THE VISUAL LANGUAGE OF VIRTUAL PRODUCT DESIGN: THE SEMIOTICS OF COLOUR AND SHAPE IN SMARTPHONE APP ICONS

by

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Abstract

A product's colour and shape conveys crucial information about what the product is, what it does, and how well it performs (Kumar & Noble, 2016). Product appearance research has focused on physical goods, foodstuffs, and packaging; however, many of the products consumers interact with are not physical in nature, but digital. This thesis presents findings from two studies that analysed how colour and shape in smartphone app icons convey meaning and their impact on smartphone users. The relationship between these visual elements and consumer behaviour was assessed by app downloads instore and smartphone user evaluations of app icons.

Colours tended to play attention-grabbing, aesthetic, and symbolic roles that created visual contrasts and coherence, and served as identifiers for the app's brand, category, and function. Shapes were found to convey more specific information about the app's category, function, and ergonomic value, as they related to objects and structures we recognise in our environment. The figurative and distinctive uses of colours and shapes did not reliably connect with higher download rates. Their limited impact on smartphone users' evaluations suggests that colour and shape may require additional cues to contextualise them in app icon design and make them more meaningful to consumers.

Keywords: *Visual Semiotics, Product Design, Colour, Shape, Consumer Behaviour*

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Contents

List of Figures

List of Tables

List of Abbreviations

§ - Refer to section denoted
App - Applications; software that is downloaded by the user to a phone

1. Introduction

The modern shopping experience presents consumers with a vast array of similar products to buy. Assortments of goods are crammed along supermarket aisles, store shelves, and scrolling e-catalogue lists, waiting to be picked. Although products are usually organised into aisles, categories, or menus, having to make purchase choices can be overwhelming for customers (Schwartz, 2006). Whilst shopping, consumers perceive their choices within seconds and often base their reasons for choosing a product on its appearance (Crilly, Moultrie, & Clarkson, 2004; Hansen, Pracejus, & Gegenfurtner, 2009; Daye, 2011; Bowman, Jöckel, & Dogruel, 2015). Consumer choices hinge on the visual perception of the product and its exterior design, which incorporates multiple elements, including form (shape), visual cues (e.g. colour or size), auditory signals (e.g. sound effects or music), and motion (e.g. movements or gestures) (Kumar & Noble, 2016). These elements can be used as signs to communicate company messages, information about the product, and elicit emotional responses from consumers that can influence their purchase behaviour (Nöth, 1990; Bloch, 1995; Opperund, 2004; Hall, 2007).

The visual elements of a product, such as its colour and shape, can provide useful, experiential information about a product that helps to inform customers' instore choices (Creusen & Schoormans, 2005; Kumar & Noble, 2016). Studies have shown that the colours and shapes used in product packaging for foodstuffs can communicate vital information about its type and quality. For example, packaging that

uses ‘natural’ colours and muted tones (i.e. greens, browns, and pastels), as well as rounded and smooth shapes, can be associated with notions of health and relate to the organic qualities of healthier foodstuffs. Conversely, bright colours (e.g. red, yellow, blue, etc.) and angular edges can be associated with notions of artificiality and engineered aspects of a product that relate to processed foodstuffs (Oswald, 2012: 52-53; Ngo, Piqueras-Fiszman, & Spence, 2012).

This thesis will look at visual product design from the perspective of semiotics, the study of signs and making of meaning. Of principal interest is the relation between the form of a sign (such as elements in the appearance of a product) and the meaning of a sign (such as the message conveyed to the consumer) (Chandler, 2017: 13). A sign’s meaning depends on the context in which it is found, and can be established and regulated through conventional, cultural, or genre-specific practices (Chandler, 2017: 178). Advertising and product marketing perpetuates the use of signs that aids the entrenchment of their meaning, such that they can be “organised into meaningful systems” called *codes* (Goldman, 1992: 39; Chandler, 2017: 177). Semiotic codes, and indeed semiotics in general, are an integral part of our language and communication (Hall, 2007: 5).

Visual elements in particular, such as colour and shape, can convey meaning that is understood inter-culturally and intra-culturally through their relations with our environment and embodied experiences (Kress & Van Leeuwen, 2006; Chandler, 2017). As such, colour and shape are frequently used in the design of a product’s appearance to draw on recognised relations that convey key messages to consumers

about the product (Pinson, 1988; Beasley & Danesi, 2010; Kress, 2010; Oswald, 2012; Chandler, 2017). The semiotics of colour and shape of physical goods, particularly foodstuffs and packaging, has been extensively researched and found to have a persuasive influence over consumer perceptions, preferences, and purchase decisions (e.g. Maga, 1973, 1974; Clydesdale, Gover, & Fugardi, 1992; Francis, 1995; Spence & Gallace, 2011; Ngo, Piqueras-Fiszman, & Spence, 2012; Spence, 2012; Velasco et al., 2013). However, the design of virtual products in online marketplaces and its impact on consumer behaviour has received comparatively less attention (Oswald, 2012).

With the app market becoming "a prime example of a digital market", it is important to explore how visual semiotic elements can operate as informative and persuasive tools for the online marketing of virtual products such as smartphone applications (henceforth apps) (Joeckel, Dogruel, & Bowman, 2017: 621). The rise of the "smartphone society" in the UK has facilitated the growth of digital marketing, as increasing amounts of content are consumed by smartphone users, including digital media, advertising, and virtual environments (Google, 2015; Chaffey & Ellis-Chadwick, 2016; Ofcom, 2015: 6, 2016, 2017; Freier, 2018). As of August 2017, 76% of UK adults own a smartphone, which is around 46.4 million people, and the number of smartphone users is expected to increase over the next 5 years (Statista, 2017b; Ofcom, 2017). The popularity of smartphones provides companies with more opportunities to access the consumer market, connect with their customers, and sell their products and services online (Kim, Lee, & Taylor, 2013; Nielsen, 2014). App markets especially, such as the Android based *Google Play Store*, are becoming ever more successful and are generating larger annual revenues. In the fourth quarter of

2016, the Google Play Store had a total of 2.6 million apps available and earned an estimated 3.3 billion USD revenue, approximately 2.45 billion GBP (Statista, 2017a; Oliynyk, 2017). By September 2017, the number of available apps had grown to 3.3 million, and is expected to rise further still (Statista, 2017a). Apps not only operate as an online extension of offline stores, but are also products in their own right, and can be bought ('paid-for') or sometimes downloaded for free, with in-app upgrades and extras ('in-app purchases').

Consumers search for, download, and use apps on a daily basis on their smartphones, and the majority of users discover apps via the app store (Nielsen, 2014; Google, 2015). However, the increasing number of available apps means that these online app stores are extremely competitive markets, with apps constantly vying for consumer attention. Effective app design is therefore essential for apps to be noticed and to persuade smartphone users to download and invest in them. One of the first points of contact consumers have with an app in the app store is with its icon, which provides a visual representation of the virtual product (Flarup, 2015). Visual semiotic elements colour and shape are particularly effective at capturing consumer attention in competitive environments (Williams, 1967; Kieras & Hornof, 2014). Yet, despite evidence that an app's internal visual design can increase consumer satisfaction, enjoyment, and downloads (Merhi, 2016; Kumar, Natarajan, & Acharjya, 2017), many studies investigating app search do not address the potential impact of the app's icon on consumer selection and purchase (c.f. Gage Kelley et al., 2012; Gage Kelley, Cranor, & Sadeh, 2013; Bowman, Jöckel, & Dogruel, 2015; Dogruel, Joeckel, & Bowman, 2015).

This thesis investigates how visual semiotic elements colour and shape are used in smartphone app icons to convey meaning, thus operating as part of a visual language in virtual product design, and whether these visual elements have any impact on smartphone users. The thesis presents findings from two studies. Study 1 is a corpus analysis of 250 smartphone app icons collated from Communication, Health and Fitness, Productivity, Social, and Tools app categories in the Android based Google Play Store. The corpus was used to identify the colours and shapes used in smartphone app icons and to analyse their conveyed meaning. Study 2 is a smartphone user response study that captures how smartphone users evaluate app icons in various colour-shape combinations with regard to their distinctiveness, appeal, and typicality for the types of apps available in the app store. After discussing existing research that contextualises the thesis (section 2; henceforth §2), I detail the methods for studies 1 and 2 (§3), and report and discuss the results from study 1 first for colour (§4.1) and then for shape (§4.2), followed by study 2 (§4.3).

There are conflicting definitions for the terms 'icon' and 'logo', with many design companies and businesses using them interchangeably (Schenker, 2017). Flarup (2015) argues that "icons and logos are not the same and shouldn't be forced into the same context." In an attempt to provide *The Missing Guide to Logo Design Terms*, Schenker (2017) defines an icon as a "straightforward and bold representation of a company", and suggests that the over-arching term 'logo' encompasses various terms including 'icon', 'mark', 'brand', and 'emblem'. DesignCrowd (2016) defines an icon as representing an "idea, concept, operation, or action" of a product, and is commonly used by apps. An app icon operates as a "graphical representation" of the app's

function, which is useful for smartphone users to decode what an app can do. A logo, they argue, is instead a "recognisable symbol primarily used to represent a business or organisation" as a "graphical summary of the company 'brand'" and its values (i.e. not its function). Using the example of the Dropbox icon (figure 1a), though, DesignCrowd hint that an icon can be "integrated" into a logo (figure 1b).

Figure 1: The Dropbox icon (a) and logo (b) demonstrate how an icon can be integrated into a logo

(a)  (b) 

For the thesis, I use the term 'icon' as these are more commonly used as visual representations for apps. The term 'icon' is useful to explore graphical elements colour and shape, and their potential in communicating the concepts, functions, and values of the app itself, which may also reflect the company's values and their brand.

The term 'colour' is used to refer to the visual perception of chromatic (i.e. red, green, blue, yellow, orange, purple, pink, etc.) and achromatic (i.e. white, grey, or black) colour differentiations of a figure (Machin, 2016). The words 'physical' and 'virtual' are used to emphasise that online stores with 'virtual' products such as smartphone apps have received less scholarly attention than physical products such as foodstuffs available in offline marketplaces, although it is insightful to consider the interconnectedness of online and offline environments in the analysis of meaning in the studies (Jurgenson, 2012: 85).

2. Theoretical Background

In this section, I discuss the importance of visual semiotic elements in advertising and product design (§2.1) and app research (§2.2). I review studies about how colour and shape convey meaning through visual search (§2.3), categorisation (§2.4), symbolism (§2.5), and aesthetic value (§2.6). These discussions provide a theoretical background to the thesis, demonstrating how visual elements colour and shape can operate as part of a visual language (§2.7), and formulate informed expectations for how colour and shape might operate as informative and persuasive tools in mobile app marketing when used in the design of smartphone app icons (§2.8).

2.1. Visual Semiotics in Advertising and Product Design

Semiotics is the study of signs and how they make meaning. Among other things, semiotics deals with the associations between the *form* of a sign and its *meaning* (Chandler, 2017: 13); also respectively referred to as the *signifier* and the *signified* (Saussure, 1995; Saussure, 2011). Semiotics encompasses both linguistic and non-linguistic sign systems. The meaning of a sign can be regulated through "interpretive and representational practices", known as *semiotic codes* (Chandler, 2017: 178). Such codes are established through convention, culture, genre, and visual experience (Arnheim, 1970; Barthes, 1972, 1977). For example, understanding that a red light means ‘stop’ requires an awareness of the code of traffic lights. In order to interpret

the meaning of the colour red in the context of traffic lights, we have to decode the meaning, which relies on red's relation with the traffic light code (Chandler, 2017).

Peirce (1931-1958) identified three different relationships that can occur between the form and meaning of a sign, known as symbolic, iconic, and indexical sign systems. Symbols have an arbitrary relationship between the signifier and signified, and their relations have to be learned conventionally. For example, an image of a house might be used to signify a link to a website homepage, but rather than resembling any particular house, the sign is symbolising the concept of a 'home'; a place to which guests can return and restart, refreshed (Chandler, 2017). We see the house sign often on our digital devices and on the internet, yet we are not born with the knowledge of its meaning; it has to be learned. An icon, on the other hand, is based on perceived similarity, resemblance, or imitation of an entity between the signifier and signified, such that a painting of a house may have at least some degree of likeness to the house that has been depicted (Hall, 2007). Meanwhile, an index is based on a direct connection between the signifier and the signified, be that physical, causal, or inferred through nature; for instance, weather, symptoms, signals (e.g. phone ringing), pointers (e.g. fingers or arrows), or personal trademarks (e.g. handwriting).

However, there is much criticism surrounding iconicity, questioning whether signs can ever be purely iconic (e.g. Morris, 1971; Eco, 1976: 191ff; Worth, 1981). For example, a road sign with an elephant on is an icon of an elephant; yet, what is truly being communicated might be that there is a zoo nearby, which represents the

elephant as standing for the larger domain of the animal kingdom (a metonym), and can therefore be described as being indexically symbolic. Indeed, while these Peircean sign systems have become recognised by many as 'types of signs', they are not mutually exclusive and can be found, quite often, to overlap (Beasley & Danesi, 2010; Chandler, 2017: 54). Peirce himself stated that "it would be difficult if not impossible to instance an absolutely pure index, or to find any sign absolutely devoid of the indexical quality" (1931-1958: 2.306). Therefore, it might be more conducive to use sign systems as a means to evaluate how a sign communicates meaning, rather than serving as definitive labels in isolation. As such, these Peircean sign systems are used in addition to other resemblance sign systems (see discussed below and in the methodology [§3.1.5]) to aid the interpretation of how meaning is conveyed by colour and shape in smartphone app icons.

Semiotics not only explains the relation between the form and meaning of a sign but also the relation between different signs. Barthes (1972, 1977) proposed that a sign can encode a message underlying the primary meaning that provides access to other signs and their meanings, which he coined as the *mythic meaning*. Although this term is not widely used in the literature, Barthes' mythic meaning considers how certain information born from one sign can be 'endowed' on or transferred to another sign, resulting in their relation with each other (Bignell, 2002: 32). By relating to one another, signs can communicate large amounts of information very efficiently, which is particularly useful in marketing when advertisements have very limited exposure time to communicate with busy customers.

Two ways in which signs can relate to one another are through comparison and connection. Metaphor and metonymy are sign systems that establish these correspondences between signs (Littlemore, 2015; Chandler, 2017). Metaphor operates by transferring meaning from the signifier of one sign (or domain) to the signified of another, from which process a new sign emerges that has encoded the transferred meaning (Chandler, 2017). Metonymy draws on connections between signs and acts as a kind of "shorthand" that provides access to multiple signs and their meanings (Littlemore, 2015: 5). Metonymy has received comparatively less scholarly attention than metaphor (Pérez-Sobrino, 2016b: 73), although much research has investigated both metaphor and metonymy manifestations in visual modes, including images and visual advertising where they are particularly abundant (Forceville, 1996, 2000, 2008, 2009a, 2009b; Hidalgo & Kraljevic, 2011; Pérez-Sobrino, 2016a, 2016b, 2017).

The focus of this thesis is on visual semiotic elements colour and shape, and as such their meanings are based on relations with their appearance. Stern (2008: 273) comments that "there is no one kind of associated property (e.g. feature of resemblance) that serves as the ground for all metaphors; rather interpretations draw on all sorts of properties." Metaphors can convey meaning by indexing correlations with our experiences (*correlational metaphor*) and through resembling objects in our environment (*resemblance metaphor*) (Gibbs, 2008). Experiential correlations are motivated by our associations with orientation, ontology, and human physiology (Grady, 2007). For example, "the correlation between affection and body warmth, produced by physical proximity" relates to our experience from infancy of "being held

affectionately and feeling warm" (Grady, 1997: 197; Johnson, 2008: 46). The experiential correlation can affect our attitude and behaviour, with warmth priming people to have more positive evaluations of others and to be generous in their purchase decisions (Williams & Bargh, 2008a, 2008b).

On the other hand, resemblance metaphors are motivated by the appearance of physical properties in our environment (Grady, 1999). For example, the colour red's association with anger (*Anger is Red*) resembles the colour our faces go when we get angry; when all the blood rushes to the surface of our skin, we go red (Littlemore et al., forthcoming). Moreover, spikey objects such as cacti and the spines on hedgehogs and porcupines are a protective mechanism that, to other entities, may index pain, danger, or a warning. Spikey, angular shapes resemble these entities in the environment and associate with their message, which we replicate in our triangular road signs (Dondis, 1973: 44).

These examples demonstrate how we use our experiential correlations (e.g. *Affection/Proximity is Warmth*) and resemblance to entities or the environment (e.g. *Anger is Red*, *Danger is Angular*) to aid our construal of metaphorical signs in visual semiotics. The concentration on colour and shape in the thesis means the motivations for their interpretation are primarily based on resemblance, that is to say: resemblance metaphors that are motivated by physical properties (e.g. colour and shape) more so than by behavioural comparison (Ureña & Faber, 2010: 124). Metonymy can also be motivated by the physical properties of a sign or entity; for example parts of the entity or its constitution can be used to represent the whole of

the entity itself or its category (see Littlemore, 2015: 20-21). As such, the sign systems metaphor and metonymy are useful in interpreting the meanings conveyed by colour and shape choices in app icons.

Semiotics (including sign systems metaphor and metonymy) plays a key role in advertising and product design (Pinson, 1988; Beasley & Danesi, 2010; Kress, 2010; Oswald, 2012; Chandler, 2017). Advertising reuses signs and codes that are commonly known to most of the population or to a particular group of people to ensure that their intended meaning can be decoded and understood by targeted consumers (Goldman, 1992: 39). Colours are often used as codes for emotion (Kaya & Epps, 2005; Littlemore et al., forthcoming), and have strong associations with concepts of nature, danger, and trust (see Labrecque & Milne, 2012). Even simple shapes can communicate information. For example, an arrow signifies movement or direction (Kress & Van Leeuwen, 2006), rounded shapes can signal serenity, grace, and sentimentality, and angular shapes can associate with robustness, vigour, and seriousness (Hevner, 1935; Dondis, 1973).

The visual design elements of a product, such as its colour, shape, size, sound, and motion, can communicate crucial information about what the product is, what it does, and how it performs (Kumar & Noble, 2016). These visual semiotic elements (e.g. colour and shape) can therefore function as a kind of visual language that conveys messages to the consumer about the product that companies either do not wish to express in words or that are "beyond words" (Heath, 2012; Chandler, 2017: 184). Creusen and Schoormans (2005: 75) have identified six roles that the visual elements

of a product's appearance can play in influencing consumer attitude and behaviour (table 1).

Table 1: Six Roles of Product Appearance for Consumers
(adapted from Creusen & Schoormans, 2005: 75)

Role	Influence on Consumers
Attention-drawing	Engages consumer attention instore
Symbolic	Cues symbolic product associations Communicates brand image/personality
Categorisation	Eases product categorisation Offers differentiation from the product's typical category
Functional	Highlights features and functions of the product Cues information about the product's technical quality
Ergonomic	Highlights parts for consumer-product interaction Shows consequences for using external aspects of the product
Aesthetic	Serves as a basis for aesthetic appreciation and appropriateness Suggests suitability with the environment

In their study, Creusen and Schoormans (2005) found that two of the most prevalent visual elements participants used to interpret a product's function, competency, and aesthetic appeal were its colour and shape. Participants often reported that the symbolic meaning of the product's appearance was the reason for their purchase choice, saying that it communicated ideas about its aesthetic qualities (i.e. that it was "expensive, friendly, or business-like…modern or contemporary") and functional qualities (i.e. that it was durable, reliable, and solid) (Creusen &

Schoormans, 2005: 76). Their study suggests that consumers interpret colour and shape design choices to access information about a product.

We interpret signs all the time such that it becomes fundamental to our processing of the world. The effects of visual semiotics can often be very implicit and communicate to us without our conscious awareness (e.g. Pollio, Smith, & Pollio, 1990; Gibbs, 1994). Indeed, in many cases in Creusen and Schoormans' (2005) study, although participants could report the *signified* meaning of the product's appearance (e.g. its aesthetic or functional value), they struggled to identify the reason for their interpretation, or the *signifier* from which the meaning originated. When perceiving a product's appearance, colours and shapes in particular are hardly ever seen as a sign in themselves by consumers; rather as "complementary" or "decorative" aspects of a product (Beasley & Danesi, 2010: 41). Kress and Van Leeuwen (2001: 58-59) argue that there are limits to how much colour and shape can be said to be signs on their own. When studied in isolation, their meaning is "open-ended" and subjective (Beasley & Danesi, 2010: 24). However, when they are situated in context, they provide a subtle yet efficient way to convey meaning in product design (Arnheim, 1970; Barthes, 1972, 1977).

Physical products in offline stores can provide experiential opportunities to consumers, who can interact with the product before they buy. Physically interacting with a selected product allows consumers to learn more about its capabilities and limitations before buying, leading to more informed purchase decisions (Crilly, Moultrie, & Clarkson, 2004). However, online stores provide comparatively limited

experiential opportunities for their products due to the constraints of their virtual environment (Rosa & Malter, 2003). Therefore, online markets rely considerably on the appearance of their products to inform consumers of its operation, weight, stability, ergonomics, and ease of use (Creusen & Schoormans, 2005). Although some companies are exploring how to simulate experiential opportunities for customers shopping online, these are few, and app marketing strategies are still in their infancy (Rosa & Malter, 2003; Kim, Lee, & Taylor, 2013). The thesis explores how colour and shape can communicate experiential information about the app through their use in the app icon before consumers opt for download by applying Creusen and Schoormans' (2005) product appearance typology to app icon analysis. The typology aids the consideration for how colour and shape may be used to fulfil different roles of virtual product appearance to inform consumers about the app prior to download.

A large portion of product design literature has focused on the role colours and shapes play in influencing consumers' perception of taste, quality, and acceptability of edible items in food marketing (Spence & Gallace, 2011; Spence, 2012; Velasco et al., 2013; see Spence, 2011 for a further review). Reviewing these studies may prove useful to inform potential meanings colour and shape can convey in smartphone app icons. In Ngo, Piqueras-Fiszman, and Spence's (2012) study, the colours of packaging for still and sparking water may have been associated with certain colours due to their symbolic meaning (see §2.5.1). Participants associated the colour blue more with still water than sparking water, which they associated with colours blue, red, and green. The colour blue is often associated with notions of 'calm', reflecting the tranquillity of still water, and the colour red is associated with notions of 'activity', reflecting the

activity of the bubbles in the sparkling water. Certain shapes were also considered by participants to be more appropriate in representing still and sparkling water in their logos. The still water logo was preferred with organic shapes that were rounded and smooth, which are shapes typically associated with sweet tastes (Velasco et al., 2013). Sparkling water was preferred with angular shapes, which are typically associated with sour tastes, and perhaps relates to the bitterness of the carbonated bubbles (Velasco et al., 2013; see also Spence & Gallace, 2011).

The colour and shape of food items influence consumers' perception of flavour; darker colours and rounded, edible forms are associated with sweetness, while angular forms are associated with sour tastes (e.g. Francis, 1995; Velasco et al., 2013; Maga, 1974). The perceived appropriate colouration of food products also has a bearing on consumers' acceptability and evaluation of the item's freshness (Clydesdale, Gover, & Fugardi, 1992); for instance, regular (lighter) coloured chips were preferred over darker coloured chips in normal lighting by consumers (Maga, 1973). Therefore, it is interesting to observe whether colour and shape communicate experiential information and ergonomic values when used in app icons.

2.2. App Research

Given the overwhelming amount of apps available to smartphone users in the app store, Joeckel, Dogruel, and Bowman (2017: 621) argue that it is “unreasonable” to propose that consumers engage in elaborate cognitive processes to evaluate each app

they see when browsing the market. Indeed, in an earlier study, they found that smartphone users spend very little time searching for apps and considering their choices before selecting one to download (Dogruel, Joeckel, & Bowman, 2015). Over half of the smartphone users in their study viewed only one app per search (57%, *N* = 49). It is therefore more reasonable to suggest that consumers rely on certain criteria to whittle down their choices of apps to simplify the selection process.

Further app studies have shown that smartphone users consider multiple criteria to inform their app selection, including its name, reviews, price, in-app functions, permissions, and aggregated ratings (Gage Kelley et al., 2012; Gage Kelley, Cranor, & Sadeh, 2012; Dogruel, Joeckel, & Bowman, 2015). Crucially, smartphone users report that they often base their download decision on the aesthetic appearance of an app (Bowman, Jöckel, & Dogruel, 2015; Google, 2015). An app's visual appeal has been found to increase consumers' satisfaction, enjoyment, and perception of quality of the app (Merhi, 2016; Kumar, Natarajan, & Acharjya, 2017). While these app search studies are useful to gain an insight into how consumers search and select apps online, not much work has looked directly at the impact of the visual characteristics of the app icon itself.

