.1 Descriptive Statistics

A descriptive analysis would be useful in summarising and characterising the data gathered. Thereby, the frequency distribution would be calculated for selected variables.

For each scenario the frequencies of the below variables are calculated and displayed in a tabular format.

- Variable 1: Which prototype did you find more engaging? (Engagement)
- Variable 2: Which prototype help you to visualise the food item better? (Visualisation)
- Variable 3: Which Prototype encourage you to make a purchase decision quickly? (Encouragement)
- Variable 4: How likely you are to purchase from prototype 01? (Prototype 01 Likelihood)
- Variable 5: How likely you are to purchase from prototype 02? (Prototype 02 Likelihood)
- Variable 6: Was prototype 02 more effective in persuading you to make a purchase decision compared to prototype 01? (Effectiveness)

For better representation of data, the results of the variables that can be shown in the same table without out any complications, would be presented as such, which would result in three separate tables per scenario. The first table would present the frequency distribution results of variable1, variable 2 and variable 3 while results of variable 4 and variable 5 would be displayed in the second table and the results of variable 6 would be displayed in a separate third table.

Scenario 1: Sneaking or Information hiding

	Prototype 01	Prototype 02
Which prototype did you find more engaging?	8	17
Which prototype help you to visualize the food item better?	3	22
Which Prototype encourage you to make a purchase decision quickly?	9	16

Table 2: Frequency distribution of Variable 1, Variable 2 and Variable 3 of scenario 1

	1	2	3	4	5
How likely you are to purchase from prototype 01?	0	7	8	6	4
How likely you are to purchase from prototype 02?	0	0	3	14	8

Table 3: Frequency distribution of Variable 4 and Variable 5 of scenario 1

	Yes	No
Was prototype 02 more effective in persuading you to make a purchase decision compared to prototype 01?	19	6

Table 4: Frequency distribution of Variable 6 of scenario 1

Scenario 2: Interface Interference

	Prototype 01	Prototype 02
Which prototype did you find more engaging?	2	23
Which prototype help you to visualize the food item better?	1	24
Which Prototype encourage you to make a purchase decision quickly?	4	21

Table 5: Frequency distribution of Variable 1, Variable 2 and Variable 3 of scenario 2

	1	2	3	4	5
How likely you are to purchase from prototype 01?	1	7	12	2	2
How likely you are to purchase from prototype 02?	0	0	3	11	11

Table 6: Frequency distribution of Variable 4 and Variable 5 of scenario 2

	Yes	No
Was prototype 02 more effective in persuading you to make a purchase decision compared to prototype 01?	23	2

Table 7: Frequency distribution of Variable 6 of scenario 2

Scenario 3: Associative Dark Patterns

	Prototype 01	Prototype 02
Which prototype did you find more engaging?	6	19
Which prototype help you to visualize the food item better?	7	18

Table 8: Frequency distribution of Variable 1, Variable 2 and Variable 3 of scenario 3

	1	2	3	4	5
How likely you are to purchase from prototype 01?	1	3	11	8	2
How likely you are to purchase from prototype 02?	0	0	4	13	8

Table 9: Frequency distribution of Variable 4 and Variable 5 of scenario 3

	Yes	No
Was prototype 02 more effective in persuading you to make a purchase decision compared to prototype 01?	17	8

Table 10: Frequency distribution of Variable 6 of scenario 3

AR prototype comparison

The frequency distribution should be done for the variables in the AR prototype comparison section similar to the above calculations. Since this section doesn't include multiple variables that have same output values, their frequencies have to be displayed in separate tables.

	Scenario 1	Scenario 2	Scenario 3
Which AR scenario prototype was your favourite?	9	13	3

Table 11: Frequency distribution of favourite AR prototype

	1	2	3	4	5
How much extra effort did you have to put to use the AR prototype?	4	6	7	7	1

Table 12: Frequency distribution of extra effort needed for AR prototypes

	Yes	No
Do you think the effort you put for an AR prototype is worth it?	24	1

Table 13: Frequency distribution of worthiness of effort

4.2.2 Inferential Statistics

The data gathered from the post experiment questionnaire, have to be analysed using inferential statistics tests in order to extract conclusions and predictions based on the data. This section would focus on performing Chi-square (X^2) test of independence on selected variables of the data set. As the questionnaire gathered categorical data, Chi-square test of independence is the most suitable statistical test available to determine the association between two categorical variables of the research's dataset. For each of the three dark pattern scenarios, Chi-square value of the effectiveness of AR prototype was calculated against engagement, visualisation and

encouragement with the objective of determining the association between two variables. The Chi-square test of independence was performed using IBM's SPSS[5] software where the significance level (p) is set to 0.05.