With the limited time users spend choosing the 'right app', researching how the visual characteristics of an app icon can be effective may go some way to address the apparent gap in the literature for app research and visual app design. Burgers et al (2016) has begun by investigating whether the visual characteristics of an app icon influences consumer attitude and behaviour. The study found that visual metaphor,

represented primarily through shapes and figures, was frequently used in app icons (*N* = 249 of 500). Moreover, the apps that had visual metaphor in their icons were likely to be more appreciated and downloaded than those without. Apps with visual metaphor were therefore considered to be more persuasive than those without visual metaphor. This line of research will be extended to the influence of the app icon's colour and shape in this thesis. It may be that figurative instances of colour and shape are connected with higher downloads; although they cannot be said to *cause* higher downloads as there are many other factors at play for why consumers download apps.

2.3. The Effectiveness of Colour and Shape in Visual Search

In the following section, I argue that to understand the impact of colour and shape in app icons, it is fruitful to look at the psychological literature on visual search, and the role of colour and shape in directing attention. To understand this, we need to consider what it is people look at in app icons when browsing the app store.

Visual search is a part of everyday computer and smartphone usage (Kieras & Hornof, 2014). People engage in visual search when they are looking for files on their computer, apps on their smartphone, or products when browsing online stores. For the majority of the time, smartphone users discover apps through proactive app search, with 40% discovering them via the app store (Google, 2015).[1] Searching the app store also accounts for the majority of app downloads, putting it as the leading

[1] Google's (2015) methodology constituted a survey with responses from 8,470 regular smartphone users aged 18-64 years between 12th September and 22nd September 2014.

source of app discovery (mobileCore, 2015). Consumers can process information taken from a product's appearance within seconds of seeing it for the first time (Daye, 2011; Hansen, Pracejus, & Gegenfurtner, 2009). However, in order to be noticed, the app first needs to attract consumer attention.

The Google Play Store and the Apple App Store are the two largest app markets available to smartphone users. Boasting 5 million apps between them as of September 2017, the number of instore apps has grown considerably since both their launches in 2008 (Gage Kelley et al., 2012; Statista, 2017a, 2017c. Due to the sheer amount of apps available, these online stores are extremely competitive markets. Making a product stand out in a crowd is one of the main challenges companies face. Primary visual elements of a product's appearance, such as its colour, shape, and size, are particularly effective at capturing consumer attention in competitive environments (Williams, 1967; Shen, Reingold, Pomplun, 2000; Williams & Reingold, 2001; Pomplun, Reingold, & Shen, 2001; Kieras & Hornof, 2014). During visual search, these elements cue the next eye fixation and engage the attention on the target object (Findlay & Gilchrist, 2003). These findings suggest that the colour and shape of an app's appearance can influence how a consumer selects an app to download. More confirmatory testing of colour and shape in visual search on mobile devices is required, in addition to computer monitors, before their effectiveness is confirmed (Ivory & Magee, 2009).

Colour and shape operate differently within the visual system, and have different effects on consumers. The highest visual acuity of colour, shape, and size is

achieved when they are perceived in the centre point of gaze (foveal vision). However, once the eye moves away to another target, the shape of the object quickly becomes unavailable for recall. Yet, colour can be perceived in the periphery (parafoveal vision) far more reliably than the shape or size of an object, and can be accurately identified within 500 milliseconds at eccentricities up to 50 degrees (Hansen, Precejus, & Gengenfurtner, 2009; Kieras, 2009). Moreover, consumers remember icon colour palettes better than their shape (signs.com, 2017). Colour is therefore particularly effective at capturing attention and being remembered in competitive environments when there are multiple products vying for attention.

Colour palettes are used by companies to not only improve the visual coherence of the product's aesthetic but also to signal relations across multiple products and associate them as the same brand (Daye, 2011). Colour coding is very effective in search and identification tasks, particularly when it involves multiple and varied stimuli, compared to codes involving geometric shapes, letters, or numbers (Christ, 1975; Sanders & McCormick, 1993). The colour of an app icon is useful as a brand identifier, as it can be perceived even in the periphery, and encode key values about the app consumers can decipher even before looking at the product directly (Jackdaw, 2016). The advantages of using colour to capture consumer attention mean that consumers can process their options more efficiently such that it eases their product selection process.

Some brand competitors emulate similar colour schemes of reputable brands in their own product designs, which operate as a *strategic attention distracter*, and

misdirect consumer attention from the well-known brand to a competitor's product (Ludwig & Gilchrist, 2002). By associating lesser-known products with reputable brands through the use of similar colour palettes, competitors can draw on the successful brand's reputation and qualities and relate these to their own products. Often, competitors offer their product at a considerably lower price than the popular brand, providing an incentive for consumers to opt for the cheaper option. Over time, a market can become populated with similar colour schemes that can gradually become recognised as identifying a specific product category. Therefore, the colour choice of a product encodes a message about its category and brand that can relate to multiple products (see Barthes' *mythic meaning*, §2.1).

2.4. The Role of Colour and Shape in Categorisation

Most marketplaces organise products by category to aid consumers' navigation of the store and to allow them to evaluate products alongside competitors and make more informed purchase decisions (Kumar & Noble, 2016: 391). The products of a specific category often have similar visual elements in their design that identify them as belonging to that category. These recognisable visual elements may have originated for a number of reasons. One probable explanation is that certain visual elements have been used by a successful product or brand initially and then imitated by competitors in an attempt to capitalise on sales. This perpetuates these visual elements for a particular type of product and results in their conventionalisation as denoting a product category.

Garber (1995: 656) defines visual typicality as "the look or appearance that most consumers would associate with a product category, and by which they identify brands that belong to the category." In other words, consumers' interpretation of a product's visual characteristics begins to take on the meaning of a particular category. Consider the following example: in the UK, still water is typically sold in a blue-topped bottle; whereas sparkling water is typically sold in either a red- or green-topped bottle. In their study of these products and the colour and shape of their packaging, Ngo, Piqueras-Fiszman, and Spence (2012) found that participants associated still water with the colour blue compared to sparkling water, which was associated with blue, red, and green. The association participants had with the colour choices and the two different types of water products matched the visual typicality these products have in the market. As such, the colour choices are seemingly entrenched in consumers' expectations of water product design and meant that participants could relate the colours to a specific product type or category.

Products are easier to categorise if they look like other products of the same category (Loken & Ward, 1990). Consumers tend to buy products that resemble attributes that are typical of a specific category, particularly when making low-involvement purchases since more distinctive or complex designs requires more effort to process (Hoyer, 1984). Visually atypical products can receive very different responses. Visually novel or distinctive products can engage consumer attention and encourage them to identify why it appears different and to which category it might belong to (Schoormans & Robben, 1997; Rindova & Pekova, 2007). An atypical

appearance can highlight a product's new or additional functional capabilities and are more likely to be considered important by the customer (Sujan & Bettman, 1989). On the other hand, atypical design that is too different or too complex can confuse consumers and make it difficult for them to recognise or categorise a product (Kumar & Garg, 2010; Truong et al., 2014).

In order to stand out from other products, a product's appearance has to strike a balance between visual typicality and visual complexity such that the product appears slightly distinctive in some aspects of its design to encourage consumer engagement but not so different that it is too hard to interpret information about it. It is finding the right balance that makes market research important and impactful in business. Establishing the typical (frequent) and atypical (infrequent) colours and shapes of smartphone app icons in the corpus analysis of instore apps provides the means to compare how participants respond to colour-shape combinations in app icons tested in the smartphone user response study with regard to their typicality. The results will consider the impact visually typical versus visually atypical colours and shapes of app icons instore have on smartphone users.

2.5. Symbolism: The Figurative Meaning of Colour and Shape

This section will focus on the figurative meanings of colour (§2.5.1) and shape (§2.5.2) that may inform their role in app icons.

2.5.1. Colour and Symbolic Meaning

Different colours are associated with different meanings. Many semioticians and metaphor scholars have studied the varied meanings of colour (e.g. Pepper, 1995; Labrecque & Milne, 2012), which are often driven by associations with real-world entities and experiences (Kress & Van Leewuen, 2002; Littlemore et al., forthcoming). Colour associations in nature aid the identification of an object or animal (Swain & Ballard, 1991). For example, certain coloured pigments can index danger or a warning (e.g. yellow and black stripes on wasps and bees), or enticement for sexual selection (e.g. colours deemed alluring by species that attract a suitable mate). Colour can also evoke affective values through cognitive associations (table 2).

Table 2: Summary of the cognitive associations of colour
(adapted from: Labrecque & Milne, 2012; and multiple cross-cultural studies)

Colour	Cognitive Associations	References (A-Z)
Red	Excitement Arousal Active Strong Happy	Bellizzi, Crowley, & Hasty (1983) Clarke & Costall (2007) Crowley (1993) Fraser & Banks (2004) Gorn et al (1997, 2004) Hevner (1935) Murray & Deabler (1957) Walters, Apter, & Svebak (1982) Wexner (1954) Wilson (1966)
Green	Nature Security	Clarke & Costall (2007) Kaya & Epps (2004)

Blue	Competence Intelligence Trust Efficiency Duty Logic Calm Serene Sad Dignity	Fraser & Banks (2004) Hevner (1935) Mahnke (1996) Wright (1988)
Yellow	Sincerity Optimism Extraversion Friendliness Happiness Cheerfulness	Clarke & Costall (2007) Fraser & Banks (2004) Kaya & Epps (2004) Murray & Deabler (1957) Odbert, Karwoski, & Eckerson (1942) Wexner (1954) Wright (1988)
Orange	Excitement (less so than red) Arousal (less so than red) Lively Energetic Extroverted Sociable	Mahnke (1996) Wexner (1954)
Purple	Luxury Authenticity Quality Dignity	Fraser & Banks (2004) Mahnke (1996) Murray & Deabler (1957) Odbert, Karwoski, & Eckerson (1942) Wexner (1954) Wright (1988)

Black	Sophistication Glamour Powerful Dignity	Fraser & Banks (2004) Mahnke (1996) Odbert, Karwoski, & Eckerson (1942) Wexner (1954) Wright (1988)
White	Sincerity Purity Cleanness Simplicity Clarity Peace Happiness	Clarke & Costall (2007) Fraser & Banks (2004) Mahnke (1996) Wright (1988)
Brown	Seriousness Reliability Support Ruggedness Nature Protection	Clarke & Costall (2007) Fraser & Banks (2004) Mahnke (1996) Murray & Deabler (1957) Wexner (1954) Wright (1988)

Table 2 demonstrates how each colour is associated with multiple meanings. Colours hold so many diverse meanings simultaneously that sometimes people find it difficult to assign specific meanings to isolated patches of colour without context (Wheatly, 1973; Hine, 1995: 215). For example, the colour green can represent the colour of nature through its relation to the environment, signifying concepts including growth, organic, and health; however, it can also represent the opposite, such as illness (Kress & Van Leeuwen, 2002: 354). It is the context in which it is found that gives green its specific meaning.

The meaning of colour can also vary considerably across different cultural contexts (Adams & Osgood, 1973; Madden, Hewett, & Roth, 2000). For example, while the Western sphere associate the colour white primarily with purity, and sometimes yellow with hatred, China associate these colours with righteousness and trustworthiness respectively (Fadzil, Omar, & Murad, 2011). Some colours, however, have similar meanings across cultures (Jacobs et al., 1991). For instance, red is evaluated as the most 'active' colour, black and grey the most 'passive', and black meaning 'badness' and white 'goodness' in multiple, different countries (Adams & Osgood, 1973). To control the potential of cultural differences in colour meaning, the thesis analysed apps accessed from the UK and asked native speakers of English to evaluate them in the smartphone user response study.

Interestingly, Dogruel, Joeckel, and Bowman (2015) suggest that app markets have very few cross-cultural differences in structure and found that the cultural background of participants did not significantly impact their app evaluation in their study. However, they did not look at the visual impact of app icons specifically. Further studies should conduct app research in different countries to test whether there is any cultural difference in the meaning and impact of colour and shape in app icons on consumer understanding, attitude, and behaviour.

2.5.2. Shape and Symbolic Meaning

Similarly to colour, a product's shape also drives inferences (Dichter, 1971; Spence, 2012; Truong et al., 2014). These inferences can be informed by existing associations

with objects in our environment. For example, *Schweppes*' Orangina drink imitates an orange fruit's textural exterior, being round with pimpled skin, in the appearance of their bottle's design (figure 2). There are few (if any) drinks brands that have similar bottle designs to Orangina, which makes the design distinctive in the market. As a result, Orangina not only has a "differential advantage" over its competitors, but it also informs the consumer of what type of drink it is and what it contains through the bottle's appearance (Berkowitz, 1987: 274). Orangina's design uses metonymy to connect the form of the bottle to an orange or citrus fruit, *Shape for Fruit*. In doing so, it transfers the qualities of the fruit (e.g. high in vitamin C, healthy, and natural ingredients) onto the product itself to indirectly claim that Orangina also has these qualities.

Figure 2: *Schweppes*' Orangina drinks demonstrate the semiotic use of shape in the appearance of its bottle design (Orangina.eu, 2019)

The symbolic meaning of shapes can be informed by social, cultural, and environmental contexts. Shapes that have hard, angular lines and edges, such as squares and rectangles, dominate the form of our buildings, cities, and roads and serve important mechanical, technological, and constructional functions in civilised society (Kress & Van Leeuwen, 2006). Angular forms and geometric shapes such as squares, triangles, and circles are often interpreted as being 'quasi-scientific' and 'mechanical' (Mondrian, in: Jaffé, 1967: 54-55) and associate with technical and digitally-operated objects such as smartphones (Creusen & Schoormans, 2005; Piqueras-Fiszman et al., 2010).

Shapes are also attributed affective meanings, which can have an emotional impact on consumers (Gabo, in: Nash, 1974: 54). Hevner (1935) discovered that participants evaluated circles, waves, and curves as serene, graceful, and sentimental. Contrastingly, squares and angles were thought of as robust, vigorous, serious, and dignified. Geometric shapes such as squares, circles, and triangles have specific values attributed to them. Squares can represent honesty and straightforwardness; circles connote endlessness, warmth, and protection as they are more self-contained; and triangles convey generative power, action, conflict, and tension, which may be partly due to their role in road warning signs (Dondis, 1973: 44; Thompson & Davenport, 1982: 110; Kress & Van Leeuwen, 2006: 54).

Lines often index metaphorical meanings according to their angle, orientation, height, and resemblance to rounded or spiked surfaces (Poffenberger & Barrows, 1924; Hevner, 1935; McCloud, 1993: 125; Horn, 1998: 147). For example, Poffenberger

and Barrows (1924) found that an upward orientated line indexed positive meanings such as merriment, joy, and ambition; whereas its downward orientation indexed sadness, relaxation, or faintness. These meanings are reflected in the conceptual metaphors *good is up* and *bad is down*, as in phrases *cheering up* and *feeling down*, which relates verticality to goodness such that elevation is conceptualised as a positive quality and demotion as a negative quality (Kövecses, 2002: 40; Lakoff & Johnson, 2003: 18). Although these metaphors are not based on resemblance, they demonstrate how the meaning of shape can also to correlate with our cognitive associations and experiences. Being that these meanings are evident across research fields shows that these relations can connect across different modes and sign systems.

Many studies have applied the meanings of lines and forms to typography (Van Leeuwen, 2006; Williams, 2008; Hyndman, 2016). Typefaces that use particular forms can elicit symbolic, affective, and cognitive meanings that enable companies to communicate core values about their brand (Van Wagener, 2003; Lupton, 2004; Machin, 2010). Text and its typography is another kind of visual communication. However, humans comprehend more information from perceiving purely visual stimuli (e.g. colour, shape, size, and motion), than reading text, with our brain receiving 8.96 megabits of visual data with the eye per second compared to only 0.000082 megabits of textual data (Koch, 2006). While text and typography are observed in smartphone app icons in the thesis' corpus study, the analysis focuses on the colours and shapes represented in the icons and the nature of their form; for instance, if they are: (1) hard, angular forms; (2) soft, rounded forms; or (3) a hybrid of the two. The

smartphone user response study assesses how smartphone users evaluate the colours, shapes, and form of app icons.

2.6. The Aesthetic Value of Colour and Shape in Product Design

A product's aesthetic value is the "pleasure derived from seeing the product, without consideration of utility" (Holbrook, 1980; Creusen & Schoomans, 2005: 65). The aesthetic value of a product was mentioned the most over other roles of product appearance by participants in Creusen and Schoormans' (2005) study. Over half of participants (65%, *N* = 92) based their product choice on its attractiveness. Interestingly, attention-drawing products were considered less attractive to consumers. The aesthetic value of a product can vary according to a number of factors, including the context in which a product and its visual elements are found and assembled (Whitfield & Wiltshire, 1983), and an individual's age, experience, and personality (Block, 1995). These influential factors are discussed in turn with respect to the aesthetic value of mobile devices and apps in sections 2.6.1 and 2.6.2.

2.6.1. App Complexity: Keeping it Simple

With the evolution of smartphone technology, mobile devices are becoming increasingly multifunctional, and consequently their design is changing. Smartphones can accomplish ever more complex tasks, similar to the capabilities of personal computers, which can lead to them having more complex designs. Many people find

the functional and visual complexity of high-tech products intimidating (Feldman, 1995). A product's appearance can influence how consumers evaluate its ergonomic value and determine its ease of use; a simple design may suggest that the product is easy to use, while a complex one infers that there are multiple facets to the product.

The icon acts as a visual representation of an app, and if this is too visually complex then it can be distracting, confusing, and require too much cognitive effort for consumers to identify and process (Sanders & McCormick, 1993). Complicated logos containing lots of detail and different shapes are less likely to be perceived at a glance and are also harder to recall (signs.com, 2017). Complex icons may not sufficiently engage or motivate consumers to inquire further. Consequently, the app may miss out on being selected and considered for download.

Previous research has found that it is possible to package a large amount of information into a simple icon and logo through the effective use of colour palettes (Labrecque & Milne, 2012; signs.com, 2017), recognisable shapes (Koutsourelakis & Chorianopoulos, 2010), and by utilising semiotic sign systems (e.g. metaphor in Burgers et al., 2016). Apps that are visually simplistic are more perceptually fluent and are considered to be more truthful, likeable, and reliable (Reber & Schwarz, 1999; Schwarz, 2004; Oppenheimer, 2006, 2008). Indeed, many app icons have been redesigned and simplified to contain fewer visual details, emphasising primary or related colours, and displaying basic geometric shapes (Kieras & Hornof, 2014).

One component of visual complexity is the interplay of different colours when presented together. The ease with which consumers can perceive combinations of

colours and shapes in an app's appearance can influence their preference and attitude toward it. The more cluttered the environment, the more eye fixations are required and the longer the process takes for consumers to search for and find suitable apps to download in the app store (Kieras & Hornof, 2014).

Colour discrimination can be affected by the surrounding environment, including the close proximity of other colours. Certain colour combinations with limited contrast between them, such as red and blue, can become particularly difficult to see. Different colours vary in their readability; from the easiest to hardest: light blue, dark blue, green, red, and yellow (Schwarz, 2004). Colours are often better perceived if their combinations with other colours are able to preserve the colour identity of a product, even in different lighting (Rheinfrank, 1984; Julier, 2000). Maximising colour contrast between elements of the design can help improve colour discrimination, with red signalling a marked advantage over runners-up green, yellow, and white respectively (Reynolds, White, & Hilgendorf, 1972).

According to Labrecque and Milne (2012), the majority of modern app icons consist of a single colour or one dominant colour with a subordinate accent colour, and at most use three main colours that are often red, blue, and black. They suggest that colourful app icons improve consumers' perception of excitement and competence of the product. Colour contrasts in app icons with minimal different colours may help consumers perceive the app more easily in a crowded app store.

2.6.2. The Effect of Age and Experience on Aesthetic Value

The age and experience of an individual can influence their evaluation of a product's aesthetic value. Most studies involving mobile devices have only considered the younger cohort for participant samples. Yet, the age of the consumer can affect their evaluation of mobile phones and app icons (Piqueras-Fiszman et al., 2010; Koutsourelakis & Chorianopoulos, 2010; Piqueras-Fiszman, Ares, & Valera, 2011). Younger users (20-30 years) prefer devices with touchscreen or slider interfaces with a straight top and rounded edges; whereas older users (55 years and above) prefer folder-type devices with straight edges and square central button (Piqueras-Fiszman et al., 2010). Younger users also have more terms to describe mobile devices than older users, suggesting that the former cohort are more aware of the multifunctionality of mobile phones and are more experienced in using the device.

Consumers' experience with mobile phone technology affects their product evaluation and purchase intentions (Kim, Lee, & Taylor, 2013). In order to control for individual differences in the thesis' smartphone user response study, the age of participants, their experience with apps (e.g. length of smartphone ownership, app search, and download habits), and their colour preference were recorded and balanced in the sample.

2.7. Colour and Shape as a Visual Language

Gestalt psychology supports the idea that visual elements can have meaning as independent parts, but also as a whole (Koffka, 1999). Kress and Van Leeuwen (2002, 2006) argue that images have a 'visual grammar' that constitutes compositional elements (e.g. colour and shape) that, similarly to language, convey meaning both in their parts and in their assemblage. In other words, "a grammar approach is interested in how these individual signs can be used in combination with other signs to create meaning." (Machin, 2016: 2).

The meaning of semiotic elements can vary across contexts and cultures (Adams & Osgood, 1973; Madden, Hewett, & Roth, 2000; Fadzil, Omar, & Murad, 2011). The variation in what visual elements mean can be said to resemble *dialects*, which reflect the differences in the context and culture of the people who use and interpret it (Machin, 2016). However, as we have seen in section 2, visual codes have common relations between form and meaning that are conventional, correlational to our experiences, and resemble aspects of the environment. Although visual language is not universally understood, the evidence that visual semiotic elements, such as colour and shape, can be similarly interpreted by people sometimes from very different backgrounds and in different contexts shows that these elements can communicate even across these 'visual dialects'.

Dillon (2006, cited in Machin, 2016: 188) proposes that whether or not there is visual literacy "depends on whether or not we think that such codes must be learned

or whether viewing images is simply very much like viewing the world around us." Even viewing the world around us teaches us codes that can be applied to other aspects of life and are used to interpret their meaning. Therefore, "the designer can rely on a broadly shared knowledge of visual language" between particular groups of people to communicate information about the product to the company's target market (Machin, 2016: xii). Similarly to spoken language, visual codes and their meaning can evolve (Chandler, 2017: 219). In the media, advertising, and especially online marketing, fast-paced business demands ideas to be distinctive, at least slightly, from common conceptions or conventions in order to draw consumers' attention to the product (see *visual typicality* in §2.4). As such, colour and shape are observed with regard to how they communicate information about the app and also draw attention to it.

Machin (2016) points out, however, that if visual communication had a grammar, it is likely to operate on different parameters to spoken and written language. Applying a grammatical concept so close to spoken and written language to visual language may not reveal the important ways visual elements communicate. Although the grammatical parameters of spoken or written language may not comfortably describe visual language, the ways in which even the most abstract of visual elements can convey common meanings on their own *and* together show that they can be a part of a visual language that ultimately aims to communicate.

One kind of visual grammar is how shape and colour play together. Colour and shape have their own meanings and are key semiotic resources for product designers.

However, colours and shapes cannot survive in isolation (Kress & Van Leeuwen, 2002: 351). Colour cannot exist without resembling some figure or another, and nor can a shape manifest itself without exhibiting some sort of hue. Indeed, visual elements such as colour and shape are observed and experienced together in the real world (Findlay & Gilchrist, 2003). Therefore, it can sometimes become difficult to determine which evaluations correspond to which element of a product's design – its colour or its shape (Hevner, 1935). While I recognise that colour and shape can communicate in their own way information about a product, their synergetic meaning will also be considered when analysing the potential meanings conveyed in the visual design of smartphone app icons.

2.8. Thesis Outline

Taking into consideration the existing research on visual semiotic elements colour and shape discussed above, this section will outline the general aims and research questions of the thesis. Specific expectations for studies 1 and 2 are refined during the analysis.

First, the thesis aims to explore how visual semiotic elements colour and shape are used in smartphone app icons to visually represent the virtual product of smartphone apps to develop the limited scholarly research of visual semiotics in virtual product design and builds on research of physical goods, foodstuffs, and packaging. Creusen and Schoormans' (2005) product appearance typology is applied to

the semiotic analysis of colour and shape in app icons to guide the exploration of how these visual elements convey meaning. The kinds of forms (e.g. hard, soft, or hybrid) used in app icons are also analysed to determine whether they contribute to the meaning conveyed. Visual semiotic elements colour and shape are part of a visual language and so it must be observed how they convey meaning independently and together in app icons to aid the construal of messages about the app.

Second, the thesis aims to observe whether colour and shape in smartphone app icons have any impact on the attitude and behaviour of smartphone users to develop research on virtual products and online stores that has been less widely studied than physical products and offline stores (Oswald, 2012). As studies suggest that many purchase decisions are made on the basis of the product's appearance (its colour and shape in particular), the impact of these visual semiotic elements on consumers are measured by the amount of downloads and evaluations an app receives from smartphone users in the Google Play Store (study 1) and in the smartphone user response study (study 2) respectively.

Advertisements that contain figurative messages (including symbolic, iconic, and indexical meanings), are more likely to be appreciated by consumers as they require more decoding than literal messages (Van Mulken, Le Pair, & Forceville, 2010; Littlemore & Pérez-Sobrino, 2017). Indeed, Burgers et al. (2016) found that apps that had visual metaphor in their icons were downloaded and appreciated more than apps without visual metaphor in their icons. Therefore, apps with instances of colour and shape that convey figurative messages are expected to have a connection with higher app downloads than those without. Yet, because humans interpret signs all the time,

and colours and shapes are considered as decorative embellishments rather than signs necessarily, they may not receive as high a ratings from smartphone users when they evaluate app icons with various colour-shape combinations in the response study.

Figure 3: Summary of thesis aims and research questions

The thesis aims to investigate:

1. How visual semiotic elements colour and shape are used in smartphone app icons to convey meaning about the virtual product.
2. How colour and shape in smartphone app icons impact smartphone users' attitude and behaviour by measuring their connection with app downloads instore and observing how smartphone users respond to app icons with various colour-shape combinations.

Research questions:

1. How is colour and shape used in smartphone app icons?
    a. What are their roles in app icon appearance?
    b. What meanings do they convey individually and together?
    c. What forms do they take and does it complement their meaning?
2. Does the colour and shape (and form) of app icons have an impact on consumer attitude and behaviour?
    a. Do they have a connection with app downloads?
    b. Do they have an effect on smartphone users' evaluations?

3. Methodology

In order to fulfil the aims of the thesis, one must first look at what app colours and shapes are commonly used in the market, whether they are associated with specific app categories or functions, and what roles they play in app icon design. Second, how colour and shape affect potential consumers must be considered. These are investigated through two studies.

Semiotic research is largely qualitative due to contextual factors ensuing its variability in meaning but it is "not incompatible with quantitative techniques" (Chandler, 2017: 168). The analysis of two studies involved a mixed methods approach to minimise extrapolating from the data (De Fina & Georgakopoulou, 2012: 85; Hashemi, 2012). In sections §3.1 and §3.2, I detail the design and procedure for studies 1 and 2 respectively. A full ethical review and approval was received prior to data collection and analysis.

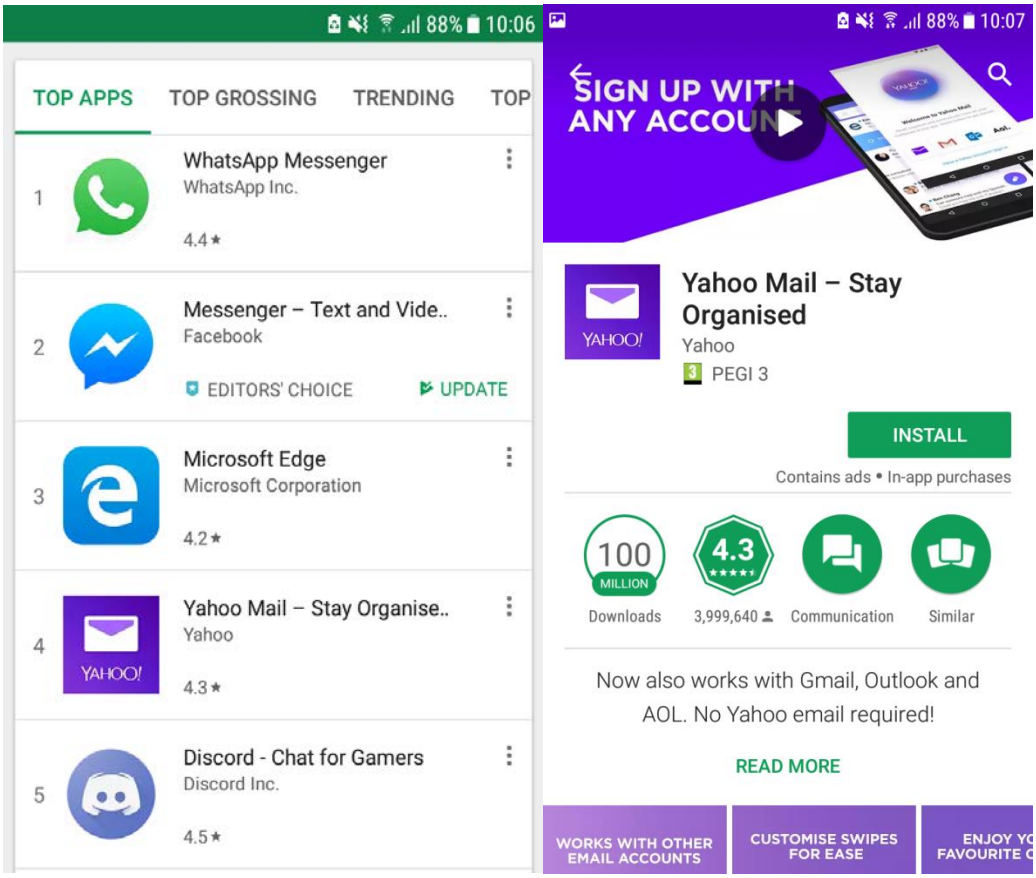
3.1. Study 1: Corpus Analysis of Smartphone App Icons

3.1.1. Corpus Compilation

The app market is an expanding and evolving online environment. Compiling a corpus of smartphone app icons provides a real-world snapshot of the market that is more representative than case studies or selected examples (e.g. Pérez-Sobrino, 2016b). A

corpus of 250 apps was collated from the Google Play Store, accessed via the same Android Samsung Galaxy A3 (2016) smartphone. A total of 500 apps were periodically screenshotted on 25th January 2018 between 10.00 and 16.30 GMT from the top 100 ranked apps in the 'top charts > top apps' list for each of the five app categories: Communication, Health and Fitness, Productivity, Social, and Tools. Screenshots captured apps up to rank 100 on the rank page for each category, of which 50 apps from each category were analysed in the corpus. A further screenshot recorded the individual app information page for each of the total 500 apps, of which 250 apps were analysed in the corpus (figure 4).

Figure 4: Screenshot examples from the Communication category 'top charts > top apps' list for the rank page (left) and app information page (right)



All app screenshots were saved securely and the app data was recorded in a spreadsheet (table 3).

Table 3: App data recorded from app rank page and app information page screenshots

Data V / From >	Rank Page	App Information Page	Comment
Rank Number	✓		
App Name	✓	✓	
App Icon	✓	✓	
App Designer	✓	✓	
Short Description		✓	Default display
Function		✓	Informed by short description
Downloads		✓	Record number
Average Star Rating (ASR)	✓	✓	
Reviews		✓	Record number
Additional Information		✓	'in-app purchases', 'contains ads', or 'editors' choice'

Preinstalled apps on Android smartphones (i.e. system apps) were excluded from the corpus because they have artificially high numbers of downloads and are more familiar to smartphone users. Only non-system apps were analysed in the

corpus. Apps that appeared in more than one category were analysed once in the first category they appeared in alphabetically.

The higher rank number of apps does not guarantee higher downloads. Google ranks apps using an algorithm that accounts for multiple factors including: the quality and quantity of user reviews; the number of keywords in each review; the frequency and recentness of reviews written; the historical success of the app developer; the keywords in the app name and description; the star ratings; and the downloads (installs and uninstalls) across the app store and mobile web search (Peris, 2013; Zolotareva, 2013; mobileCore, 2015).

App downloads and average star ratings are indicative measures of app popularity. Download rates and average star ratings reliably positively correlate with each other ($rho = 0.18$, $p < 0.003$); a finding supported by Burgers et al (2016). Download rates and average star ratings may be similar measures for app popularity; however, average star ratings are given to apps once they have been downloaded and experienced by the consumer. The average star rating is more indicative of the consumer's evaluation of the app's internal design and operative features. Download rates are considered to be more indicative a measure for the connection between the initial impact of the app and consumer purchase, and may be more informative for the commercial success of an app. As such, I decided to only report downloads as an indicative measure of app popularity in this thesis. It is noted that correlation between visual elements and download rates is not causation because other factors may influence a consumer to download an app (as discussed in §2.2). Therefore, I only use

app download rates as an indicative measure for the impact of colour and shape in app icons on consumer behaviour.

3.1.2. Choosing App Categories

Colour and shape are useful in categorising products or identifying brands (§2.4). I studied apps from five different categories to see whether particular colours and/or shapes were associated with any particular app category. The five chosen app categories (Communication, Health and Fitness, Productivity, Social, and Tools) are dominant categories in the app market and represent a range of functional complexity types that require increasing degrees of consumer engagement (Nielsen, 2014; Google, 2015).

Dogruel, Joeckel, and Bowman (2015) suggest that an app's functional complexity may have implications for how consumers perceive and consider them for download, with functionally complex apps requiring more elaborate decision-making processes. Productivity and Tools apps have more discrete functions, meaning that they fulfil a specific action or task, and are therefore perceived as being more straightforward in operation (Hartmann, 2009). Communication and Social apps utilise internet-based interactions that requires direct engagement. Finally, Health and Fitness apps require active physiological engagement that ranges from guided meditation to tracking running activity, encouraging users to engage in physical activity external to the app.

3.1.3. Coding for Shape in Smartphone App Icons

Initial observations of app icons found that colours and shapes play different roles in an app icon's composition. A role hierarchy was formulated that coded colours and shapes according to whether they appeared as an outline, background, geometric shape, object, or text. Table 4 explains how each figure (colour and shape) was coded in the app icon's composition.

Table 4: Coding procedure for the aesthetic roles of figures in app icon composition

	Definition
Outline	Usually the outer shape of an app icon that traces around the background, or a geometric shape or object
Background	A large portion of the icon featuring behind a foregrounded geometric shape, object, or text
Geometric Shapes	Either simple geometric shapes (e.g. square, circle, and triangle) or complex shapes (e.g. arrow, swirl, and curved line).
Objects	The iconic representation of a thing that exists in the real world (e.g. phone, envelope, animal, etc.). An icon is based on perceived similarity, resemblance, or imitation of the signifier with the signified, such that a picture of a phone resembles a physical phone (Hall, 2007).
Text	Symbolic shapes that are numbers, letters, or words. Symbols have an arbitrary relationship between the signifier and signified, and their relations have to be learned conventionally (Chandler, 2017). Text was only briefly discussed in the analysis due to the focus of the thesis being on colour and shape rather than typography.

The icon's geometric shapes, objects, and text were identified as being the focus of interest, known as the *figure* in Gestalt psychology; whereas the outline and background appeared to serve as the visual setting of the icon, known as the *ground* (Stevenson, 2014). Therefore, shapes with different aesthetic roles had different salience in the icon. When multiple shapes appeared in an app icon, more salient figures were determined by their size. When shapes were equal in size but appeared in different colours, those appearing on the left were prioritised over those on the right, following the Western reading direction and given-new image structure in advertising, which suggests that consumers tend to interpret text and shapes on the left before the right (Kress & Van Leeuwen, 2006). If the same, equally-sized shapes have the same colour, these were coded as one shape only. The salience hierarchy applied for each role shape played in app icon composition.

The form of each figure was also coded, including hard, soft, and hybrid forms. Hard forms have angular or sharp edges or lines; soft forms have rounded or curved edges or lines; and hybrid forms constitute a mix of hard and soft forms (figure 5). Circles and ovals were always coded as soft forms because they have curved, rounded edges; whereas other shapes were attributed different forms. For instance, squares with sharp edges were coded as having hard forms, while squares with rounded edges were coded as having soft forms. Shapes such as speech bubbles that had both rounded and angular edges were coded as having hybrid forms.

Figure 5: Geometric shapes with different forms from left to right

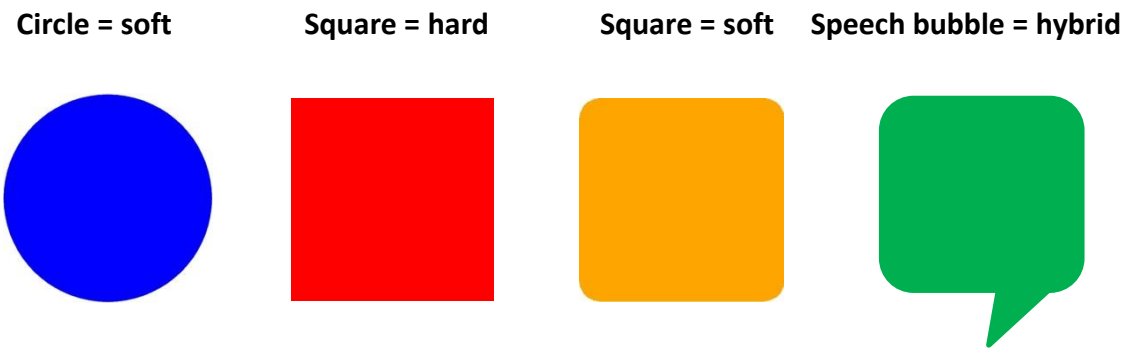
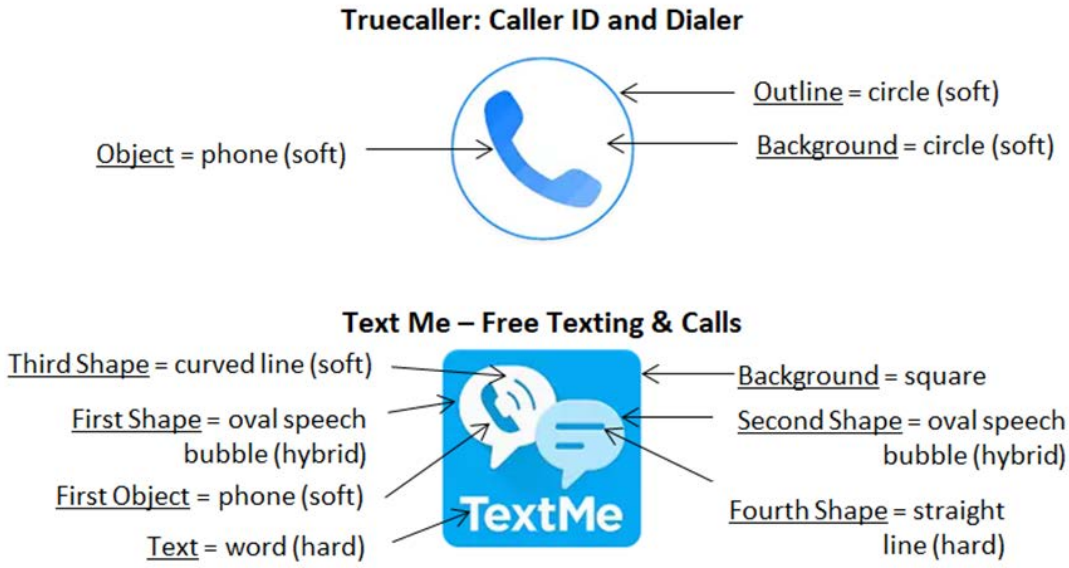


Figure 6: Two app icons demonstrate how each figure was coded for its aesthetic role



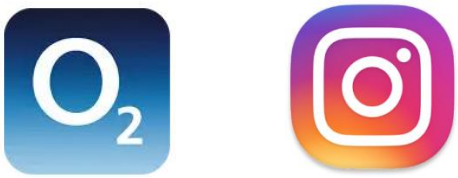
Note: The third and fourth shapes were coded as such because the third shape appeared inside a more salient shape than the fourth.

3.1.4. Coding for Colour in Smartphone App Icons

The name and hexadecimal (#) values of each colour were recorded with the help of *Pixolor*, version 1.2.9 (EmberMitre Limited, 2018). Where shapes had a gradient of the same hue, the shade covering the majority of the shape was recorded. For example,

O2's app icon had a gradient of light to dark blue, which was coded as blue (figure 7). Where two or more different colours were perceived as being a part of the same shape, the colour was coded as 'mix' (e.g. Instagram in figure 7).

Figure 7: Gradient and mixed colour examples from *O2* and *Instagram* (left to right)



The colour names from Pixolor were later grouped into broader colour categories: red, yellow, blue, green, orange, purple, black, and white. Colours that contained descriptive elements as part of their name in Pixolor (e.g. Light Blue 100, Light Brown 500, Dark Blue 800, etc.) were classified as the main colour specified in their name (e.g. Light Blue 100 = Blue, Light Brown 500 = Brown, Dark Blue 800 = Blue). Colours with integer 100 or more were classified as being the colour corresponding to their label (e.g. Red 100 = Red, Green 300 = Green, Blue 900 = Blue, etc.). Colours with integer 50 (e.g. Red 50, Green 50, etc.) were classified as white (#FFFFFF) because the contrast of these shades were so slight that they still appeared white in the app icon to the human eye; for example, the white speech bubble outline in the WhatsApp icon (figure 8).

Figure 8: WhatsApp icon exemplifies an outline hard to identify against Google Play Store background

Colours that did not include the colour category in their label were classified accordingly: teal = green; cyan, indigo, and blue grey = blue; lime = yellow; and amber = orange. Grouping the colours into broader categories enabled an overall analysis of their use in app icons and for comparisons to be made with previous research.

3.1.5. Interpreting the Meaning of Colour and Shape in App Icons

Once app icons had been coded in the corpus, the meaning of the colours and shapes used were qualitatively analysed. Interpreting semiotics can often be intuitive or subjective, and so it is important to have a procedure in order to approach semiotic analysis to produce salient interpretations. An eight-step protocol inspired by Beasley and Danesi (2010: 24) was employed for the semiotic analysis of smartphone app icons (figure 9).

Figure 9: Protocol for interpreting the semiotics of colour and shape in smartphone app icons (inspired by Beasley & Danesi, 2010: 24)

1. Who or what created the sign (i.e. the addresser)?
2. What is the main underlying message being communicated?
3. What signs are part of the conveying the message?
4. What aspect/s of the sign/s (i.e. the signifier) is/are cueing the activation of the meaning (i.e. colour or shape)?
5. What signified/s does this allude to?
6. What is the relationship between the signifier and signified (i.e. what potential sign systems are at play)?
7. What signification system does it generate and how do the sign systems interact?
8. How many interpretations (signification systems) are possible and can they be prioritised considering the context and steps 1, 2, and 3 for more salient meanings?

For steps 6 and 7, the identification of the sign system/s at play were not used as definitive labels, but rather as exploratory tools that aided the consideration of different generative meanings, which enabled deliberation over the most salient meaning/s with regard to contextual factors. Peircean (1931-1958) symbolic, iconic, and indexical sign systems were considered to interpret different relationships between the form and meaning of colour and shape in smartphone app icons (see §2.1 for definitions). Resemblance (physical and behavioural) and correlational metaphors and metonymies were also considered to enlighten potential figurative meanings for the use of colour and shape in app icons (see §2.1 for definitions). The hard, soft, and

hybrid forms of figures were analysed in conjunction with shapes in the icons to interpret their potential meanings.

Creusen and Schoormans' (2005) product appearance typology was applied to the semiotic analysis of colour and shape in app icons to guide the interpretation of these visual elements and explore the potential roles they play in app appearance. Individual colours and shapes were considered in addition to their combination with other colours and shapes during their corpus analysis so as to reach salient interpretations for how these visual semiotic elements create meaning not only independently but also together as a visual language (Machin, 2016: 2). Furthermore, discussing the results from studies 1 and 2 together in section 5 was intended to provide a more robust interpretation of the use and meaning for the colour and shape in smartphone app icons and their impact on smartphone users.

3.2. Study 2: Smartphone User Response Study

The second study was an online experiment used to determine how smartphone users respond to different colour-shape combinations of app icons with regard to their attention-grabbing and aesthetic values and categorisation (table 1, §2.1). The experiment was designed with Qualtrics (2018) and was distributed via email, social media platforms Facebook, Twitter, and LinkedIn, and Amazon Mechanical Turk.

3.2.1. Questions

The experiment had two sections. The first randomly presented participants with 36 fabricated app icon designs with various colour-shape combinations. Participants were asked to evaluate these icons on their distinctiveness, visual appeal, and typicality for five app categories: Communication, Health and Fitness, Productivity, Social, and Tools. These three evaluation questions tested three main roles of product appearance: attention-grabbing, aesthetic, and categorisation (table 1, §2.1). The icon's distinctiveness and visual appeal was marked on a 7-point scale from 1 (generic/unappealing) to 7 (distinctive/appealing) (for a similar design, see Noble, Bing, & Bogoviyeva, 2013; Van Mulken, Le Pair, & Forceville, 2010: 3423). A third question asked participants to rate how typical the icon was for each of the five app categories (aforementioned) by ranking them from 1 (most typical) to 5 (least typical). The question aimed to establish whether smartphone users utilise the colour and shape of app icons for app categorisation (see §2.8 for more information). The second section of the study asked participants for general information: age, gender, native language, and ethnicity, colour preference, smartphone ownership, and app search and download experience.

3.2.2. Stimuli Design

The 36 fabricated app icons were designed to focus participants' evaluations on the colour and shape of the icons presented in the experiment (see appendix 1, §7.1).

Following the shift toward simplistic app icon design in the app market, the stimuli used primary and secondary colours from the six-point RYB colour wheel: red, yellow, and blue primary colours, and green, orange, and purple secondary colours; and basic, geometric shapes in hard and soft forms: oval (soft only), circle (soft only), square (hard and soft, see templates in appendix 2, §7.2), and triangle (hard and soft, see template appendix 3, §7.3). These visual characteristics of app icons presented to participants allowed me to test for whether the colour, shape, or form of app icons had any influence on smartphone user evaluations.

Hexadecimal values were used to replicate the exact colour for the stimuli when viewed onscreen and to enable replication in later studies (RapidTables, 2018). The stimuli adhered to the standardised Google Play Store dimension requirements for app icons, being no more than '512px by 512px', and were displayed as approximately 128px by 128px to emulate the size in which they would normally be perceived in the Google Play Store (Peris, 2013). The icons were created with *Paint 3D* (Microsoft Corporation, 2018).

Colour detection can be difficult with shadowing and background noise (Sanders & McCormick, 1993; Su, Fang, & Zou, 2016). The same background colour as Google Play Store was used for the experiment (#FFFFFF) to simulate the environment participants would normally perceive app icons, and to control for the influence of visual background noise. Smartphone and computer screens can also adjust screen brightness without introducing shadowing or background noise effects.

Reductions in visual acuity and contrast detection, or its degeneration, can impact how accurately the colour and shape of objects are perceived by reducing the quality and quantity of information that is received, particularly in older consumers or those with impaired vision (Sanders & McCormick, 1993: 99; Schwarz, 2004). Participants with colour blindness and/or vision impairment without correction (i.e. without the aid of glasses, contact lenses, or laser eye surgery) could not complete the experiment. Those with visual aids or corrections were accepted because their visual acuity and contrast detection makes them visually able (Sanders & McCormick, 1993).

3.2.3. Pilot Study

The online experiment was piloted with four native English-speaking smartphone users. The experiment was shortened according to feedback about the experiment's length by removing colours white and black for the final version in order to lessen participant fatigue effects (Day et al., 2012), which also may be stronger in internet-based studies (Savage & Waldman, 2008).

3.2.4. Distribution

The final experiment was distributed via email, social media platforms Facebook, Twitter, and LinkedIn, and community postings (henceforth ESC), and Amazon Mechanical Turk (AMT). First, an anonymous URL to the online experiment was sent via email to undergraduate, Master's, PhD, and distance-learning students after permission was granted from the relevant email administrators.