Scenario 1: Sneaking or Information hiding

Engagement vs Effectiveness

- Null hypothesis - There is no association between engagement and effectiveness
- Alternative hypothesis - There is an association between engagement and effectiveness

The Chi-square test of independence 0.001 is less than the significance level 0.05. Therefore, the test indicates that there is a significant association between engagement and effectiveness in scenario 1, hence the alternative hypothesis is true.

S1_Engagement * S1_Effectiveness

Crosstab

Count

| | | S1_Effectiveness | | |
		No	Yes	Total
S1_Engagement	Prototype 01	6	2	8
	Prototype 02	0	17	17
Total		6	19	25

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	16.776[a]	1	<.001		
Continuity Correction[b]	12.916	1	<.001		
Likelihood Ratio	18.557	1	<.001		
Fisher's Exact Test				<.001	<.001
N of Valid Cases	25				

Figure 7: Chi-square engagement vs effectiveness of scenario 1

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[5] https://www.ibm.com/products/spss-statistics

Visualisation vs Effectiveness

- Null hypothesis - There is no association between visualisation and effectiveness
- Alternative hypothesis - There is an association between visualisation and effectiveness

The Chi-square test of independence 0.065 is higher than the significance level 0.05. Therefore, the test indicates that there is no significant association between visualisation and effectiveness in scenario 1, hence null hypothesis is true.

S1_Visualisation * S1_Effectiveness

Crosstab

Count

		S1_Effectiveness		Total
		No	Yes	
S1_Visualisation	Prototype 01	2	1	3
	Prototype 02	4	18	22
Total		6	19	25

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3.402[a]	1	.065		
Continuity Correction[b]	1.263	1	.261		
Likelihood Ratio	2.873	1	.090		
Fisher's Exact Test				.133	.133
N of Valid Cases	25				

Figure 8: Chi-square visualisation vs effectiveness of scenario 1

Encouragement vs Effectiveness

- Null hypothesis - There is no association between encouragement and effectiveness
- Alternative hypothesis - There is an association between encouragement and effectiveness

The Chi-square test of independence 0.001 is less than the significance level 0.05. Therefore, the test indicates that there is a significant association between encouragement and effectiveness in scenario 1, hence alternative hypothesis is true.

S1_Encouragement * S1_Effectiveness

Crosstab

Count

		S1_Effectiveness		
		No	Yes	Total
S1_Encouragement	Prototype 01	6	3	9
	Prototype 02	0	16	16
Total		6	19	25

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	14.035[a]	1	<.001		
Continuity Correction[b]	10.618	1	.001		
Likelihood Ratio	16.097	1	<.001		
Fisher's Exact Test				<.001	<.001
N of Valid Cases	25				

Figure 9: Chi-square encouragement vs effectiveness of scenario 1

Scenario 2: Interface Interference

Engagement vs Effectiveness

- Null hypothesis - There is no association between engagement and effectiveness
- Alternative hypothesis - There is an association between engagement and effectiveness

The Chi-square test of independence 0.022 is less than the significance level 0.05. Therefore, the test indicates that there is a significant association between engagement and effectiveness in scenario 2, hence the alternative hypothesis is true.

S2_Engagement * S2_Effectiveness

Crosstab

Count

		S2_Effectiveness		Total
		No	Yes	
S2_Engagement	Prototype 01	1	1	2
	Prototype 02	1	22	23
Total		2	23	25

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	5.210[a]	1	.022		
Continuity Correction[b]	.854	1	.356		
Likelihood Ratio	2.939	1	.086		
Fisher's Exact Test				.157	.157
N of Valid Cases	25				

Figure 10: Chi-square engagement vs effectiveness of scenario 2

Visualisation vs Effectiveness

- Null hypothesis - There is no association between visualisation and effectiveness
- Alternative hypothesis - There is an association between visualisation and effectiveness

The Chi-square test of independence 0.001 is less than the significance level 0.05. Therefore, the test indicates that there is a significant association between visualisation and effectiveness in scenario 2, hence alternative hypothesis is true.