Most studies investigating mobile devices and applications have only considered the younger cohort for participant samples, and relying solely on these email lists for study 2 would have gathered a large youth sample. Therefore, the experiment was also distributed among the researcher's social network, community postings, via face-to-face solicitation (similarly to Ngo, Piqueras-Fiszman, & Spence, 2012), and Amazon Mechanical Turk, which, in all, constituted a more diverse participant demographic. “Amazon Mechanical Turk (AMT) is an online crowdsourcing service where anonymous online workers complete web-based tasks for small sums of money” (Crump, McDonnell, & Gureckis, 2013). AMT’s online community consists of a more diverse demographic from various cultures, although the majority are from the US and reflect the characteristics of the internet-using population (Goodman & Paolacci, 2017). Workers were given a 4.50 GBP payment for completing the experiment.

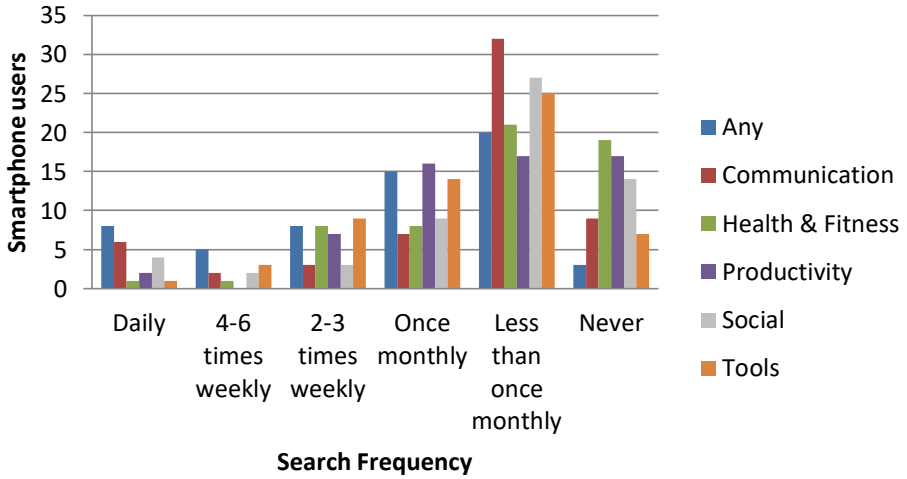
3.2.5. Participants

Participants had to be aged 18 years or over, fluent in English, visually able (i.e. not colour blind or without necessary visual aid), and a smartphone user to complete the experiment. These criteria ensured that the experiment adhered to ethical guidelines and that participants were able to comprehend the questions without difficulty.

A total of 59 suitable complete responses were received, and 3 were discarded due to not meeting the criteria. All non-native speakers were excluded from analysis. The responses received were from 39 females, 19 males, and 1 gender-undisclosed

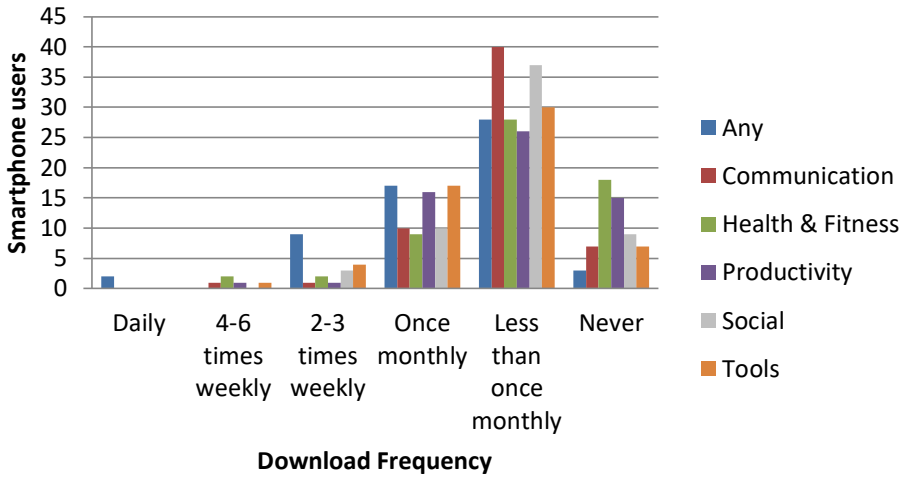
participant, ranging from 18 to 70 years (*M* = 37 years, *SD* = 14.36). Participants owned a smartphone for an average of 7 years (ranging from 2 to 10 years, *SD* = 2.35).[2] Android was the most popular operating system (OS), used by 73% of participants (*N* = 37), followed by Apple (32%, *N* = 19), Windows (3%, *N* = 2), and Amazon (2%, *N* = 1). Participants reported a range of search habits for apps from different categories (chi-square test of independence: $\chi^2 = 33.89$, *df* = 20, *p* = 0.027; figure 10). Participants reported searching for apps in general once or less than once monthly, but search for Productivity and Tools apps more often. Participants also reported downloading apps generally once or less than once monthly (figure 11).

Figure 10: Smartphone users reporting how often they search for apps from different categories



[2] Where participants provided a range of years (e.g. "about 7-8 years") for which they owned a smartphone, the lowest number was taken to avoid over-estimation.

Figure 11: Smartphone users reporting how often they download apps from different categories



Participants' search and download habits enabled a comparison with previous surveys investigating smartphone user behaviour (e.g. Google, 2015; Ofcom, 2015, 2016). Data from self-reports is not always reflective of actual behaviour, and it appears that smartphone users report they search for and download apps less regularly than their actual behaviour, which has been established in previous studies that have tracked smartphone user behaviour with a 'research app' that "passively measures the consumer experience of using mobile services" (Nielsen, 2014; Ofcom, 2017: 4).

3.3. Statistical Procedures and Open Access

All data was quantitatively analysed using statistical programming software R, version 3.5.0 "Joy in Playing" (R Core Team, 2018) within the statistical computing environment R Studio, version 1.1.442 (RStudio Team, 2016). Packages 'tidyverse',

version 1.2.1 (Wickham, 2017) and 'data.table', version 1.11.4 (Dowle & Srinivasan, 2018), were used for data processing and visualisation. In the view of reproducibility and transparent analysis, all raw data (.csv files) and R scripts for studies 1 and 2 are available on the Open Science Framework (2018) repository accessible via the following URL:

https://osf.io/dwv5j/?view_only=d03b841510e24adcada6cc880acbe8c9.

4. Analysis and Discussions

For the analysis and discussion, I report and discuss the findings for study 1, the colour and shape in the corpus of smartphone app icons (§4.1 & §4.2 respectively), and study 2, the smartphone user response study (§4.3). The following subsections describe the colours and shapes identified in smartphone app icons, decode the potential meanings in their appearance, measure the connection between the colour and shape in app icons and app downloads, and report smartphone users' reactions to different app icon colour-shape combinations.

Study 1's respective sections for colour and shape are organised such that quantitative results are reported first, followed by a discussion of their general use in smartphone app icons, and then their common and distinctive instances with examples from the corpus.

Study 2's section discusses the how smartphone users respond and evaluate colour and shape in smartphone app icons in respective subsections. Within these subsections, the distinctiveness, appeal, and typicality of colour and shape are discussed sequentially, with a general discussion of the user response study results to conclude.

Finally, in the following section, an overall discussion summarises the findings and ideas born from the analysis of both studies (§5).

4.1. Study 1: What Colours are Used in Smartphone App Icons and What Do They Communicate?

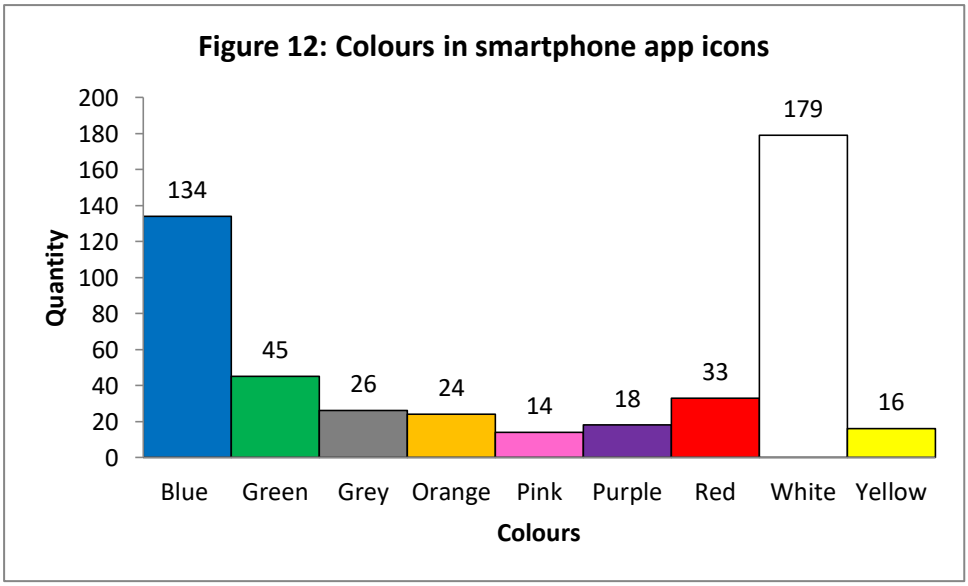
This section first reports the quantitative results (§4.1.1) and then discusses the qualitative results with examples for the use and meaning of colour in smartphone app icons in general (§4.1.2), and for common and distinctive instances (§4.1.3).

4.1.1. Quantitative Results for the Use of Colours in the Smartphone App Icon Corpus

Across the corpus of 250 smartphone app icons, there were a total of 574 instances of colour identified. The difference in colour frequency in app icons was significant (chi-square test of equal proportions: $\chi^2 = 694.49$, $df = 11$, $p < 2.2e\text{-}16$)[3]. White (31%, N = 179 of 574) and blue (23%, N = 134 of 574) were the two most common colours used in app icons. Mixed colours featured in 13% (N = 74 of 574) of app icons in the corpus and featured mainly as the main object (46%, N = 34), geometric shape (19%, N = 14), or background (23%, N = 17). The analysis focuses on colours that are classifiable as a definitive colour as opposed to mixed colours. Green was the fourth most frequent colour identified in app icons (N = 45 of 574), followed by red (N = 33 of 574). There were only 6 black and 5 brown app icons in the corpus and were subsequently removed from further statistical analysis due to their low data points, although reasons for their limited use in app icons are considered in the discussion (§4.1.2c).

[3] Tested variables sometimes had low data points or contributed multiple data points that produced a mild violation of the *independence assumption*; therefore, these results are approximate.

Figure 12 shows the classifiable colours identified in smartphone app icons with more than 6 data points, which excludes mixed colours (*N* = 74), black (*N* = 6), brown (*N* = 5), and NA values (*N* = 3) where a colour could not be identified.



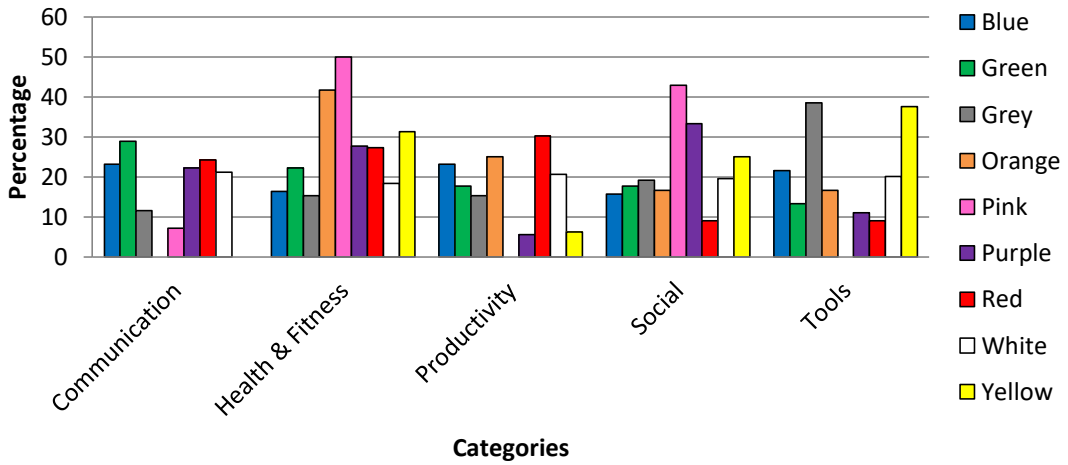
Categorising a product by its appearance enables consumers to interpret what the product is and what it does. When considering the categorisation role colours and shapes might play in app appearance, it was found that certain app functions of apps featured in particular app categories (table 5). Analysing how colour and shape may signal both the category and its function provides a more in depth understanding of how these visual semiotic elements can convey information about an app.

Table 5: App functions found across five app categories studied*						
Function (v)	**Communication**	**Health & Fitness**	**Productivity**	**Social**	**Tools**	**TOTAL**
Browser	11	0	0	0	0	**11**
Cleaner	0	0	3	0	10	**13**
Data Transfer	0	0	5	0	3	**8**
Instant Messenger	18	0	0	15	0	**33**
Mobile Network	5	0	2	0	6	**13**
Pedometer	0	13	0	0		**13**
Printer	0	0	4	0	4	**8**
Scanner	0	0	3	0	4	**7**
Security	4	0	2	0	10	**16**
Video	0	0	0	10	0	**10**
Word Processing	0	0	11	0	0	**11**
Workouts	0	13	0	0	0	**13**
TOTAL	**38**	**26**	**30**	**25**	**37**	**156**
* Displays functions with more than 6 data points						

Different colours were used in the icons of apps from different categories (chi-square test of independence for categories: $\chi^2 = 59.57$, $df = 32$, $p = 0.002$), suggesting that particular colours might be used as brand or category identifiers. The top four most common classifiable colours in app icons (white, blue, green, and red) were distributed proportionally across the five app categories (Communication, Health and Fitness, Productivity, Social, and Tools), meaning that they were not particularly

associated with any one of the categories studied. Their high frequency and proportionality across the corpus suggests that they may be used as the standard colours for app icon design. In contrast, colours grey, orange, and pink were used more by apps in certain categories: grey was used more in Tools apps, orange in Health and Fitness apps, and pink in Social *and* Health and Fitness apps (figure 13).

Figure 13: Percentage of each colour featuring in the five app categories



App downloads are interpreted as a measure of app popularity. The average app downloads from certain categories and functions received indicate what apps are popular with smartphone users and reveal the types of apps they are more likely to use. Communication apps were downloaded the most of all five categories (*M* = 111.8 million; table 6) and instant messenger apps were downloaded the most of all twelve common app functions (*M* = 174.1 million; table 7). Other popular app functions facilitated mobile printing, data transfer across mobile devices, and optimising performance of the mobile device.

Table 6: Average downloads for app categories				
Category	**Average Downloads (reported figures)**	**Average Downloads Rank**	**Average Download Logs**	**Average Download Logs Rank**
Communication	111.8 million	1	6.72	4
Health & Fitness	8 million	5	6.40	5
Productivity	70.8 million	2	6.93	1
Social	66.9 million	3	6.76	3
Tools	30.8 million	4	6.90	2
* Rank draw where indicated				

Table 7: Average downloads for app functions				
Function	**Average Downloads (reported figures)**	**Average Downloads Rank**	**Average Download Logs**	**Average Download Logs Rank**
Instant Messenger	174.1 million	1	7.31	1
Printer	131.4 million	2	7.30	2
Data Transfer	90.6 million	3	7.22	3
Cleaner	71.6 million	4	7.01	4*
Word Processing	55.6 million	5	7.01	4*
Browser	30.8 million	6	6.88	6
Video	24.3 million	7	6.81	8
Security	17.4 million	8	6.54	10
Scanner	13.0 million	9	6.87	7
Pedometer	13.0 million	10	6.70	9
Workouts	4.6 million	11	6.39	11
Mobile Network	1.4 million	12	5.91	12
* Rank draw where indicated				

Colours and shapes that associate with popular app categories and functions are more likely to connect with higher downloads. For example, overall, blue apps were downloaded the most on average (*M* = 69.81 million downloads), closely followed by white (M = 69.38 million), and green apps (*M* = 51.60 million) (table 8). These colours are frequently used in instant messenger apps too, which are the most popular type of app overall. As such, over time these colours may become associated with popular apps such that they play a categorisation role in the app market, which might encourage smartphone users to download apps displaying these colours.

Table 8: Average downloads and average download logs per colour in app icons

Colour (A-Z)	Average Downloads	Average Download Rank	Average Download Logs	Average Download Logs Rank
Blue	69.81 million	1	6.81	2
Green	51.60 million	3	6.68	5
Grey	9.99 million	9	6.62	6
Orange	20.95 million	6	6.64	5
Pink	10.11 million	8	6.37	9
Purple	20.09 million	7	6.52	8
Red	21.37 million	5	6.60	7
White	69.38 million	2	6.76	4
Yellow	43.00 million	4	6.89	1

4.1.2. Discussion: The General Use of Colours and Their Meaning in Smartphone App Icons

In this section, I discuss how colours may be useful heuristic tools for consumers to recognise successful apps or their competitors (§4.1.2a) or as colour codes that serve as brand identifiers (§4.1.2b). I also consider why there is a lack of black and brown apps in the corpus (§4.1.2c). During this section, I discuss specific examples to illustrate these points.

4.1.2a. The Colours of Successful and Competitive Apps

Due to the amount of apps available instore, it is not realistic for consumers to carefully consider all their options individually before selecting an app to download. Joeckel, Dogruel, and Bowman (2017) posit that smartphone users depend on heuristics to make faster decisions about app selection. Heuristics involve a process of *learning through discovery* based on past experiences that simplifies consumers' decision-making processes. Consumers rely considerably on the visual appearance of a product to convey information about it and often base their reasons for choosing a product on its appearance (Crilly, Moultrie, & Clarkson, 2004; Creusen & Schoormans, 2005; Bowman, Jöckel, & Dogruel, 2015). Therefore, it is reasonable to suggest that smartphone users' exposure to and experience of the app market allows them to learn to relate particular visual characteristics of a product with certain information about the product itself.

White and blue are perpetually used in the icons of apps that are downloaded more than apps using other colours, meaning smartphone users are more likely to be exposed to and engaged with apps that have white and blue in their icons. Consumers find products they are familiar with more preferable to ones with which they are unfamiliar (Campbell & Keller, 2003). Heuristically, consumers may learn to recognise these colours as relating to apps that they are familiar with, trust, and use regularly.

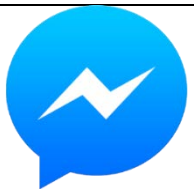
Consumers also rely on aggregated ratings (e.g. views, downloads, and star ratings) and reviews (e.g. individual reviews and comments) to inform their purchase decisions (Goldstein & Gigerenzer, 1999; Porter Felt et al., 2012; Gage Kelley, Cranor, & Sadeh, 2013). The amount of downloads an app has can contribute to the *majority vote heuristic*. Higher downloads suggests that the app is trustworthy and reliable (Henning-Thurau & Walsh, 2004; Huang & Chen, 2006). Over time, smartphone users may learn that blue and white signal apps with a higher number of downloads. By using these colours in their app icons, companies can make indirect claims about their trustworthiness and reliability. An app's colour choices can therefore operate as a persuasive tool to encourage more smartphone users to download their app.

Successful companies can popularise visual design characteristics that appear in their app icons due to their reputation in the market. Companies that provide desirable services to consumers and invest in effective marketing strategies to advertise their brand increase their perceived value and visual presence in the app market. As a result, smartphone users may be more exposed to and aware of successful apps, their icon, and its design characteristics, which increase the chances

of the app being selected instore. As discussed in section 2.3, colour codes are more memorable and identifiable in search tasks than other visual elements of an icon, including its shape and text (Christ, 1975; Sanders & McCormick, 1993; signs.com, 2017). The advantage of colour's visibility in competitive markets means it is an essential marketing tool for apps and their icons.

Interestingly, the top five downloaded apps in the corpus (Whatsapp, Facebook Messenger, Skype, Facebook, and Instagram) used the top four most frequent colours in their icons: blue, white, mixed, and green. Table 9 shows how competing apps emulate the colour and shape choices of these successful apps. The frequent colour choices of white, blue, green, and red might be perpetuated by competing apps, who want to emulate the look of successful apps in order to associate with them. This, in turn, may popularise particular visual elements such as colours and shapes in app icon design due to their desirable association with popular and reputable apps.

Table 9 demonstrates that competing apps use similar colours to successful apps: (1) WhatsApp, (2) Facebook Messenger, and (3) Instagram. Their main colours (1) green, (2) blue, and (3) mixed background a contrasting white colour that foregrounds the icon. The arrangement of these colours with the white contrast colour for the main figure may improve the visual perception of their icons instore. Due to the visual likeness between competing and successful apps, the appearance of competing apps might operate as a *strategic attention distractor* that misdirects consumer attention from popular to competitive apps in the market (Ludwig & Gilchrist, 2002).

Table 9: Competitive apps emulating icon colours (and shapes) of popular apps*			
	1. WhatsApp	**2. Messenger**	**3. Instagram**
			
A	Kik 	Messenger Messenger 	InFigures: Who viewed my Profile for Instagram 
B	free video calls and chat 	Messages, Text and Video Chat for Free 	Who Viewed My Profile? 
C	WeChat 	Messenger 	Who viewed my profile? 
D	Call Free – Free Call 	Messenger for Facebook 	Repost for Instagram 
E	Latest Whatsap status 2018 	Text Me – Free Texting & Calls 	Who Viewed My IG Insta Profile 
*displayed in order of rank in 'top apps' list in Google Play Store			

By emulating the colours (i.e. white, blue, mixed, and green) and shapes (e.g. soft squares, speech bubbles, and profile busts) of popular apps, competing apps can cue a transfer of information associated with successful apps to their own app. Successful apps have established values such as trustworthiness, reliability, and

desirability that may be born through their higher downloads (majority vote), reputation, and effective marketing strategies. By imitating popular app colour and shape choices in their icons, competitive apps may be able to relate these qualities to their app.

Competing apps may also emulate the appearance of reputable apps to signal that they serve similar functions. Some competing apps in table 9 are extensions of existing apps' function or service, and they signal the connection through their similar colour choices of existing apps' icons. App 3D in table 9 has more subtle colour coherence with Instagram compared with the others; the majority of its icon is blue with only a thin line of Instagram's distinctive mixed colours at the bottom. While app 3D may be claiming its own identity with a blue background, its relation to Instagram is still evident and suggests that its services are related to Instagram. In contrast, app 3E does not use the same or even similar mixed colours to the Instagram icon, and instead uses a green colour gradient. The app appears distinctive from the others but relates to Instagram in another way. Instead of using familiar colours, the icon has a rounded white square that resembles the abstract camera shape in the Instagram icon. Thus, the connection between the two apps is still realised and shows that not only colour but also shape can draw relations between two app icons through their resemblance.

The transfer of associated values and functions from successful apps to competing apps can be highlighted through similar visual design choices such as colour and shape. This can be critical for newly-developed apps that join a growing,

competitive market. New apps, having no reputation, can 'piggy-back' on the success of established apps by harnessing their recognised colour schemes. As more apps choose blue, white, and green for their icon designs, these colours are propagated in the app market, contributing to their high frequency. Recognising particular colour choices as relating to an existing reputable brand can package crucial information about an app that consumers can perceive and process with minimal effort and time spend.

Many app icons use similar shapes in their design, such that colour becomes a distinctive visual element that distinguishes apps from each other. For most app icons in the corpus, the background covers a larger area per pixel than other shapes and objects. The size of a target increases its chances of being noticed in competitive environments. As the size of an app icon in the market is fixed, the amount of space the background of an app icon covers in comparison to its other figures is important for its colour to be noticed more readily over other elements (Chandon, Chtourou, & Fortin, 2003; Kieras & Hornof, 2014). As discussed in §2.3 (and in §4.1.2b), colour can be very useful as a brand identifier, especially in a cluttered environment, enabling consumers to recognise an app as belonging to a specific brand. Its use in the background of an app may therefore improve app and brand visibility in the app market.

The background colour of an app icon can also create visual coherence with other visual elements in the icon itself, which creates a sense of visual harmony that can increase consumer appreciation of the product (Creusen & Schoormans, 2005).

However, Kumar and Garg (2010: 488) found that visual elements with "high levels of harmony are more likely to provide less information to consumers to process." In other words, if visual elements are too harmonious with each other, their environment, or competitors, then a product may be less likely to capture consumer attention because its appearance is too complementary. Products that appear with even a small degree of contrast are more likely to effectively capture and maintain consumer attention because the contrast offers the consumers the opportunity to decode additional information about the product.