S2_Visualisation * S2_Effectiveness

Crosstab

Count

		S2_Effectiveness		Total
		No	Yes	
S2_Visualisation	Prototype 01	1	0	1
	Prototype 02	1	23	24
Total		2	23	25

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11.979[a]	1	<.001		
Continuity Correction[b]	2.497	1	.114		
Likelihood Ratio	5.625	1	.018		
Fisher's Exact Test				.080	.080
N of Valid Cases	25				

Figure 11: Chi-square visualisation vs effectiveness of scenario 2

Encouragement vs Effectiveness

- Null hypothesis - There is no association between encouragement and effectiveness
- Alternative hypothesis - There is an association between encouragement and effectiveness

The Chi-square test of independence 0.171 is higher than the significance level 0.05. Therefore, the test indicates that there is no significant association between encouragement and effectiveness in scenario 2, hence null hypothesis is true.

S2_Encouragement * S2_Effectiveness

Crosstab

Count

		S2_Effectiveness		Total
		No	Yes	
S2_Encouragement	Prototype 01	1	3	4
	Prototype 02	1	20	21
Total		2	23	25

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.870[a]	1	.171		
Continuity Correction[b]	.131	1	.717		
Likelihood Ratio	1.399	1	.237		
Fisher's Exact Test				.300	.300
N of Valid Cases	25				

Figure 12: Chi-square encouragement vs effectiveness of scenario 2

Scenario 3: Associative Dark Patterns

Engagement vs Effectiveness

- Null hypothesis - There is no association between engagement and effectiveness
- Alternative hypothesis - There is an association between engagement and effectiveness

The Chi-square test of independence 0.002 is less than the significance level 0.05. Therefore, the test indicates that there is a significant association between engagement and effectiveness in scenario 3, hence the alternative hypothesis is true.

S3_Engagement * S3_Effectiveness

Crosstab

Count

		S3_Effectiveness		Total
		No	Yes	
S3_Engagement	Prototype 01	5	1	6
	Prototype 02	3	16	19
Total		8	17	25

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.560[a]	1	.002		
Continuity Correction[b]	6.708	1	.010		
Likelihood Ratio	9.363	1	.002		
Fisher's Exact Test				.006	.006
N of Valid Cases	25				

Figure 13: Chi-square engagement vs effectiveness of scenario 3

Visualisation vs Effectiveness

- Null hypothesis - There is no association between visualisation and effectiveness
- Alternative hypothesis - There is an association between visualisation and effectiveness

The Chi-square test of independence 0.093 is higher than the significance level 0.05. Therefore, the test indicates that there is no significant association between visualisation and effectiveness in scenario 3, hence null hypothesis is true.

S3_Visualisation * S3_Effectiveness

Crosstab

Count

		S3_Effectiveness		Total
		No	Yes	
S3_Visualisation	Prototype 01	4	3	7
	Prototype 02	4	14	18
Total		8	17	25

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.824[a]	1	.093		
Continuity Correction[b]	1.448	1	.229		
Likelihood Ratio	2.713	1	.100		
Fisher's Exact Test				.156	.116
N of Valid Cases	25				

Figure 14: Chi-square visualisation vs effectiveness of scenario 3

According to the results of the Chi-square tests, all three scenarios or dark patterns have indicated a significant association between variables;

- engagement and effectiveness
- encouragement and effectiveness.

Dark pattern	Engagement vs Effectiveness	Visualisation vs Effectiveness	Encouragement vs Effectiveness
Sneaking/ Information Hiding	Significant association	No significant association	Significant association
Interface Interference	Significant association	Significant association	Significant association
Associative Dark Patterns	Significant association	No significant association	Significant association

Table 14: Chi-Square Test Summary

4.3 Qualitative Analysis

The qualitative data gathered through the post experiment questionnaire had interesting observations and insights, where some of which supported the idea of AR based mobile application for a food menu while some opposed the idea. Prior to performing any analysis on the qualitative data, the comments collected were read more than once to get familiarized with the data set. Then the data set coding was done where, phrases with similar meaning were categorised together.