4.1.2b. Colour as an App Brand Identifier

Colours can be perceived at a glance, even in the peripheral vision and therefore serve as useful brand identifiers that simplify consumers' market search (Hansen, Precejus, & Gengenfurtner, 2009; Kieras, 2009). Indeed, there were examples in the corpus of companies using colour coherence to draw relations between different apps and highlight a common brand (table 10). For example, *BT* apps (1) used the same deep purple colour and *Fitbit* apps (2) the same shade of blue (Cyan 600) to signal their belonging to their respective brands. *Veryfit* apps (3) had perceptually similar colours in their icons to connect them to the brand, with *Veryfit Pro* and *Veryfit for heart rate* using deep orange and *Veryfit 2.0* light red.

Table 10: Colour coherence of app icons as brand identification (and app purpose)			
	1. BT	**2. Fitbit**	**3. Veryfit**
A	BT Mobile (mobile plan management) 	Fitbit (exercise management) 	Veryfit Pro (exercise management) 
B	My BT (profile management) 	Fitbit Coach (coached exercise) 	Veryfit for heart rate (exercise management) 
C	BT Wi-fi (BT wi-fi hotspot access) 		Veryfit 2.0 (exercise management) 

Table 10 shows that apps belonging to the same brand can use similar colours in their icons to relate to each other, but also that these apps use different shapes in their icons to signify their different functions. For example, the three BT apps use a smartphone, human silhouette, and curved lines (wifi symbol) to convey their different functions to the smartphone user.

First the *BT Mobile* app (1A) has a smartphone as the main object in its icon. The iconic sign of the smartphone relates to BT's mobile service and the app's function: to enable BT members to manage their mobile phone plan. A mobile phone plan, or contract, plays a key part in how mobiles operate with regard to their minutes (calls), texts, and mobile data allowance. The smartphone can metonymically stand for

a mobile phone plan or contract, and this representation is frequently used in mobile phone advertising (Ford, 2017). Metonyms are particularly useful in communication and advertising because they can act as a sort of "shorthand" that provides conceptual access to closely related domains or concepts (Littlemore, 2015: 5). Metonymy is frequently used in advertising in general to convey more detail about a sign or a product that consumers can interpret and elaborate on, often intuitively (Pérez-Sobrino, 2017). The smartphone icon enables consumers to elaborate on the sign's signified meaning to access information about its services, such as its plan, and, when applying their elaborations to the app, it helps them to identify the app's function too.

Second, *My BT* (1B) uses another iconic sign that resembles a human silhouette. This sign is often symbolically employed as a thumbnail on websites for pages that display members' personal profiles. The sign alludes to the function of the app that allows BT members to manage their personal profiles for their BT account. Third, the *BT Wi-fi* app (1C) features three curved lines that symbolise wifi, which reveals information about the app's function to provide BT wifi hotspot access to BT members through its visual design.

Using familiar signs increases the chances for consumers understanding the app's function and positively evaluating the product (Campbell & Keller, 2003). Consumers are likely to interpret information about the app's function more reliably if familiar, recognisable shapes are used rather than obscurer shapes. For instance, while *Fitbit*'s (2A & 2B) main geometric shapes convey figurative meanings, they cue a more open-ended interpretation of the app when the app's function is unknown. For

example, 2A's multiple circles *could* represent the multiple exercises and aspects of fitness the app can help users manage; and 2B's star *might* relate to the concept of excellence that represents the quality of expertise of the fitness coach. However, these interpretations are only relatable when the app's function is known and can be very subjective to the perceiver.

When consumers are browsing the store for a new app to download, they may not know the app's function before their initial perception of the icon. Therefore, shapes that rely too much on contextual information for accurate interpretations depend on consumers' willingness to access the app's information pages for supporting information, which requires further effort on the part of the consumer. Without the contextual information, these apps may rely solely on their aesthetic appeal rather than the informative decoding of their icons by consumers. Fortunately for Fitbit, the brand is already very successful and well-known, so when the icon is accompanied with the app's name, the brand is likely to be recognised. Therefore, the company can afford to use basic, geometric shapes that are more open-ended in their meaning.

4.1.2c. The Lack of Black and Brown in App Icons

According to Labrecque and Milne (2012), the majority of modern app icons often use colours blue, red, and black. While the colour blue was found to be very frequent and red fairly frequent in the corpus, supporting Labrecque and Milne's (2012) findings, black and brown were identified the least in app icons. Although black and brown

colours can have positive connotations in marketing (see table 2, §2.5.1), and are often used by corporate businesses to convey a tone of seriousness and professionalism, they also have very negative connotations across cultures, symbolising concepts of death or evil (black) and dirt (brown) (Adams & Osgood, 1973). Despite some successful companies using black in particular as their brand colour, such as *giffgaff* and *WeTransfer* (figure 14), that stands out in a colourful marketplace, many other companies may choose to avoid these colours to save risking the negative interpretations consumers may have of these colours. However, it must be noted that the corpus only analysed app icons from five categories. With this in mind, the colours identified only reflect those used in this sample of app categories.

Figure 14: *giffgaff* and *WeTransfer* app icons

4.1.3. Discussion: The Use and Meaning of Common and Distinctive Colours in Smartphone App Icons

In the following subsections, I first discuss the top four most common classifiable colours in smartphone app icons: white (§4.1.3a), blue (§4.1.3b), green (§4.1.3c), and red (§4.1.3d). Second, I discuss more distinctive colours that indicate some association with specific app categories: orange (§4.1.3e), pink (§4.1.3f), and grey (§4.1.3g). Finally, I explore the distinction between warm and cool colours in smartphone app icons (§4.1.3h). Each colour is considered both independently and together with

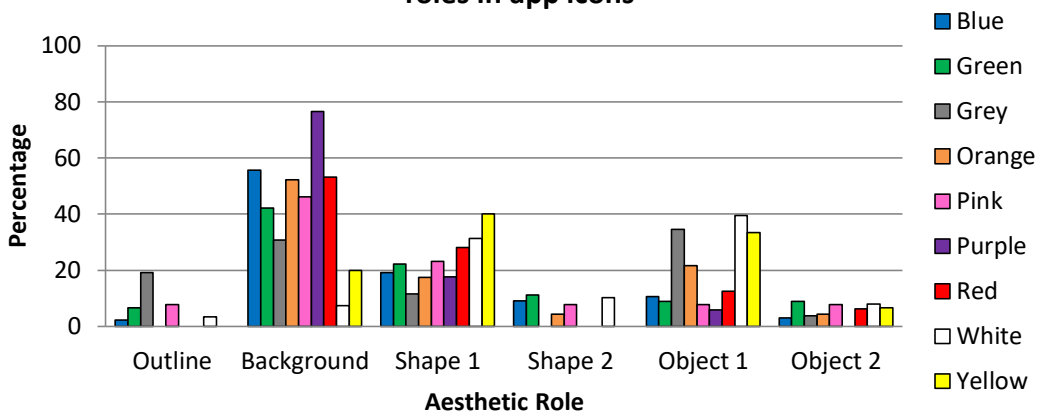
complementary elements including other colours and shapes so as to enlighten the meaning of the colours on their own and with regard to their contextual environment.

4.1.3a. White

White was the most common colour in the corpus of app icons (31%, *N* = 179 of 574). While the colour was not associated with any particular app category, it did feature in apps with certain functions more than others (chi-square test of independence: χ^2 = 24.35, *df* = 8, *p* = 0.002). White was frequently used in apps that functioned as instant messengers (*N* = 28). Of a total 33 Instant messenger apps that were identified in the corpus (accounting for 16.5% of all apps), 87.9% (*N* = 29) had white in their icon.

In order to understand how white is used in smartphone app icons, it is important to observe its application not only on its own, but also in its assemblage with other elements, where it may convey further meaning (Kress & Van Leeuwen, 2002). White was used primarily as a visual contrast between the background and the main shape or object of an app icon (figure 15), which increases the salience of these figures by drawing attention to them (see table 9, §4.1.2a & table 10, §4.1.2b). The figures themselves may subsequently convey key messages to the consumer about the app.

Figure 15: Percentage of each colour playing different aesthetic roles in app icons



In the instant messenger app icons white appeared in, 55% (*N* = 16) co-occurred with the colour blue and 27.6% (*N* = 8) with the colour green, which were usually the background colour.[4] All instances of blue and green in instant messenger apps also co-occurred with white, suggesting that colours white, blue, and green may frequently co-occur together, which might help explain why these colours are all highly occurring app icon colours in general.

According to previous studies, white can symbolise luxury, sincerity, and clarity (see table 2, §2.5.1). Many popular technological products on the market, from cars to computers to smartphones, are white in appearance (e.g. Kelley Blue Book, 2018; Olesen, 2018). White products can convey a sense of luxury and reflect the high standards of the owner, as they can be difficult maintain and keep clean. The pure colour of white can relate to the value of sincerity. Its use in app icons may portray apps as being more sincere and willing to help consumers. Many people are intimidated by the visual and functional complexity of modern technology (Feldman,

[4] N includes the colour of text in IM app icons

1995). A product's appearance can inform consumers of the product's ergonomic value and ease of use, and using white can associate it with clarity and simplicity. Apps that have a clearer, simpler design may ease the perception of the app and suggest that because it appears to be simple, it is also simple to use (Sanders & McCormick, 1993).

Having white as a contrasting colour may serve to highlight the information carried by the other shapes and objects in the icon. Indeed, the colour white can draw attention to the shape or object that takes its hue due to its contrast with the other background colour/s in the app icon (as seen in table 9, §4.1.2a & table 10, §4.1.2b). It can also serve as a neutralising colour that blends with the Google Play Store background. Figure 16 shows how the *imo* app has a white square background that is hardly noticeable, even when it contrasts with the blue speech bubble. The colour contrast between the icon's background and main shape fortunately makes it easier to perceive the speech bubble. Speech bubbles are almost exclusively used in instant messenger app icons, giving a clearer idea to consumers about what the app is and what it does (for more on speech bubbles, see §4.2.3c).

The 180 app has a green outline that defines the app against the Google Play Store's background. Yet, the choice of white as the app background colour here, again, plays a neutral, non-intrusive role that instead of capturing attention itself, leads the attention to other elements of the icon that are more likely to carry meaning. With the help of the neutral white colour contrast, the 180 app icon draws attention to the

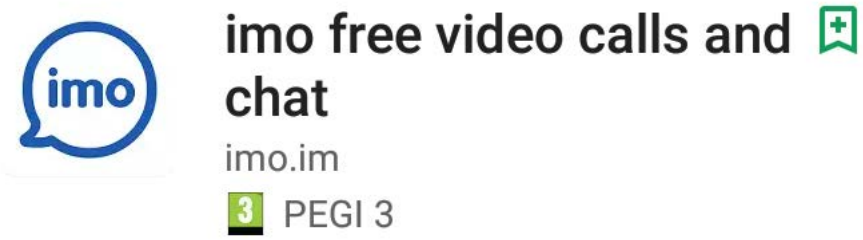
green colour coherence of the outline and text that creates a visual harmony in the icon, which improves its aesthetic appeal and highlights its name to consumers.

The ubiquity of white in app icon design across the corpus suggests that it could be entrenched in the visual discourse of app icon design in general. White can communicate values including luxury, sincerity, and simplicity; however, its more practical role might mean that smartphone users do not necessarily interpret its signified meanings. White's role as a neutral colour serves as a visual contrast to highlight the main figures, or other shapes and objects, in the icon that may carry additional meaning about the app or foreground the colour coherence of other colours. Nevertheless, apps with white in their icon were downloaded the second most (M = 69.4 million) in the corpus, closely following apps with blue in their icon (M = 69.8 million), showing that it is certainly a common colour choice for app icon design.

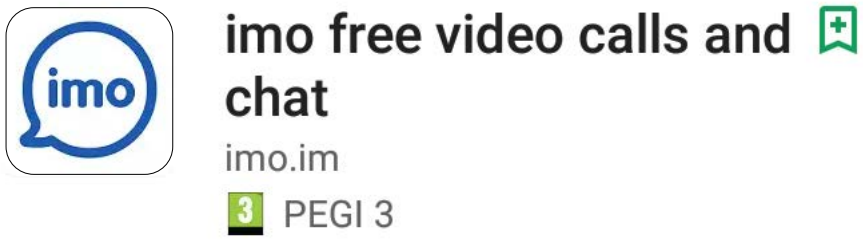
Figure 16: The *imo* and *180* apps exemplify how some apps use a white background to neutralise the background colour and ease the perception of other visual elements in the app icon

See the original app icon (a) compared to the highlighted background square (b). *Note: on some screens, the original square background may not be perceivable; in which case, refer to the 'background square highlighted for demonstration only'.*

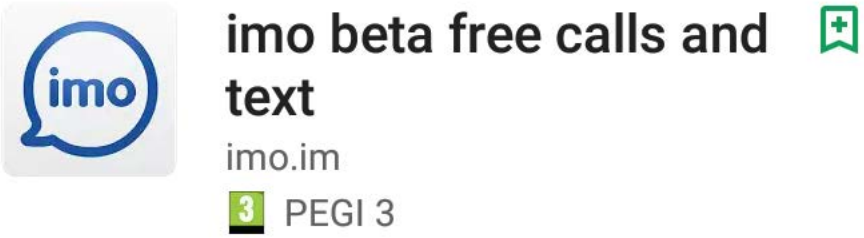
(a) Original app icon, as seen in the Google Play Store:



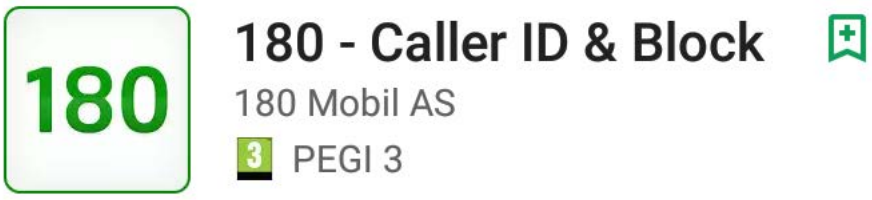
Background square highlighted for demonstration only:



(b) Original app icon for different version of *imo* app, known as *imo beta*:



Original app icon with an outline:



4.1.3b. Blue

Blue was the second most common colour in smartphone app icons (23%, *N* = 134 of 574). Similar to white, the colour blue was not associated with any particular category; however, it did occur in the icons of apps with certain functions more than others (chi-square test of independence for functions: $\chi^2 = 43.714$, $df = 19$, $p = 0.001$). Blue was most frequently used in instant messaging apps (*N* = 18), followed by security apps (*N* = 13). A total of 16 security apps were identified (accounting for 8% of all apps in the corpus), of which 68.8% (*N* = 11) had blue in their icon, and of these 63.6% (*N* = 7) co-occurred with the colour white (table 11).[5] The majority of security apps use white as the colour of the main object, with a blue background, which reflects the general trend of app icon design (e.g. table 9, §4.1.2a & table 10, §4.1.2b). Blue featured as the background colour 54% of the time (*N* = 75) and as the main shape for only 10% (*N* = 25). The evidence that white and blue frequently co-occur in app icons, and their commonality across app icons in general, suggests that they may be considered as the standard colours for app icon design.

The colours blue and white have complementary meanings. Blue can convey a sense of competency and trustworthiness (see table 2, §2.5.1), which is perhaps why it is often used by security apps that promise protection from software bugs or viruses. White has an association with cleanliness. The semiotic meaning of colours white and blue complement each other. Many security apps also claim their ability to "clean" the phone to "boost" its performance, in addition to providing competent, trustworthy antivirus protection.

[5] Including the colour of text in security app icons

Table 11: Security apps		
A. Security Elite – Clean Virus, Antivirus, Booster 	**B.** Virus Cleaner (Hi Security) – Antivirus, Booster 	**C.** Network Protector – Security and Speed Test 
D. Network Security – Fast Cleaner & Speed Booster 	**E.** Net Protector – Security & Speed Test 	**F.** Power Security-Anti Virus, Phone Cleaner & Booster 

Security app icons not only use colours that have complementary meanings for the app, but also use particular shapes that provide further information about the app's function. Demonstrated in table 11, the shield occurred 7 times in security apps of a total of 13 instances identified in the corpus. The shield symbolises a defence against other forces in battle. Viruses relate to disease or illness that can infiltrate and infect a body or entity, and we, as humans, often frame viruses as a battle against illness or evil (e.g. Semino, Demjén, & Demmen, 2018). The shield thus conveys a figurative message that metaphorically frames software viruses as enemies that need to be fought and defended against. The defence of the shield is provided by security apps and their protective function is conveyed by their use of the object in the app icon.

Contrary to expectations, the cognitive associations of blue and white colours and the figurative associations of the shield shape in security apps do not correlate

with a higher number of downloads than security apps without these visual elements. As such, while the colours blue and white and the shield shape may be said to be informative about what the security app is, what it does, and how well it performs, they may not be persuasive enough to influence the download rate. The blue colour and shield shape are arguably more common in security app icons as they appear more often than not, and so might be considered more conventional visual characteristics for that type of app's icon. More distinctive app icons for security apps may instead be more effective in increasing download rate, such that products with a novel or distinctive appearance can engage consumer attention and increase consumer preference (Schoormans & Robben, 1997; Rindova & Pekova, 2007).

In order to establish whether more conventional visual design in app icons (e.g. blue, white, and shields in security apps) or distinctive visual design effect download rates, a longitudinal study should test whether a change in colour can influence a subsequent change in download rate.

4.1.3c. Green

Green was the third most common classifiable colour in the corpus (N = 45 of 574) and featured significantly in the icons of apps that functioned as instant messaging apps (N = 10; chis-square test of independence for functions: $\chi^2 = 77.189$, $df = 24$, $p < 0.001$). Green always co-occurred with white in these app icons. Green's aesthetic role in app icons was as a background colour 42% of the time (N = 19) and as a main shape for 22% (N = 10) of the time.

Green has strong associations with health, nature, and positivity (see table 2, §2.5.1). The use of green in app icons other than instant messenger apps utilised these relations to convey what the app does. *Lifesum* is a diet tracker from the Health and Fitness category and uses a muted green soft square with an inner circle formed from a white semicircle joining a darker green semi-circle that resembles a progression or health bar (table 12).

Foodstuffs often use 'natural' colours and muted tones such as green, browns, and pastels in addition to rounded and smooth shapes to relate to the organic properties of a product (Oswald, 2012: 52-53; Ngo, Piqueras-Fiszman, & Spence, 2012; Kress & Van Leeuwen, 2006). Using green and rounded shapes in *Lifesum*'s icon reinforces its focus on tracking food consumption and providing recipes for their users to eat healthily. Progression or health bars are commonly used in gaming and help us to conceptualise how our health can be improved or damaged as a consequence of our actions (Brown, 2018). By using a progression or health bar, *Lifesum* suggest that using their app improves the user's life and helps them to achieve a healthier self.

Table 12: The colour green used in apps icons to symbolise health, energy, and nature	
Lifesum – Calorie Counter, Macro Tracker & Recipes 	Power Battery – Battery Lifesaver & Health Test 
Forest: Stay Focused 	Nextdoor 

The *Power Battery* app constitutes a green background with a white battery containing green fluid. The green in the icon may, in part, be motivated by an association with a healthy life and also the general convention of power buttons being green. Indeed, English speakers often say that when they are tired they are 'running low on energy' or 'need to recharge', and compare their lack of energy to that of a machine; when a machine runs low on power, it ceases to work properly or at all (Pérez-Sobrino & Littlemore, 2017). The app's name "Battery Lifesaver & Health Test" and description, "Save your battery life and improve your battery health" assists the comparison with battery power and human life. The green colour, the app's name, and its description help frame the association between the battery sign and the concept of a human life that is healthy and full of energy as a metaphor, such that *Battery is Life (Energy*).

Natural colours green and brown are used by the *Forest* app, which encourages users to plant and grow trees in a virtual garden whilst they work to improve their

productivity. The green colour in the Forest app's icon draws on its conventional association with the environment and nature. Furthermore, the green plant may be used to represent the concept of growth. Arguably, the plant in the Forest app metaphorically represents the growing productivity achievable for users with this app.

Meanwhile, *Nextdoor* is a private social networking app for neighbours. Nextdoor imply that their app's integration with neighbour interaction is a natural and positive experience through its use of the colour green in the icon. The greens and browns used in the icon are also coherent with the app's cover graphics located at the top of the app information page, which depicts a natural, forest environment, and suggests that the goodness of nature has positive evaluations. By using these natural colours in their icon, Nextdoor are claiming that their app's function as a neighbourhood social networking service is natural and positive.

Overall, green's symbolic meanings for life, health, nature, and positivity are utilised by apps in their icons. The qualitative analysis demonstrates that while the colour green sets up these associated meanings, the icon's shape and app's description can guide the interpretation to reach more salient messages about the app.

4.1.3d. Red

Red was the fourth most frequent classifiable colour identified in app icons (*N* = 33 of 574) and featured mostly as the colours of the background (52%, *N* = 17) or main shape (27%, N = 9). Red was used significantly in the icons of apps that functioned as

workouts, mobile networks, and ad blockers (*N* = 6, 5, 4 respectively; chi-square test of independence for functions: χ^2 = 58.069, *df* = 24, *p* = 0.0001).

The meaning of the colour red has been extensively researched and found to regularly represent activity and arousal (see table 2, §2.5.1). Workout apps involve intense physical activity as part of their app engagement, which relates to red's cognitive associations, and the colour red featured in 38.5% (*N* = 5 of 13)[6] of workout apps (table 13). The colour red also draws on human physiological reactions to exercise; our bodies go red when blood rushes to the surface of our skin while we exert ourselves. Physiological connections with colours demonstrate how we use embodied and physical experiences to aid our understanding of each other and other beings in our environment (Littlemore et al., forthcoming).

The shapes in the workout app icons are metonymically linked to exercise and bodybuilding, which reveals more information about the app's function. Each app's main figure focuses on part of a whole object, which is either a male's muscular torso (apps A and B), a weight (C), or bicep (D) that stands for the consumer or an aspirational figure (A and B), the activity of body building itself (C), or the power gained from doing so (D).

[6] Including the colour of text in workout app icons

Table 13: Workout apps with male target audience use red in their icons

A	B
  Home Workout - No Equipment Leap Fitness Group	  6 Pack Abs in 30 Days - Abs Workout Leap Fitness Group
C	**D**
  Fitness & Bodybuilding VGFIT LLC PEGI 3	  ManFIT - Workout at Home with No Fitness Equipment Health Group: Fitness, Eyes Protect, D..

Interestingly, the red workout apps are largely aimed at a male audience, which is implied by the app's icon and cover graphics that focus on the shapes of male torsos, muscles, and weights. Female figures are also used in workout apps, but these apps primarily use mixed colours in their icons. Red can associate with anger and aggression (Hupka et al., 1997; Fetterman et al., 2010; Littlemore et al., forthcoming), which are stereotypically masculine traits (Archer, 2004). The connection with red and the male-oriented figures may be being used to associate workout apps targeting a male audience with masculinity and typically masculine associations.

4.1.3e. Orange

Orange, which is closely related to red, was used significantly more in the Health and Fitness category than any other category (chi-square test of independence for categories: $\chi^2 = 11$, $df = 4$, $p = 0.03$). As the Health and Fitness category includes apps that encourage physiological experiences external to the app itself, such as waking up, meditating, walking, and running, the orange colour used in apps like pedometers ($N = 4$) and alarm clocks ($N = 2$) may be used to demonstrate that these apps do what they are designed for – to encourage and monitor activity.

4.1.3f. Pink

Pink was used more in Health and Fitness and Social apps than in other app categories. The colour appeared in apps that functioned primarily as period trackers ($N = 4$), heart rate monitors ($N = 3$), and dating apps ($N = 2$). The choice of pink over red deliberately softens the visual impact of the app and utilises pink symbolically. Period tracker apps may have chosen pink when representing menstrual blood to emphasise femininity (Koller, 2008). The pink hearts in the dating apps draw on the symbolic connotation of a heart, meaning love. Choosing pink as a cooler colour to represent an affectionate and tender love compared to the hot, lustful, passionate red, suggests that the dating apps advocate a love that lasts, rather than one that might burn out. The colour choice of pink therefore presents key messages about the values of the app's dating company and suggests that the app aims to facilitate love and long-term relationships rather than lust and short-term desire.

4.1.3g. Grey

Grey was used the most in the Tools app category (38.5%, *N* = 10 of 26). For the majority of instances, its aesthetic role was as an object (e.g. printer, paper, car, or TV screen), which alluded to the function of the app involving the represented items. These objects are useful for accomplishing particular tasks; for example, managing mobile printing, car maintenance and repairs, or enabling users to control the TV with their smartphone acting as a remote control. Typically, physical tools are often associated with constructive instruments such as hammers, screws, and cogs, which are generally grey in their metallic appearance. Indeed, the settings app on all smartphones is usually represented as a grey cog, comparing the cog in a machine contributing to its efficient operation and the purpose of the settings app being to improve the operation of a smartphone – the machine in question.