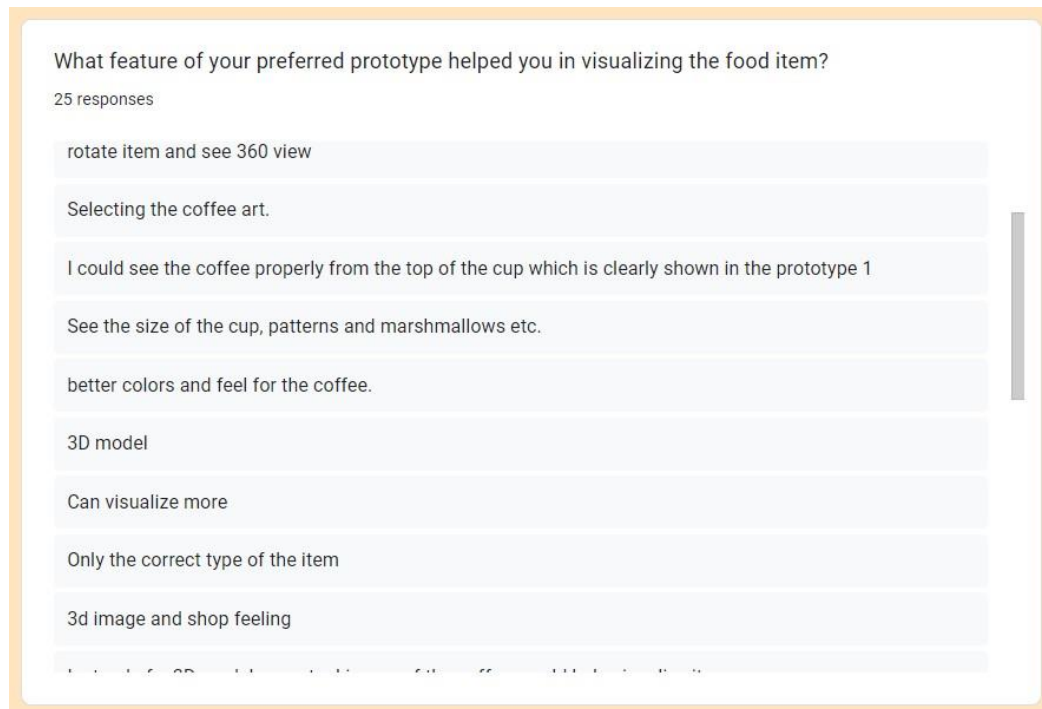| Participant Comment	Code
Ability to have a closer and better look on the product using 360-degree view and zoom in.	360 view
Use of colours	Colours
preview the burger from any angle and highlighted display items to catch the attention	360 view
Colours and 3D visualisation	Colours, 3D model
better realistic visualization of burger	Realistic feeling
eye catching colors	Colours
atmosphere that creates with prototype 2 was more engaging	Realistic feeling
Ability to visualize the cake in 3D	3D model
3D representation helps to visualize	3D model
Ability to see the burger and ingredients in 360 view	360 view
3D model and the background music	3D model
Ability to visualize the cake in 3D	3D model
Interactive interface and eye-catching colors and styles	Colours and style
Ability move around the cake and get the full view with finer details	360 view
better colors and styles	Colours and style
Able to see the details in 360 view	306 view
Accurate feel of a coffee shop given with background noise	Realistic feeling

Table 15: Comments with assigned codes

What feature of your preferred prototype helped you in visualizing the food item?

25 responses

rotate item and see 360 view

Selecting the coffee art.

I could see the coffee properly from the top of the cup which is clearly shown in the prototype 1

See the size of the cup, patterns and marshmallows etc.

better colors and feel for the coffee.

3D model

Can visualize more

Only the correct type of the item

3d image and shop feeling

Figure 15: Comments from questionnaire- 1

Did you notice any limitations/drawbacks in the augmented reality prototypes?

25 responses

For businesses that want customers to focus on the quality of their product and ambiance, adding AR elements might divert attention away from the product itself.

AR elements might divert attention away from the product itself.

Might not work with customers in hurry and who already knows what to buy. Additional steps required to interact with food. Depend on the background, food visual may set different tone.

NA

Think its unlikely to use AR in a food ordering app given due to the effort that needs to be put.