While grey was used more in the Tools category, no particular function of app demonstrated a trend for using grey in their icon, save perhaps the sense of it being a practical application. Grey apps were connected with the lowest downloads of all common colours identified in the corpus (see Average Downloads, table 8, §4.1.1), suggesting that grey is not rated as a particularly attractive colour in app icon design. Its use in the Tools category, however, shows that it is used mainly for representing practical objects.

4.1.3h. Warm and Cool Colours

Many researchers distinguish warm from cool colours (Townsend, 2017). Typical warm colours are red, orange, and yellow, and typical cool colours are blue, purple, and green. Online marketing using warm colours is more likely to generate attention, physiological arousal, and increased consumer engagement than using cool colours (Lohtia, Donthu, & Hershberger, 2003; Moore, Stammerjohan, & Coulter, 2005; Magee, 2012; Sokolik, Magee, & Ivory, 2014). Harnessing warm colours over cool colours in app icon design may allow companies to draw on relations with activity, as red does (§4.1.3d), and elicit increased consumer engagement with apps available on the market so that they are more likely to be considered for download. However we know from the quantitative corpus analysis results (§4.1.1) that cooler coloured apps were downloaded more than warmer coloured apps.

Further analysis of the app icon background colours discovered that all five app categories studied had a preference for cool colours (i.e. blue, purple, and green) over warm colours (i.e. red, orange, and yellow). Productivity and Health and Fitness categories that required more active engagement from consumers used more warm colours in their icons than other categories Communication, Social, and Tools that can operate with passive engagement from consumers. Although the differences were not significant ($p > 0.05$), the results suggest that the background colour might be indicative of the varying engagement consumers are expected to have with these apps. However, in order to confirm this idea further testing would be need to be carried out in a future study.

4.2. Study 1: What Shapes are Used in Smartphone App Icons and What Do They Communicate?

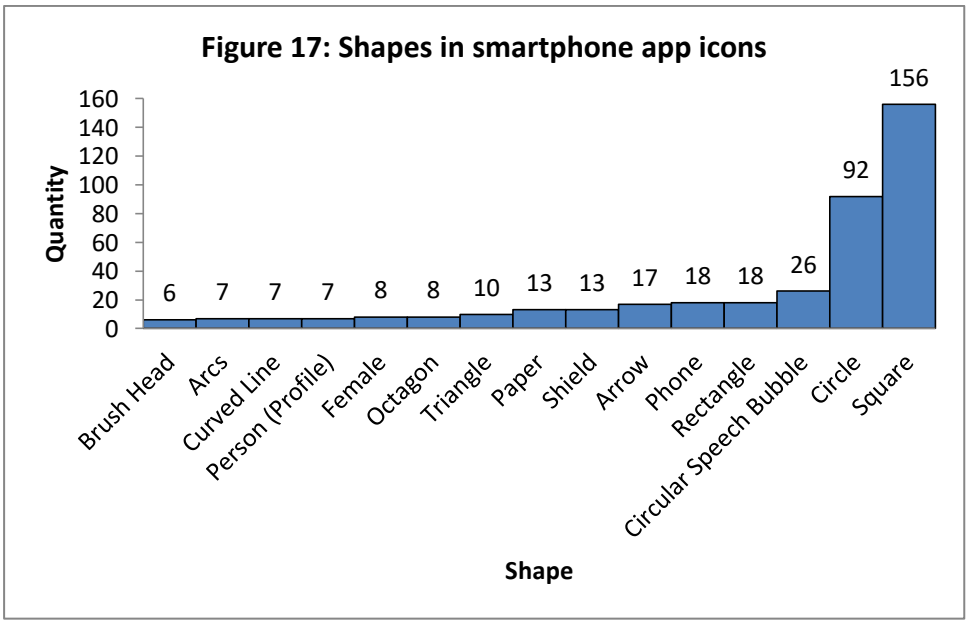
Having previously looked at colours, we must now look at shape in smartphone app icons. This section first reports the quantitative results (§4.2.1) and then discusses the qualitative results with examples for the use and meaning of shape in smartphone app icons in general (§4.2.2), and for common and noteworthy instances (§4.2.3).

4.2.1. Quantitative Results for the Use of Shapes in the Smartphone App Icon Corpus

A total of 577 instances of shape were identified across the corpus of 250 app icons. The difference in the frequency of shapes identified in app icons was significant (chi-square test of equal proportions: $\chi^2 = 6268.6$, $df = 110$, $p < 0.0001$). The most common shapes were squares (27%, $N = 156$), circles (16%, $N = 92$), and circular speech bubbles (5%, $N = 26$). Overall, 171 shapes occurred less than 6 times in the corpus and were excluded from further analysis due to their low data points. There were 105 instances of text occurring in app icons (table 14). For the majority of cases, these were the words (42.9%, $N = 45$) or initials of the app's name (40%, $N = 42$), and were either the first word or letter (51%, $N = 54$) or the second word or letter (22.9%, $N = 24$). The meaning of text in app icon design and its impact on consumers was not the focus of the thesis but requires investigation in another study.

Table 14: The role text in app icons	
Role	**Frequency**
First Initial Letter	29
First Word	25
Second Initial Letter	12
Second Word	12
Number	8
Letter & Number	3
Multiword (App Name)	8
Multiword (Other)	4
Other	4
TOTAL	**105**

Figure 17 displays the shapes identified in the corpus of app icons, excluding shapes with less than 6 data points (N = 171) and text (N = 105).

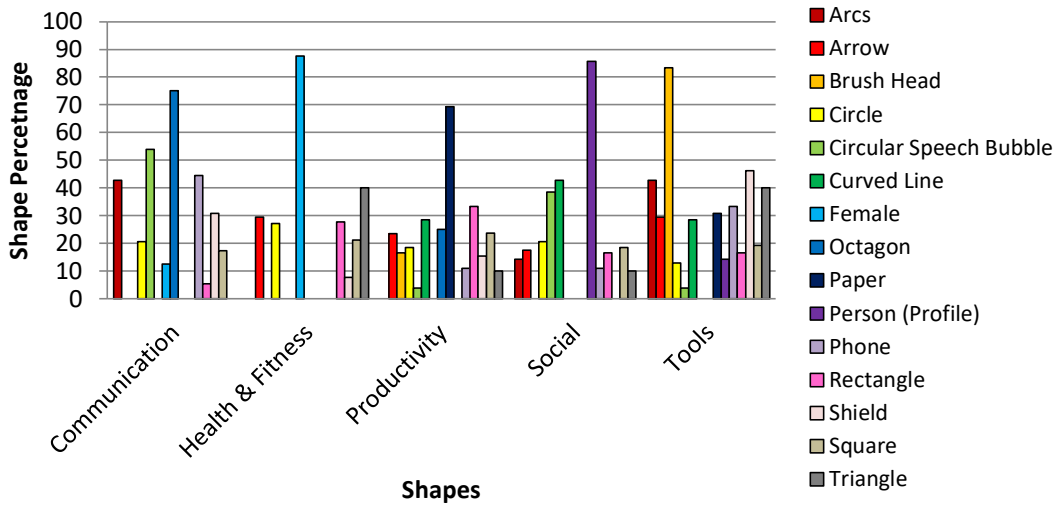


Different shapes were used in the icons of apps from different categories (chi-square test of independence for categories: $\chi^2 = 183.95$, $df = 56$, $p < 0.001$; figure 18), suggesting that particular shapes might be associated with certain app categories.

Squares and circles were proportionally distributed across four of the five app categories, but squares appeared more in the Tools category and circles in the Health and Fitness category than expected compared to other shapes. Although, for the categories these shapes appeared in, they did not feature in any one category significantly more than others (chi-square test of independence: $p > 0.05$). The high frequency of squares and circles and their fairly even distribution across categories suggests, similarly to colours white and blue, that they might be used as the general shapes for app icon design.

Meanwhile, circular speech bubbles were used considerably more in Communication and Social app categories than other categories (chi-square test of independence for categories: $\chi^2 = 31.31$, $df = 4$, $p < 0.0001$). Moreover, other shapes were used more in certain categories than others: octagons and phones featured more in Communication, female figures in Health and Fitness, paper in Productivity, and brush heads in Tools. These shapes may provide useful information for decoding the app's category and function, and are explored further in §4.2.3.

Figure 18: Percentage of each shape featuring in the five app categories



The average downloads for common shapes revealed that circular speech bubbles featured in apps that were downloaded the most (M = 192.69 million), followed by apps with a phone (M = 120.73 million), and brush head (M = 120 million) in their icons (table 15). The higher downloads for apps with circular speech bubbles, phones, and brush heads might relate to the type of app smartphone users tend to download or that are more popular on the market: circular speech bubbles almost exclusively occurred in instant messenger apps; phones were used in the icons of apps that were call managers or smartphone flashlights; and brush heads were used in cleaner apps that optimise smartphone performance.

The shape could possibly have an influence on the selection process; for instance, if Communication apps are popular, people may find a Communication app more easily if it has a common shape in its icon that has a recognisable communicative meaning, such as a speech bubble or phone. If the shape represents popular app

categories and/or functions in the app store then then it may be more likely that they are downloaded. This idea is explored in §4.2.3 with common and noteworthy shapes.

Comparatively to speech bubbles, phones, and brushheads, apps with squares and circles were downloaded 48.5 million and 30.4 million times respectively. Lower downloads for these frequently used shapes imply that squares and circles do not evoke associations with apps that are necessarily desirable for smartphone users. However, they may instead be used as generic shapes in app icons, and be overlooked by smartphone users who are accustomed to an app's visual design. These results suggest that some shapes may mean more to smartphone users than others. Shapes that have a distribution bias toward certain categories may aid consumer decoding of what the app is, what it does, and how well it performs, and signify the types of apps consumers are looking to download.

Table 15: Average Downloads, Average Download Logs, and ASRs for shape in app icons				
Colour (A-Z)	**Average Downloads**	**Average Download Rank**	**Average Download Logs**	**Average Download Logs Rank**
Arcs	75.30 million	4	6.63	9
Arrow	13.62 million	11	6.89	6
Brush head	120.00 million	3	7.68	1
Circle	30.39 million	9	6.66	8
Circular speech bubble	192.69 million	1	7.27	3
Curved line	47.14 million	7	7.34	2
Female	14.88 million	10	6.30	13
Octagon	4.25 million	14	6.42	11
Paper	34.82 million	8	6.90	4*
Person (Profile)	671 thousand	15	5.67	15
Phone	120.73 million	2	6.90	4*
Rectangle	6.64 million	13	6.19	14
Shield	12.72 million	12	6.47	10
Square	48.56 million	6	6.69	7
Triangle	54.31 million	5	6.37	12
* Rank draw where indicated				

4.2.2. Discussion: The General Use of Shapes and Their Meaning in Smartphone App Icons

In this section, I discuss the kinds of forms smartphone app icons take and their meaning potential (§4.2.2a), followed by the two most common shapes in app icons, squares and circles, and their use as a kind of container of the app (§4.2.2b).

4.2.2a. The Hard, Soft, and Hybrid Forms of App Icons and Their Meaning

As discussed in §2.5.2, the form of shapes can elicit meaning through their resemblance with structures in the environment and their cognitive associations. Hard, geometric shapes are often associated with scientific, mechanical, and digital technology (Mondrian, in Jaffé, 1967: 54-55; Creusen & Schoormans, 2005; Piqueras-Fiszman et al., 2010).

Therefore, it was expected that hard forms may be more prevalent in app icons than soft forms due to its association with technological objects and products. However, soft forms dominated shapes in smartphone app icons (chi-square test of equal proportions: $\chi^2 = 361.08$, $df = 2$, $p < 0.0001$). The commonality of softer forms is contributed to by the high frequency of circles and soft squares in app icons. Softer forms may present apps as more sentimental and considerate than harder forms, which can be considered more robust and vigorous, and may encourage consumer engagement with the app technology.

Different forms were used by some categories more than others (chi-square test of independence for categories: $\chi^2 = 41.73$, $df = 8$, $p < 0.0001$). For instance, the Health and Fitness category had apps that used more soft forms and Productivity category with apps that used harder forms in their icons compared to app categories overall. Softer, rounder forms can be associated with being organic in food marketing (e.g. Ngo, Piqueras-Fiszman, & Spence, 2012), and may present a more 'natural' and 'healthy' form for apps in the Health and Fitness category that encourages healthy living, balanced dieting, exercise, and meditation. Harder forms can be associated with more scientific or mechanical meanings and represent a practical application for the Productivity category that aims to assist in accomplishing tasks in addition to aiding the user's organisation.

Whether these are conscious associations smartphone users have of app icons as a result of using these forms in particular categories may be established in study 2. I thus expect to see that, if smartphone users are aware of the associations discussed above, they will evaluate: (a) soft forms of app icons as more typical for the Health and Fitness app category, giving this category a higher typicality ranking than other categories; and (b) hard forms of app icons as more typical for the Productivity category than other categories.

4.2.2b. Squares and Circles as App Containers

Squares and circles were employed primarily as the background of the app icon (squares: 84%, $N = 131$ of 156; circles: 49%, $N = 45$ of 92). In this role they act as a kind

of container for the app icon, which could arguably be conceptually extended to represent squares and circles as a container of the app's content. Squares and rectangles contain and departmentalise our world, dominating the structure of buildings and frames (Kress & Van Leeuwen, 2006). Circles are also considered to be "self-contained" shapes (Kress & Van Leeuwen, 2006: 54).

The container schema is well documented in language and cognition (Grady, 1997; Radden & Kövecses, 1999: 41; Lakoff & Johnson, 2003: 29-32). Previous research has found that we conceptualise the virtual, online world as a space through which we can traverse, whilst this world is also being contained within our technological devices, computers, and mobile phones (Maglio & Matlock, 1998; Matlock et al., 2014; Ford, 2017). Ford (2017) found that mobile phone advertisements frequently represent mobile phone handsets and sim cards as concrete containers for their virtual features such as their apps and mobile phone plans (including texts, calls, and mobile data). These studies suggest that using shapes that are associated with containment might aid the construal of virtual products such as the smartphone app when they are used to visually represent the containment of an app icon and its content. As such, using a square or circle in the background of an app icon might help consumers understand that the abstract, virtual content of the app, its services, and functions are contained within the app and can be accessed by interacting with the app icon.

Moreover, the container schema may be more dominant when squares and circles are used in the outline around the shape of the app, when there is something inside the space of the outline; although, there were fewer examples of apps having

explicit outlines in their icons compared to backgrounds. In this vein, background shapes such as squares and circles can also be said to 'contain' the main geometric shapes and objects of the icon.

4.2.3. Discussion: The Use and Meaning of Common and Noteworthy Shapes in Smartphone App Icons

In the following subsections, I first discuss the top three most common shapes in smartphone app icons: squares (§4.2.3a), circles (§4.2.3b), speech bubbles (§4.2.3c); and other noteworthy objects that occurred fairly frequently, including phones (§4.2.3d), brush heads (§4.2.3e), octagons (§4.2.3f), and animals (§4.3.2g). Each shape is considered both independently and together with complementary elements including other shapes and colours so as to study the meaning of shapes in smartphone app icons independently and in their environment.

4.2.3a. Squares

The square was the most common shape in the corpus of app icons (27%, *N* = 156 of 577). Squares were proportionally distributed across all five app categories for the app icons it appeared in, suggesting that it might be used as one of the standard shapes for app icon design. Squares were predominantly represented in their soft form, with rounded edges (80.8%, *N* = 126 of 156), as opposed to their hard from, with angular edges (19.2%, *N* = 30).

Squares have multiple cognitive associations that may communicate different messages about the app when used in app icon design. First, squares can convey a sense of seriousness and dignity (Hevner, 1935). Yet, soft squares (squares with rounded edges) in the background of app icons may present apps as being more approachable and inviting rather than serious and proud. Squares are often used as an archetypal button shape, which might invite consumer-product interaction with the app through the ergonomic implication of its appearance in the icon. Indeed, it is the app icon itself that smartphone users actually engage with to open and use the app on their smartphone.

Second, squares are considered to be honest and straightforward geometric shapes, which might contribute to the perception of an app's simplicity in design or operation (Dondis, 1973: 44).

Third, squares can be associated with order and uniformity (Thompson & Davenport, 1982: 110). The ubiquity of squares, particularly in their more common soft forms, provides uniformity to app icon design. These app icons appear orderly arranged on user smartphones, which means that apps can fit neatly in a grid-like arrangement in the Google Play Store and on a smartphone home screen. The practical uniformity and organisation of the apps enables users to locate their apps efficiently and build habitual app engagement (Kieras & Hornof, 2014). The commonality of squares in the background of app icons may increase smartphone user familiarity with apps using this kind of visual icon design. As such, the familiarity and uniformity of square app icons might elicit higher appeal ratings from smartphone

users (Campbell & Keller, 2003); an expectation that will be observed in the results for study 2 (§4.3).

4.2.3b. Circles

The circle was the second most common shape used in app icons (16%, *N* = 92 of 577) and was fairly proportionate across all five categories, except for being overrepresented in the Health and Fitness category compared to other shapes (see figure 18, §4.2.1). When circles appeared in app icons, however, they were distributed equally across categories and so may be employed as another standard shape in app icon design, similarly to squares. In addition to being used as a background or 'container' of the app (as discussed in §4.2.2b), circles featured as the main shape of the app 29% of the time (*N* = 27 of 92). They were also found more in apps functioning as a pedometer (*N* = 8) in the Health and Fitness category, video apps (*N* = 7) in the Social category, and mobile network apps (*N* = 7) in Communication, Productivity, and Tools categories (chi-square test of independence: $\chi^2 = 43.71$, $df = 19$, $p = 0.001$).

The evidence for circles appearing in apps with different functions, and being overrepresented in the Health and Fitness categories compared to other shapes, could mean that circles communicate different messages. Circles are associated with being harmonious (Kress & Van Leeuwen, 2006: 54; Kumar & Garg, 2010). In Health and Fitness apps, circles may represent the act of staying 'harmonious' with oneself. Apps that function as a pedometer, heart rate monitor, and alarm clock track the improvement and maintenance of one's physical and mental wellbeing through

activities such as running, walking, sleeping, and meditating (table 16). Circles might be useful to represent these Health and Fitness apps as being natural and organic because they help to improve user health (Kress & Van Leeuwen, 2006). Circles also associate with endlessness and may therefore represent the continuous process of exercise (Hevner, 1935).

Table 16: Health and Fitness apps with different functions (in brackets) and circles in their icons	
A. Sweatcoin Pays You To Get Fit (Pedometer) 	**B.** Fitbit (Pedometer) 
C. VeryFitPro (Pedometer) 	**D.** Strava Running and Cycling GPS (Pedometer) 
G. GO Clock - Alarm Clock & Theme (Clock) 	**H.** Alarm Clock & Themes – Stopwatch, Timer, Calendar (Clock) 
I. Headspace: Guided Meditation & Mindfulness (Meditation) 	**J.** Fabulous: Motivate Me! Meditate, Relax, Sleep (Meditation) 

In Health and Fitness apps (table 16), circles drew on relations with tangible objects, such as a clock (G & H) and the sun (I & J), which are both typically circular. Relating to these physical objects using a resembling shape enables consumers to access information about these objects that they can then apply to the app itself. For instance, designers may choose to represent the typical visual characteristics of a clock and its face in clock apps to encourage consumers to identify the iconic resemblance between a clock's function and the app's icon. Consumers might then be able to decipher the app's claim of being a clock and having its capabilities. The app's appearance as something familiar and tangible may also improve its chances of being trusted and considered for download (Campbell & Keller, 2003). Furthermore, the *Fabulous* app (J) depicts the orange, circular sun as part of a beach or sunset scene; a scene that many consumers are likely to recognise, and which many guided meditations try to recreate as a relaxing place to visualise.

Using circles in the icons of apps that facilitate communicative functions may represent the idea of staying connected with family and friends. The circle shape might associate these apps with creating a community that revolves around or encircles the user and keeps users connected with their own network or 'social circle'. Circles are used by some mobile network apps from Communication, Productivity, and Tools categories (table 17).

Table 17: Mobile network and video apps with circles in their icons (function defined in brackets)	
K. My EE (Mobile Network) 	**L.** MyLebara Top-up (Mobile Network) 
M. Tesco International Calling: Cheap Calls, Free SMS (Mobile Network) 	**N.** My Vodafone (Mobile Network) 
O. Periscope – Live Video (Video) 	**P.** Ripl: Make Eye-Catching Videos (Video) 

Some video apps, however, use circles to resemble the human eye. For example, the *Periscope* app (O in table 17) implies that the red circle is an eye. The app's name informs us that the visual representation of the icon might be a periscope. Thus, the blue background represents the sea, the white 'tab' shape represents the periscope instrument, and the red circle inside represents the window that indexes the eye of the beholder surveying the scene through the periscope from below water. The eye symbolically indexes sight and visualisation, which relates to the visual mode of videos that has to be watched.

The relationship between the human eye and sight is also harnessed by *Ripl* (P) to represent their 'eye-catching' app; the outline circle represents the sclera, the darker blue circle the iris, and the dark grey centre circle the pupil. The use of the contrasting colours of these multiple circles not only resembles the appearance of an eye but also ripples, which are the concrete effect of making an impact on water. The ripple effect might metaphorically compare with the more abstract impact users can have on their audience when editing their videos with the app and producing eye-catching videos for people to view.

This qualitative analysis shows how circles appear to be harnessed by apps to visually convey a variety of meanings, depending on the app's category, function, and message or claims about its performance or purpose.

4.2.3c. Speech Bubbles

Circular speech bubbles were the third most common shape in the corpus of app icons (5%, N = 26). Speech bubbles are generally recognisable as typical realisations or projections of utterances or thoughts (Martinec & Salway, 2005). As such, they are commonly associated with communication. In the corpus, other figures of speech bubbles were identified, in addition to the circular kind, although these other figures were not as frequently used in app icons. The speech bubble figures included: circle (*N* = 26), oval (*N* = 3), square (*N* = 2), and rectangle (*N* = 1).

Speech bubbles in general were primarily used as a main shape (81%, *N* = 26 of 32) in the icon and featured mostly in instant messenger app icons in Communication

and Social categories. Speech bubbles may therefore relate to a particular type of online communication that smartphone users can engage in and their use in the icons of particular apps can signal the app's ability in facilitating this kind of efficient communication. Speech bubbles act as a kind of visual representation of a conduit metaphor that explains how we think and talk about communication as a transmittance of messages involving a physical transfer of items from one place to another; such as in the phrases 'trying to get your thoughts across' and 'giving you an idea' (Reddy, 1979: 284). The use of speech bubbles may be interpreted as facilitating the transmittance of messages instantly from the author to the receiver. This meaning of speech bubbles might aid smartphone users in decoding the function of apps that use the shape in their icon, such as instant messenger and Communication and Social apps.

Speech bubbles commonly occur in comics and magazine advertisements and their projections can be attributed to a represented participant or entity to which it is attached or directed towards (Unsworth, 2006). The shape's use in app icons may be said to be attributable to the essence of the app itself that informs consumers of its communicative capabilities. Instant messenger apps are the most downloaded apps in the corpus. Considering that circular speech bubbles are used predominantly in these apps, their app's functional popularity means the shape associated with this type of app thus increases its chances of being downloaded.

Speech bubbles often co-occurred with other shapes inside their figure, including squares (*N* = 12), circles (*N* = 5), other speech bubbles in a different role (*N* =

5), and phones (*N* = 4). While squares and circles were mainly background shapes and co-occurring speech bubbles were outline or secondary shapes, phones may be signalling an additional meaning to consumers about the app's capabilities.

4.2.3d. Phones

Phones occurred 18 times in the corpus and were used in the icons of apps functioning primarily as call managers (*N* = 6) and flashlights (*N* = 3) from the Communication and Tool categories. Phones were visually represented in three different ways: (1) as a cartoon image; (2) as a realistic photographic image; and (3) as a metaphoric image.

In table 18, apps A and B represent the archetypal phone icon as a cartoon image that relates to the phone's capabilities as a communication device. These phone icons can be accompanied by a circle shape (A), which might draw on concepts discussed in §4.2.3b that the consumer can relate to, such as staying connected, or being part of a network or social circle. The phone icon can also be accompanied by speech bubbles (B), which sometimes contain the phone and, in the case of app B, straight lines that refer to lines of text – text messages. Having the phone with the addition of text lines may indicate additional capabilities the app has in enabling users to communicate in different ways; for instance, the curved lines emanating from the phone symbolises sound and emphasises the voice call function of a phone and the app in question, in addition to its texting function. The meaning of the phone icons in apps A and B are highly conventionalised, which is evident from the fact that few phone models, especially smartphone models, resemble this shape anymore.

However, this type of representation of a phone is known to refer to communicative functions.

Table 18: Apps with phones in their icons and their function in brackets	
A. Truecaller: Caller ID & Dialer (Call Manager) 	**B.** TextMe – Free Texting & Calls (Call Manager) 
C. Flashlight (Flashlight) 	**D.** Flashlight (Flashlight) 
E. Copy My Data (Data Transfer) 	**F.** GPS Phone Tracker (GPS Tracker) 

The flashlight apps (C & D) used photographic representations of smartphones to demonstrate how their app would operate on the phone if downloaded. Their app icons use the popular smartphone model as a black, rounded rectangle to show that their app works on the latest smartphone devices.

Apps E and F use metaphoric representations involving phones to convey information about what their app does. App E uses arrows to signal the movement or transfer of data from one phone to another. App F combines two images; one of a map and another of a smartphone. Philips and McQuarrie (2004) label one type of visual metaphor that combines two gestalts (or images) into one entity as *fusion*. The

map is one gestalt that is being fused with the smartphone. The interpretation of the function metaphor is aided by the visual representation of the map appearing to be transferred onto the smartphone screen. By fusing the form of the two entities together, the icon compares the understanding we have of a map giving us direction and location that can be transferred to the smartphone by using the app. In other words, the conceptual comparison of these two entities being fused together conveys the message that the app enables smartphone users to enjoy GPS (Global Positioning Systems) tracking on their smartphone.

The familiarity of the phone icon in its symbolic, photographic, and metaphorical forms enable the apps using it to communicate different messages to consumers about what the app can do. It is worth pointing out that all of the apps displayed in table 18 received a high downloads rates. The discussion has revealed, however, that the representations of the phone relate to specific functions that the app claims to have. Because of this, the high download rates might reflect the popularity of the functions rather than necessarily be dependent on the shapes in the app icon alone.

4.2.3e. Brush Heads

Brush heads were not particularly frequent in the corpus (*N* = 6); however, they featured in apps that were downloaded the third most (*M* = 120 million), after circular speech bubbles (*M* = 192.69 million) and phones (*M* = 120.73 million). Brush heads

were found predominantly in the Tools category (*N* = 5) and featured exclusively in the icons of apps that functioned as cleaners (*N* = 6 of 13).

Physical brushes sweep or clean away unwanted dust or dirt. The brush in cleaner app icons refers to a metaphorical cleaning that clears away, or deletes, cached or unnecessary app files to optimise processing speed and storage. Intriguingly, the visual representations of the brush head in these apps are very similar in appearance and either has a blue handle or is white and surrounded by a blue background (table 19). Similar to the colour blue in security apps that also have a cleaning capability, blue may be associated with cleanliness and competency in smartphone app icons, aiding the construal of a cleaner app's capabilities. It is worth pointing out that cleaner apps have been downloaded 71.62 million times, and cleaner apps with a brush head in their icon are downloaded considerably more (*M* = 120 million) than those without (*M* = 30.16 million). The brush head in cleaner apps may be useful to inform consumers of what the app does and improve their recognition of cleaner apps in the app market when considering apps to download.

Table 19: Cleaner apps with brush heads in their icons	
A. Power Clean – Optimize Cleaner 	**B.** Powerful Cleaner (Boost&Clean) 
C. Super Cleaner – Antivirus, Booster, Phone Cleaner 	**D.** Clean Master- Antivirus, Booster & Phone Cleaner 
E. CCleaner 	**F.** AVG Cleaner: Clean out junk & free up storage 

4.2.3f. Octagons

Octagons featured in apps that function as either ad blockers (N = 6) or internet browsers (N = 2) and appeared in Communication (N = 6) and Productivity (N = 2) categories. All octagons were used in app icons to resemble warning or stop signs through both their shape and combination of white outline and red background colours. Their resemblance to a warning sign conveys a message to consumers that the app will stop or block unwanted ads and viruses from penetrating and compromising their safety whilst browsing the internet (table 20).

Table 20: Adblocker and browser apps with octagons in their icons	
A. Free Adblocker Browser – Adblock & Popup Blocker (Ad Blocker) 	**B.** Adblock Plus for Samsung Internet – Browse safe (Ad Blocker) 
C. Adblock Browser for Android (Browser) 	**D.** Adblock for Samsung Internet (Ad Blocker) 

The main shapes inside these warning signs enhance the concept of protection. These main shapes harness associations we have with a defensive shield (app A, table 20; also see discussion in §4.1.3b), a cover over the world icon, which is widely acknowledged as symbolising the internet (app C), and a halting hand that signifies action and barring (app D).

4.2.3g. Animals

Animals were fairly frequently used in app icons (*N* = 15). Despite animals being more common as a collective shape than over half the other commonly occurring shapes in app icons (60%, *N* = 9 of 15), as displayed in figure 17 (§4.2.1), they were initially coded as individual shapes in the corpus. The qualitative analysis of app icons revealed their noteworthiness in app icon design.

Animals appeared to be used to draw on symbolic, anthropomorphic values that are established in British culture to represent the app's claimed function and performance. The apps in table 21 aid consumers in their transfer of salient symbolic traits by referencing them in the own name; for example, app A's fox is "fast and private", B's bull is "powerful and secure", and C's lion is "brave", E's elephant is "organized", and F's hare is "turbo". These connections are explained in turn.

Table 21: Apps using visual representations of animals in their icons and their function/category in brackets	
A. Firefox Browser fast & private (Browser/Communication) 	**B.** ABull Browser – Powerful & Secure (Browser/Communication) 
C. Brave Browser – Fast Adblocker (Browser/Communication) 	**D.** POF Free Dating App (Dating/Social) 
E. Evernote – stay organized. (Reminder/Productivity) 	**F.** Turbo VPN – Unlimited Free VPN (Security/Tools) 

In table 21, the visual characteristics of the animals in the app icons aid the construal of their representing the app's capabilities. For instance, the fox in the *Firefox* app icon (A) is represented in fiery colours red, orange, and yellow, with sharp flicks of fur like flames, that reflects the name of the app. Furthermore, the fox itself

represents anthropomorphic values such as intelligence or cunning, agility and speed, and covertness, which can be transferred onto the app to frame it as intelligent, cunning technology that will work covertly behind the scenes to provide fast, secure browsing.

The *ABull* app icon (B) represents a bull to convey power and strength. Using hard and angular forms for the bull associates it with values like robustness, vigour, and seriousness (Hevner, 1935; Dondis, 1973). The red colour of the bull might be used to communicate a warning, similar to that conveyed by red ad blocker apps in the previous subsection (§4.2.3f). The bull is also encapsulated by a circle in a darker hue, which conveys a safe, self-contained environment, guarded by the bull, where unwanted software bugs and viruses dare not go.

The *POF free Dating App* (D) has a fish as its icon that is referenced in the "POF" acronym in the app's name, which stands for the idiom 'plenty of fish in the sea'. The idiomatic phrase can be taken literally, but is commonly cited in the context of dating or finding love in a relationship, where the figurative 'pond' in which fish swim is the 'pool' of people, who can be 'caught' or 'hooked in' to relationships. This concept uses a metaphor for people who are visually represented as fish, such that *People are Fish*. The teal (green) background emulates the natural colour of the sea and represents the fish as being underwater. The small white heart arguably replaces an air bubble that is typically depicted accompanying a cartoon fish. The heart itself metonymically stands for, or symbolises, love or the act of finding love through the dating app.

The elephant in the *Evernote* app (E) is also used to convey information about the app and its function. The elephant itself has a folded ear to resemble the turned corner of a note or page. Writing notes can be a sign of being organised. In British culture, it is widely acknowledge that the elephant is associated with having a good memory, such as the English phrase 'an elephant never forgets', which is a useful trait for successful organisation. The app icon uses a metaphorical fusion, which combines two gestalts into one entity, such that the note or page is one gestalt being fused with another gestalt, the elephant, to associate the notions of organisation and memory. By fusing these two entities together – the note and the elephant – the app suggests that it can provide a platform for users to help them remember and organise their lives.

Finally, the *Turbo VPN* app (F) represents a hare for speed, which relates the appearance of the hare (the signifier) to its speed (the signified), using a resemblance metaphor based on the hare's behaviour in the wild to run fast in addition to its physical appearance in the app icon itself. Ureña and Faber (2010: 124) explain that:

> *According to Grady's (1999) characterisation of resemblance metaphors, image metaphors are associated with motionless visual images, whose motivation for metaphorical transfer is based on physical properties (e.g., shape and colour). In contrast, there are other metaphors that result from behavioural comparison, and therefore, are typically linked to motion and dynamicity.*

The meaning of the hare is conveyed through its behaviour of quick motion and dynamic movement in the wilderness. Yet, the construal is not only through the behavioural resemblance metaphor, but also its physical appearance in the app icon.

The slanted form of the animal implies streamlined movement and the orange colour symbolising activeness and warmth translates to presenting the app as ‘running’ quickly and smoothly as well as being efficient and trustworthy.

The use of animals in app icon design draws on metaphorical associations established in British culture that relate the physical properties and behaviours of animals in the environment with particular values and meanings. Apps can harness these associations through using the shape of an animal or combining it with constituent elements of the appearance of the animal itself, its form, and its colour, to convey information to the consumer about what the app is, what it does, and how well it performs its function, and enhance its communicative power.

Thus, the qualitative analysis of shapes used in smartphone app icons discussed in this subsection has demonstrated that shape can operate as a visual element individually and as a constituent element that combines with other elements to communicate as part of a visual language.

4.3. Study 2: How Do Smartphone Users Respond to Colour and Shape in Smartphone App Icons?

In sections 4.1 and 4.2, the corpus analysis of colour and shape in smartphone app icons identified the meaning potential of these visual semiotic elements and interpreted how they may communicate information about the app. The analysis from study 1 has born certain expectations for smartphone users' responses to colours and shapes in app icons in study 2 that are outlined below.

The study 1 corpus analysis suggests that frequently used colours (i.e. white, blue, and green) and shapes (i.e. squares and circles) might be more familiar to smartphone users. Consumers are more likely to find products they are familiar with more appealing than ones with which they are unfamiliar (Campbell & Keller, 2003). Colours and shapes that frequently occurred in the corpus of smartphone app icons are expected to elicit higher appeal ratings from participants in study 2. Conversely, colours and shapes that were not used as often in app icons in the corpus might elicit higher distinctive ratings from participants in study 2.

Study 1 found that certain colours of app icons were used more for certain categories over others (e.g. orange in app icons from the Health and Fitness category, and grey in apps icons from the Tool category). Smartphone users may evaluate the colours associating with specific categories in the app market as being more typical of their category in the user response study, such that orange app icons may receive higher typicality ratings for the Health and Fitness app category over other app categories. In contrast, the corpus analysis revealed that squares were not associated

with any particular category when they appeared in app icons and circles were fairly equally distributed across categories. These shapes are therefore not expected to receive high typicality ratings for any one category. However, due to the commonality of shapes and circles in app icons in the corpus, smartphone users may be more familiar with these shapes than others such that they rate these shapes as more appealing.

The softer form of a shape was found to be more strongly associated with app icon design in general, although the Health and Fitness category used more soft forms and Productivity more hard forms than other categories, of which these associations may be evident in smartphone user responses in study 2. If smartphone users are aware of these associations between the form and category of an app icon, they may evaluate: (a) soft forms of app icons as more typical for the Health and Fitness app category, giving this category a higher typicality ranking than other categories; and (b) hard forms of app icons as more typical for the Productivity category than other categories.

In the theoretical background (§2.5.2), I reviewed literature that argued that angular forms and geometric shapes such as squares, triangles, and circles are often interpreted as being 'quasi-scientific' and 'mechanical' (Mondrian, in: Jaffé, 1967: 54-55) and associate with technical and digitally-operated objects such as smartphones (Creusen & Schoormans, 2005; Piqueras-Fiszman et al., 2010). If the association between hard forms and geometric shapes (e.g. squares, triangles, and circles) and

technology extends to the meaning of smartphone app icons, harder forms may elicit different responses from smartphone users in the response study.

For study 2, smartphone users were asked to evaluate different app icon designs varying in colour and shape. The experiment tested colours: red, yellow, blue, green, orange, and purple; and shapes with hard and soft forms: square (hard & soft), circle (soft only), oval (soft only), and triangle (hard and soft). Participants rated fabricated app icons on their (1) distinctiveness and (2) appeal, and (3) ranked the typicality of different app icon designs for five app categories: Communication, Health & Fitness, Productivity, Social, and Tools. These three questions observed the (1) attention-grabbing, (2) aesthetic, and (3) categorisation values of app icon's visual elements colour and shape (see §3.2 for full method).

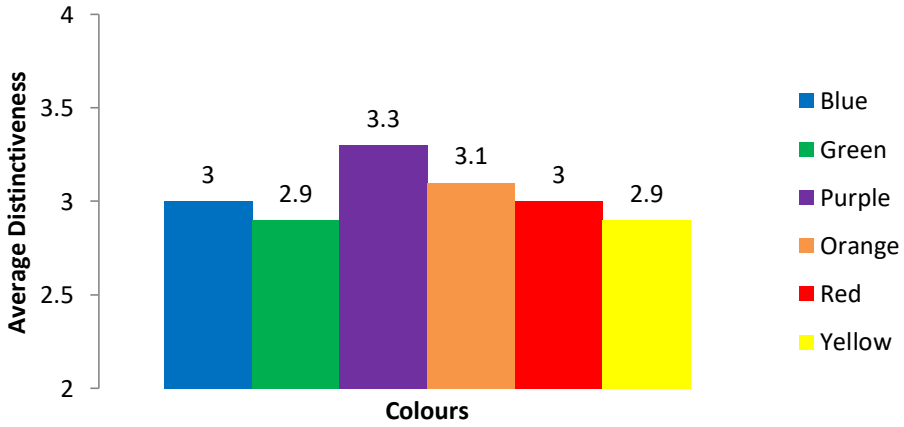
First, I report the smartphone user responses for colour (§4.3.1) and then shape (§4.3.2) for the three questions on distinctiveness, appeal, and typicality. For shape, I also report the smartphone user evaluations for app icon designs with hard and soft forms. Following this, I discuss issues regarding participant colour preference, the experiment design, and the statistical power of the results (§4.3.3).

4.3.1. Smartphone User Evaluations of App Icon Colours

4.3.1a. Distinctiveness

Smartphone users did not consider any one colour as any more distinctive than the others, and rated colours as more generic than distinctive overall (figure 19). Purple was considered the more distinctive colour (*M* = 3.3) and was a fairly infrequent colour in the corpus of app icons (see figure 12, §4.1.1). Orange also received a higher distinctiveness rating than other colours and was similarly infrequent in app icon design instore. Visual characteristics that differ from the norm capture attention as they contrast to what is expected, which may explain why purple and orange were considered more distinctive than other colours in the user response study (Kumar & Garg, 2010).

Figure 19: Average distinctiveness ratings for app icon colours



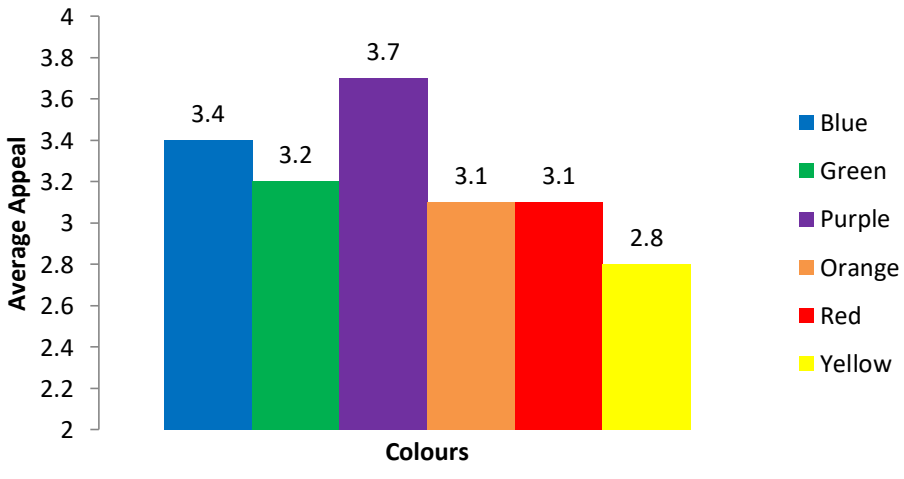
However, the expectation that infrequent colours in app icons would elicit higher distinctiveness ratings from participants was not consistent across all colours in

the user response study. Yellow was considered one of the least distinctive colours by smartphone users despite it being both an infrequent colour in the corpus and a bright, warm colour that is usually recognised for its vibrancy and extraversion, which would make it more likely to stand out in a crowded environment (i.e. make it more visually distinctive). These results therefore do not entirely support the idea that infrequent colours used in app icons elicit higher distinctiveness ratings.

4.3.1b. Appeal

The appeal ratings of colours presented to smartphone users in the experiment ranged from 2.8 to 3.7 (figure 20). Smartphone users found purple the most appealing in app icons (*M* = 3.7), followed by blue (*M* = 3.4) and green (*M* = 3.2). It was expected that smartphone users would find common colours in app icon design more familiar and therefore more appealing than other, uncommon colours that might be unfamiliar (Campbell & Keller, 2003).

Figure 20: Average appeal ratings for app icon colours



Blue and green colours are frequently used in app icons, as established by study 1 (§4.1.1), and were also considered more appealing than most other colours in study 2. However, purple is used considerably less (*N* = 18) than blue (*N* = 134) and green (*N* = 35) in app icon design and yet received the higher appeal rating overall from smartphone users.

Studies have shown that consumers prefer products that are slightly different from the prototypical ones, which may be a reason for why purple is more appealing to smartphone users than other prototypical colours of the app market, such as blue and green (Meyers-Levy & Tybont, 1989; Reber, Schwarz, & Winkielman, 2004; Creusen & Schoomans, 2005). Yet, the colour yellow may also be said to be a distinctive colour in the app market due to its infrequent use in app icons, but it was the least appealing colour in the experiment. These results do not support the expectation that colours frequently used in app icons elicit higher appeal ratings.

One explanation for yellow's low appeal compared to purple's higher appeal is that yellow might be considered a more atypical colour choice for app icons than purple. Products that are too atypical are not appreciated as much as those that only differ slightly from prototypical examples (Kumar & Garg, 2010; Truong et al., 2014). The aesthetic roles yellow and purple play could affect their salience in app icon design, which might impact on how familiar they are to smartphone users. A more salient colour might be more distinctive, noticed more often, and therefore be considered as more familiar a colour than one that plays a less salient aesthetic role. A

more familiar colour may consequently be considered as a more typical colour for app icon design than a less familiar colour.

Purple is used the most as the background colour of an app icon (78%, *N* = 14 of 18), which is a square 93% of the time (*N* = 13 of 14). For most app icons in the corpus, the background covers a larger area per pixel than other subsidiary shapes and objects and therefore increases its chances of being noticed in competitive environments (Chandon, Chtourou, & Fortin, 2003; Kieras & Hornof, 2014). As such, purple may be considered as a more distinctive colour of app icon design by smartphone users. Purple's combination with a frequently used and familiar shape – the square – may also contribute to its being considered a more typical colour for app icon design.

Using purple in the background of an app icon can convey the app's core values before it is given full attention. The cognitive associations consumers have with colours yellow and purple might influence how appealing they are to smartphone users. Purple is associated with quality, authenticity, and luxury (see table 2, §2.5.1), and its use as a background colour may convey these attractive values about the app to consumers. In comparison, yellow is used across various aesthetic roles in app icon design, primarily as the main shape or object of an app icon (44% & 31%, N = 7 & 5 of 16, respectively). In these roles, the colour yellow does not appear to communicate any particular kind of meaning or information in itself, but rather acts as a visual contrast that serves to capture the gaze and highlight the main shape or object in an app icon.

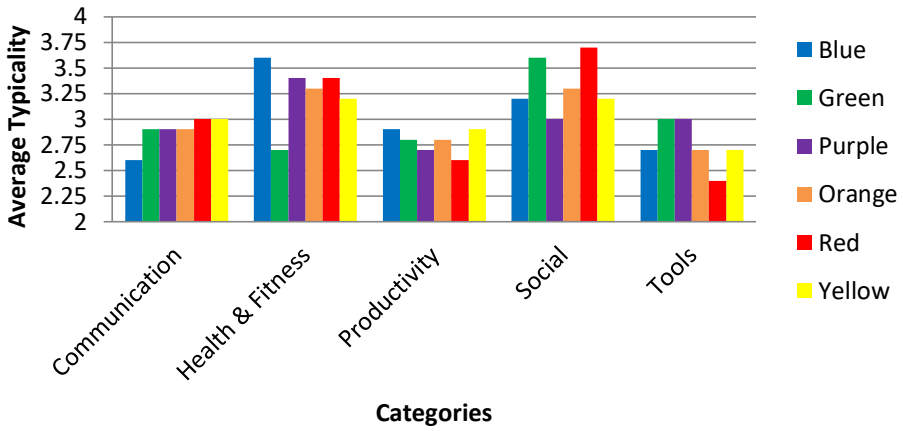
Consumers derive pleasure from decoding and successfully elaborating the meaning of inferences made by objects or products and their appearance, resulting in its increased appeal (Berlyne, 1971; Tanaka, 1994; Heath, 2001). Purple's more salient, familiar, and attractive encoded values compared to yellow's less salient, unfamiliar, and practical role may go some way to suggest why smartphone users prefer purple over yellow.

Of course there may be other reasons as to why smartphone users varied in their appeal ratings for different colours. Section 4.3.3 discusses further explanations concerning participants' colour preferences and the design of the experiment itself.

4.3.1c. Typicality

This question aimed to identify whether smartphone users associated any of the five categories with certain colours, which would indicate their using colours as a visual categorisation for apps. Smartphone users did not consider any particular colour/s as being typical of any of the five categories, which suggests that smartphone users might rely on additional cues to categorise apps (figure 21). These may be additional shapes or objects in the app's icon, and/or information external to its visual representation, such as its name, description, graphics of in-app functions, and aggregated star ratings, as shown by previous app studies (Gage Kelley et al., 2012; Gage Kelley, Cranor, & Sadeh, 2012; Dogruel, Joeckel, & Bowman; 2015).

Figure 21: Average typicality rankings for app icon colours for five categories



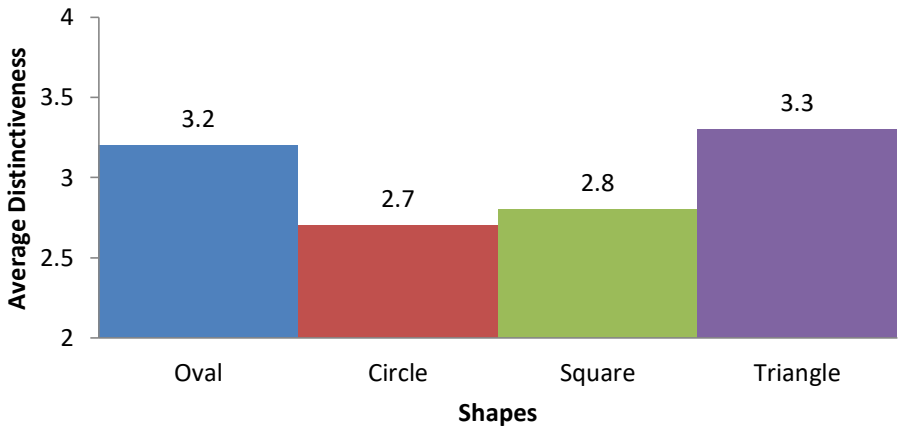
Interestingly, the warmer colours red, orange, and yellow were considered to be more typical colours for Tools and Productivity categories that have apps with discrete tasks. Red was rated as marginally more typical for Tools apps, and was the only colour to receive a rating that aired on the side of typical rather than atypical (*M* = 2.4). However, study 1 found that these warm colours occurred more frequently in the Health and Fitness category where users were required to engage more in physical activity, such as running, walking, and meditating (see §4.1.3h). Study 2 participants considered green to be more typical of the Health and Fitness category than other colours, perhaps relating to the symbolic concept of health being green and good (see §4.1.3c). Yet, green's typicality rating for Health and Fitness (*M* = 2.7) was very closely followed by typicality ratings for Productivity (*M* = 2.8), Communication (*M* = 2.8), and Tools (*M* = 2.9) and so it cannot be said for certain whether smartphone users associated green with any particular category. As such, these results do not reflect the app icon market trends for the categories studied.