Loading times are longer than non AR pictures

Consumer will be more dissatisfied if the final product varies from the prototype

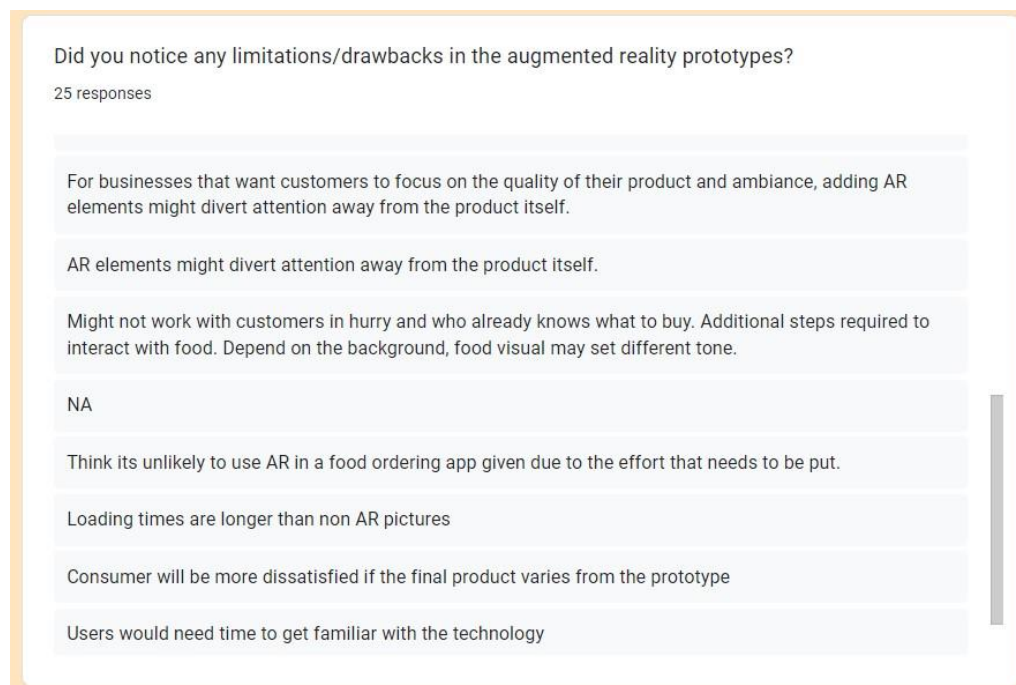Users would need time to get familiar with the technology

Figure 16: Comments from questionnaire- 2

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CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Conclusion

The introduction of pervasive and immersive technologies in to the daily life of people of all age groups happened within a few years and is expected to become more prominent. This expansion of technology captured the attention of the marketers and advertises as it brought a powerful channel to engage with consumers. This research, therefore was conducted to explore the plausible impacts one of the trending immersive technologies, namely Augmented Reality may have on consumer behaviours through its ability to manipulate the consumers.

The research identified three possible dark/manipulative design patterns that could be applied to an augmented reality embedded mobile application for food and beverages industry, by meticulously analysing the existing literature on dark design patterns in UI/UX design. The identified dark design patterns were Sneaking or Information hiding, Interface interference and Associative dark patterns. The effectiveness and impact of these identified dark patterns were then evaluated by developing a mobile application prototype and conducting prototype testing with the participation of 25 testers. The participants were given a post-experiment questionnaire in order to gather feedback and insights on the implemented dark patterns.

The questionnaire gathered both quantitative and qualitative data which were systematically analysed using both statistical and thematic approaches. The quantitative data analysed proved that there is an association between the AR prototype's ability to be engaged with the user, encourage to make a purchase decision quickly with the ability of the AR prototype to effectively persuade the user to buy the product. When analysing the qualitative data, some of the identified main themes were attractive colours, 360 view, realistic feeling, 3D model. Although, there were comments criticising the AR prototype for reasons such as additional time investment, unnecessary complexity of the interface, no participant had mentioned about user manipulation.

In conclusion, it can be stated that dark or manipulative designs in AR could impact consumer buying behaviours through its increased engagement, enhanced visualisation capabilities and encouragement to purchase through psychological manipulation.

5.2 Future work

In this research, prototypes with limited functionalities were used to evaluate the impact of manipulative designs in AR on consumer buying behaviours. If a fully functioning mobile application that embeds dark design patterns was used for the experiment, then the participants might have been able to evaluate the AR scenarios better, thus providing more meaningful perspectives. Therefore, developing a fully functional, real world like mobile application and conducting a similar experience could be done in future to gain richer insights.

Additionally, when identifying dark design patterns, their applicability on food and beverage related advertising or marketing tool was a consideration. However, there could be other dark design patterns which can be applied to an AR based application and impact consumer behaviour to a greater extent than the ones identified in this research.

Furthermore, when designing the AR prototype for this research, not much importance was given to popular and effective marketing and advertising methods used in the real world. AR dark patterns incorporated with effective and proven marketing and advertising methods may have significantly higher impact on consumer decision making and thus could be investigated.

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