4.3.2. Smartphone User Evaluations of App Icon Shapes

4.3.2a. Distinctiveness

Smartphone users rated some shapes as more distinctive than others. Their average distinctiveness ratings however were not so distinguished and showed shapes to be more generic than distinctive overall. These results suggest that there may not have been an agreement between smartphone users on how distinctive the tested app icon shapes were, although the average ratings were evidently biased toward genericity (figure 22).

Figure 22: Average distinctiveness ratings for app icon shapes

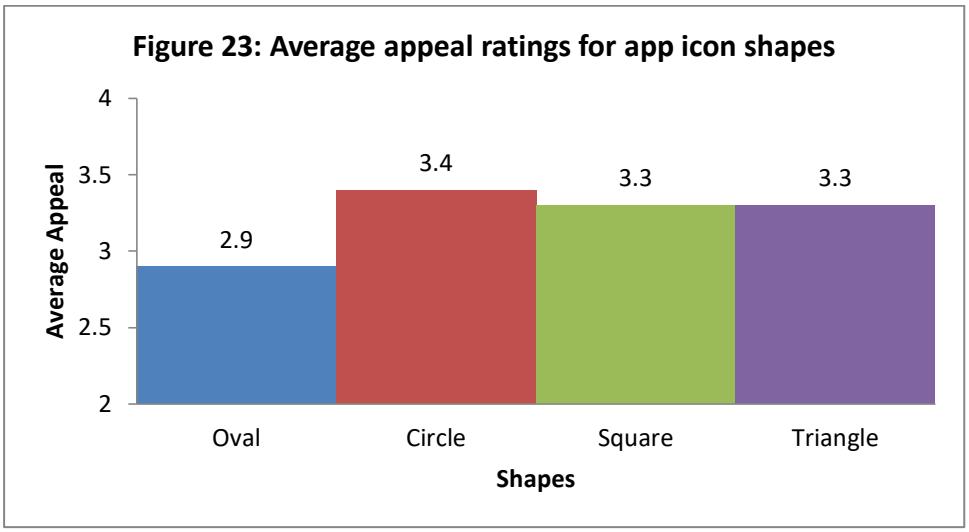


The average ratings indicated that triangles and ovals were considered to be more distinctive (*M* = 3.3 & 3.2 respectively) than squares and circles (*M* = 2.8 & 2.7 respectively). Triangles and ovals are both infrequent shapes in app icons, with triangles appearing 10 times and ovals only 5 times in the corpus.

When infrequent visual characteristics are used in product design, they can attract attention as they stand out from the familiar in a crowded marketplace (Kumar & Garg, 2010). Moreover, frequent visual characteristics may become a part of what consumers expect to see in a product's design and therefore products that wish to be noticed, or appear more distinctive, have to deviate slightly from the familiar appearance of the product established in the market. Such formulised ideas explain why infrequent and unfamiliar shapes, triangles and ovals, are considered to be more distinctive than the apparently ubiquitous shapes in app icons, squares and circles, by smartphone users. However, future research should test these ideas to determine whether they endure with stronger statistical power.

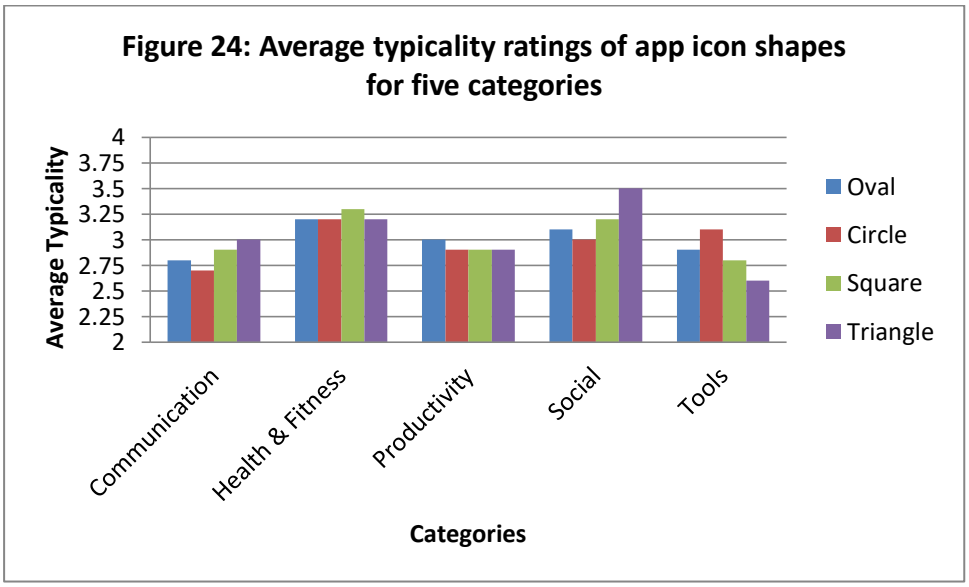
4.3.2b. Appeal

The shapes of app icons were considered unappealing by smartphone users (figure 23). Smartphone users found circles to be the most appealing shape (*M* = 3.4), closely followed by squares and triangles (*M* = 3.3 each), and ovals received the lowest average appeal rating (*M* = 2.9). Study 1 found ovals were used in app icons the least of all four shapes tested in the online experiment, meaning that smartphone users might not be as familiar with the shape's use in app icons and not find it very appealing. However, triangles were similarly infrequent and were rated as being close to, and as appealing as, common shapes circles and squares. The lack of distinguishable average ratings for shape appeal therefore cannot support the expectation that higher shape frequency might elicit higher appeal ratings.



4.3.2c. Typicality

Participants did not consider any shape/s as being typical of any of the five categories Communication, Health and Fitness, Productivity, Social, and Tools (figure 24). Smartphone users may therefore rely on other cues to categorise apps. Moreover, the fabricated app icons may have been too visually controlled to elicit contextualised responses from participants about app icons. Section 4.3.3 gives a more detailed discussion of the study's limitations.



4.3.2d. The Evaluation of the Hard and Soft Forms of App Icons

Studies have found that people evaluate hard, angular forms and soft, rounded forms differently (see §2.5.2). The round-cornered (soft) and angular-cornered (hard) square and triangular shapes of app icons presented to smartphone users in the experiment enabled the comparison between the evaluations of shapes with soft and hard forms.

Smartphone users rated both soft and hard forms as more generic than distinctive (*M* = 3.1 & 3.0 respectively). Soft forms were rated as marginally more appealing (*M* = 3.5) than hard forms (*M* = 3.1), although the difference in appeal rating was not considerable. Neither hard nor soft forms were typical of a certain category as they received very similar average ratings.

These results indicate that the distinctiveness of a smartphone app icon is not necessarily related to the form of its shapes, although the form can aid the construal of meaning conveyed by app icons, as demonstrated in study 1. Smartphone users may be more accustomed to the softer forms of app icon design on the market, which might account for their higher appeal rating for softer over harder forms in the experiment.

4.3.3. Discussion: The Evaluation of Colour and Shape in App Icons

In this section, I first discuss the potential for participants' colour preferences influencing the variation of their appeal ratings for different colours in the experiment (§4.3.3a). Second, I consider the limitations with the experiment's design, suggesting improvements to its design and execution, and highlighting opportunities for further research (§4.3.3b).

4.3.3a. The Influence of Individual Colour Preferences

Desirable product evaluations, particularly for atypical products or visual elements, can rely on individual consumer experience, preferences, and interests (Gatignon & Robertson, 1985; Hirschman, 1980; Hoegg & Alba, 2011). All participants in the online experiment were experienced smartphone users; however, individuals had different colour preferences that may have influenced their evaluations of the app icon colours.

Participants preferred blue was the most overall, chosen as a favourite colour by 26 out of 59 participants, which supports studies that have shown blue is the most liked colour in the UK and beyond (Grieve, 1991; Satyendra, 2006). Blue app icons may therefore be evaluated more favourably by consumers in the app store than apps with other colours in their icons, which might explain its rating as the second most appealing colour in the experiment and contribute toward its higher download rates in the app store. However, further investigation into the relationship between colour and product purchase, or app download, is required to explore this argument.

Both purple and yellow were preferred a similar amount, chosen as a favourite colour by 6 and 5 of 59 participants respectively, which does not provide any additional evidence that might explain the disparity in the appeal ratings of these colours in the experiment. It must be noted that participants were only asked for their *most* preferred colour in the experiment, and therefore their least preferred colour is unknown. Future research could ask participants for a preference rating for various colours, which would provide a more balanced insight into the effect colour preference (positive and negative) has on smartphone user's ratings for the appeal of app icon colours.

4.3.3b. The Limitations of the Experiment Design

The limited distinguishable ratings and null results for the distinctiveness, appeal, and category typicality of colour and shape in app icons in the experiment may be due, at least in part, to its methodological execution, particularly with regard to its stimuli design. The average ratings for distinctiveness and appeal for colours and shapes generally converged around point 3 of 7 (colour: *M* = 3.24 & 3.02; shape: *M* = 3.00 & 3.23 respectively), which meant the colours and shapes were evaluated overall as slightly generic and unappealing. The category typicality ratings for colour and shape converged on rating 3 of 5 (M = 3.00 & 3.01 respectively), which meant that the colours and shapes of app icons presented were evaluated as slightly less typical of the five app categories.

The responses to app icon colour and shape could be such due to the abstract nature of the fabricated app icons presented to participants in the experiment.

Colours and shapes can both have so many different meanings that finding salient meanings to isolated instances in stimuli without the appropriate amount of contextual information, people derive limited aesthetic pleasure from the stimuli (Hevner, 1935; Hine, 1995; Wheatly, 1973). Although the stimuli context was provided through textual instruction and using a white background so as not to interfere with the perception of app icon colours, this may not have been sufficient to contextualise the stimuli presented. Future research could embed the Google Play Store background, theme, and icon into the experiment to simulate an environment in which smartphone users would normally view apps and their icons. Or, participants could view app icons in the Google Play Store themselves, and asked questions about the icons that they see and prefer.

Previous studies have used real icons as stimuli in market research (e.g. Labrecque & Milne, 2012), which is useful to provide an insight into how icon design is evaluated by consumers. However, testing participant perceptions of these may prove unreliable because some participants may already be familiar the stimuli presented and their exposure to the known icon can influence their evaluations differently to others who have not seen them before. Alternatively, fabricated stimuli can control for these influential factors, exposing all participants to the icons for the first time to receive an unbiased impression, which is why this alternative method was chosen over the former. Although the process to create and produce fabricated stimuli comes at a cost of the stimuli being less realistic, which can also impact on participant responses.

In the experiment, while controlling for the influence of other variables on participant evaluations by showing them icons that only exposed them to various combinations of primary and secondary RYB colours and geometric shapes, these icons lacked the additional cues that would have been present in app icons available on the market, such as text, objects, and multiple colours and shapes. Further investigations of colour and shape in icons should use controlled experimentation to test how consumers respond to more realistic representations of icons in the context of an app search task, which places the stimuli in a natural, contextual environment compared to responding to repetitive experiment ratings of the stimuli. The task-related experiment could therefore study whether subtle changes in the visual characteristics of icons alter the consumer's appeal and appreciation of the product, and which of these characteristics are most effective (i.e. result in the most positive evaluations, or alter perceptions considerably in favour of the product).

5. Overall Discussion: A Summary of Findings

In this section, I will discuss the results from study 1, a corpus of 250 smartphone app icons, and study 2, a study of smartphone user responses to app icons, whilst taking into consideration the existing research on visual semiotic elements colour and shape. To do so, I will revisit the thesis aims and research questions (figure 25, a repeat of figure 3, §2.8), and consider the hypotheses, or expectations, formulated during the theoretical background and analyses of studies 1 and 2.

I will first discuss the findings that address the first aim of the thesis (§5.1), which was to investigate how visual semiotic elements colour and shape are used in smartphone app icons to convey meaning, and then address the second aim of the thesis (§5.2), which was to identify whether these visual elements have any impact on smartphone user downloads and evaluations of apps. During the discussions for aims 1 and 2, I will refer to the roles colour and shape play in app icon design outlined in Creusen and Schoorman's product appearance typology (table 22, a repeat of table 1, §2.1).

Reviewing the results from studies 1 and 2 within the context of the existing theoretical background will enable me to: (a) position the findings of my thesis within its related fields of cognitive linguistics, advertising, and consumer psychology; (b) to consider the limitations of the study; and (c) identify further avenues for research. The implications of my research and proposals for further research are detailed in the following section (§6).

Figure 25: Summary of thesis aims and research questions

The thesis aims to investigate:

3. How visual semiotic elements colour and shape are used in smartphone app icons to convey meaning about the virtual product.

4. How colour and shape in smartphone app icons impact smartphone users' attitude and behaviour by measuring their connection with app downloads instore and observing how smartphone users respond to app icons with various colour-shape combinations.

Research questions:

3. How is colour and shape used in smartphone app icons?
    a. What are their roles in app icon appearance?
    b. What meanings do they convey individually and together?
    c. What forms do they take and does it complement their meaning?
4. Does the colour and shape (and form) of app icons have an impact on consumer attitude and behaviour?
    a. Do they have a connection with app downloads?
    b. Do they have an effect on smartphone users' evaluations?

Table 22: Six Roles of Product Appearance for Consumers
(adapted from Creusen & Schoormans, 2005: 75)

Role	Influence on Consumers
Attention-drawing	Engages consumer attention instore
Symbolic	Cues symbolic product associations Communicates brand image/personality
Categorisation	Eases product categorisation Offers differentiation from the product's typical category
Functional	Highlights features and functions of the product Cues information about the product's technical quality
Ergonomic	Highlights parts for consumer-product interaction Shows consequences for using external aspects of the product
Aesthetic	Serves as a basis for aesthetic appreciation and appropriateness Suggests suitability with the environment

5.1. How is colour and shape used in smartphone app icons to convey meaning?

The following subsections address the first aim of the thesis, stated in the title, with regard to colour (§5.1.1), shape (§5.1.2), and their combination (§5.1.3).

5.1.1. The Use and Meaning of Colour in Smartphone App Icons

The most common colours for app icons were white, blue, green, and red, which partially supported Labrecque & Milne (2012), who previously found that the majority of app icons use colours blue, red, and black. While the colour blue was found to be very frequent and red fairly frequent in my corpus, black and brown were identified the least in app icons. The infrequency of black and brown colours may be due to companies not wanting to risk consumers associating the negative associations of these colours with their app.

The frequent classifiable colours white, blue, green, and red identified in the app icon corpus reflect the colours used by apps from the five app categories: Communicative, Health and Fitness, Productivity, Social, and Tools. As such, there may be other colours that are common in other by apps in other categories. Although, the four common app icon colours were distributed proportionally across the five app categories, suggesting that they are not particularly associated with any one of the categories studied. Their high frequency also suggests that they may be used as standard colours for app icon design.

Although the colours white, blue, and green were not associated with any particular app category, they did feature more in apps with an instant messenger function than in apps with other functions. These colours often co-occurred with one another in app icons in general, and particularly in the icons of instant messenger apps. Instant messenger apps were the most common kind of app available on the app market for the categories studied in the corpus and were also the most popular app, being downloaded the most of all the app functions. The commonality of instant messenger apps on the market and its icon mostly consisting of white, blue, and green colours may contribute to the higher frequencies of these colours in app icon design.

The visual design elements of popular apps' icons, such as WhatsApp and Facebook Messenger (both instant messenger apps), were emulated in the icons of competing apps as a means to draw coherence between them. This further increased the instances of white, blue, and green in the corpus. Consequently, these colours might become familiar to smartphone users and recognised as relating to certain app functions or qualities. Drawing relations between apps by using similar visual design elements can highlight similar functions and associate competing or newly-released apps with the reputable qualities of more established apps; thus increasing the chances of these competing and newly-released apps being noticed, selected, and downloaded.

App icons used colour coherence in a number of ways: (1) to operate as a strategic attention distracter that encourages smartphone users to consider competing apps as part of the app selection process when competing apps emulate

the colour choices of successful apps' icons in their own icon design; (2) to draw relations between apps that have similar functions or extend the services of existing, or popular, apps (e.g. WhatsApp, Facebook Messenger, and Instagram); and (3) to act as a brand identifier that signals multiple apps belonging to the same brand (e.g. BT, Fitbit, and Veryfit) through their similar background colour. These findings are supported by psychological literature on visual search (§2.3) that has identified colour's advantageous role in directing consumer attention in crowded environments, and being more effective and memorable than other visual elements including shape in visual search. Using colours that are coherent with the icon design of popular apps or of a particular brand enables companies to communicate information about their app's reputability and capability by transferring the established associations of an existing app or brand to their own app.

Colour contrast also proved an important part to app icon design. White was used primarily as a visual contrast between the background and the main shape or object of an app icon, which increased the salience of these figures. The commonality of white in app icons may have been due, in part, to its practical role as a contrasting colour that served to highlight important figures in the icon, which conveyed crucial information about the app. White's role as a visual contrast acted in two ways: (1) it drew attention toward key shapes or objects in the icon in its hue by contrasting with the other colour/s in the app icon background; or (2) it drew attention to the key shapes or objects in the icon by being an neutral, unobtrusive background or outline colour that blends with the Google Play Store background. In these cases, instead of drawing attention to itself, it leads the attention to other elements of the icon that

contrast with it. In both roles, white is drawing attention toward the main shapes and objects that were likely to carry more meaning about the app, such as its function, category, and figurative messages about its performance.

For instances where white plays a perceptual role in visual contrast and coherence, one could argue that white is not necessarily communicating any meaning in itself, but the meaning the figures convey about the app (e.g. function, category, and ergonomic value) would not be perceived as easily without the colour contrast to get it noticed in the app market by consumers. Therefore, the role white serves in app icon design is vital to easing consumer perception of the app in a crowded market and the messages conveyed by other figures within the icon.

Individual colours carried their own cognitive associations in app icon design, and used these symbolic meanings to convey information about the app. For some colours, these associations meant they were used in apps with certain categories more than others. For instance, grey was used more in the icons of Tools apps, orange in Health and Fitness apps, and pink in Social *and* Health and Fitness apps. Grey represented the practical functions of Tools apps through its association with physical tools that usually have a metallic or silvery appearance. Red and orange colours similarly associate with arousal and activity (orange being less strongly associated with these values than red). Their use in Health and Fitness apps such as (red) workout apps, and (orange) pedometer, alarm clock, and meditation apps, drew on their cognitive associations of activity for apps that require physiological engagement external to the app to fulfil its functional purpose. Pink is perceived as having a softer

visual impact than red and orange. Its use in period tracker and dating apps drew on its established associations with femininity and affection.

Apps generally used cooler colours (blue, green, and purple) in their icon background more than warmer colours (red, yellow, and orange). App categories Productivity and Health and Fitness, in which apps required more active user engagement, used more warm colours in their icon backgrounds than other categories Communication, Social, and Tools that required only passive user engagement. The difference between the frequencies of warm versus cool colours in app icons across categories was not significant, but I suggested that, on the one hand, the background colour might be indicative of the varying engagement consumers are expected to have with apps from different categories. For example, red, orange, and pink are used the most in the icons of apps that require consumers to engage in activities external to the apps, such as workout, meditation, and dating apps.

On the other hand, the background colour may be indicative of the type of apps that exist in specific categories, and reveal more about their function. For instance, cooler colours like blue and green are generally used in apps with an instant messenger function. This idea requires further testing across more app categories to determine whether warm and cool colours can indicate varying levels of consumer-related or function-related app engagement.

5.1.2. The Use and Meaning of Shape in Smartphone App Icons

Squares and circles were seemingly ubiquitous shapes in app icons, featuring in app icons far more than any other shape. Squares and circles were primarily used as a visual container for the app icon, acting as a background or outline shape. Their role arguably extends to serve as a conceptual container that captures the abstract concept of what an app does (i.e. its function and ergonomic value), and its operation within a virtual environment, in a more concrete figure that encapsulates the app's icon. The container schema is useful in language and cognition (Grady, 1997; Radden & Kövecses, 1999: 41; Lakoff & Johnson, 2003: 29-32), and allows us to conceptualise smartphones as containing a space in which other things can reside, such as apps (Ford, 2017). Therefore, it seems a logical extension to our understanding that we also conceptualise the app, a virtual product, and its capabilities as being contained within a square or circle figure.

Although the square or circle figures that background or outline the app icon are still fairly abstract in themselves, their relation to the shape of physical objects and structures in our environment enables us to use them to ground our understanding of the virtual app, which operates in an online space from within the smartphone, as being contained within the app icon (Kress & Van Leeuwen, 2006).

The visual container role squares and circles play informs the ergonomic and aesthetic value of the apps that use them. Squares and circles are both archetypal button shapes that invite consumer engagement, and their use in app icons maintains this ergonomic value that invites consumers to engage with the app. Indeed, it is the

app icon that consumers interact with and 'open' on their smartphones, just as we open containers, files on a computer, or links on the internet (Maglio & Matlock, 1998; Matlock et al., 2014). The aesthetic uniformity of app icons generally using squares and circles means they can neatly fit on a smartphone screen, facilitating habitual consumer engagement (Kieras & Hornof, 2014).

Similarly to colour, shapes utilised their individual cognitive associations to convey information about the app. The meaning of squares in app icons appeared to fit with the established cognitive associations identified in previous studies (see §2.5.2) that contributed to its aesthetic and ergonomic value (as discussed above). Circles drew on relations with tangible objects, such as a clock, sun, and an eye that have similar figures to convey more detailed information about the app and its capabilities. Using figures in the app icon that resembled physical objects enables companies to transfer information associated with these objects to their app without much additional cognitive effort from the consumer. Circles were often used in apps with communicative function such as instant messenger and mobile networking apps. Their use in the icons of these apps suggested that circles were representing a connected network, community, or social circle that encapsulated both the visual design of communicative app icons and the concept of its function.

Interestingly, many of the shapes used in app icons relate to conventionalised signals, such as the speech bubble, phone, and stop sign (octagon), which uses a code that is known beyond the app market and is utilised in app icon design. As such, app

icons play on our shared knowledge as consumers to efficiently communicate information about the app.

App icon figures utilised figurative associations to convey information about the app. Animal figures were used fairly often in app icons, although they were coded as separate shapes in the corpus meaning that they were not highlighted in the quantitative analysis of shapes in smartphone app icons (§4.2.1). Some apps drew on the symbolic, anthropomorphic values established in British culture to represent the app's function and performance. For example, a fox can represent values such as intelligence or cunning, agility and speed, which were useful to inform the function and performance of the *Firefox* internet browser that emphasises its fast, browsing speed. Other apps used resemblance metaphors that compared the physical properties and behaviour of the animal in its natural environment with the app to transfer desirable qualities onto the app and make claims about its performance (Grady, 1999; Ureña & Faber, 2010: 124).

Overall, there were more comparisons than connections made between signs, between the shape in the app icon and the app itself, that were identified during the qualitative analysis of app icons. It was expected that metaphoric correspondences between signs would be fairly frequent, according to Burgers et al. (2016) who found that metaphor occurred in half of apps (N = 249 of 500). Metonymy was identified comparatively less in the app icon corpus; yet, this may be due to the nature of metonymy being inherently implicit in language and cognition. Its limited research compared to metaphor means that our knowledge, identification, and classification of

metonymy may also be limited. Further research should consider the sign systems at play in smartphone app icons more closely, which may inform our understanding of visual design.

The forms of the shapes identified in the corpus included soft, hard, and hybrid forms. Due to the association of hard forms with technological objects and products established by previous literature (e.g. Poffenberger & Barrows, 1924; Hevner, 1935; McCloud, 1993: 125; Horn, 1998: 147), it was expected that hard forms would be more prevalent in app icon design. However, the opposite was found, with softer forms being more frequent, probably due to the amount of circles and soft squares identified in the app icons.

Organic, softer forms were used by apps in the Health and Fitness category; whereas harder forms were used more for apps in the Productivity category, which include more mechanical and technical apps. However, these associations were not indicated by higher typicality rankings for Health and Fitness for soft forms nor Productivity for hard forms in the smartphone user response study; thus, these associations cannot be confirmed. The assured, salient meaning of different forms therefore remains unclear through the corpus analysis and user response study; neither the hard or soft forms of app icons presented to participants were evaluated any differently in terms of their distinctiveness, appeal, and typicality. The effect of using different forms may be more salient in text, which was found to be fairly common in app icons. Incorporating text into the analysis of an app icon's visual design

in an extension of the corpus analysis study may reveal more about the meaning of form.

5.1.3. Colour and Shape as a Visual Language in Smartphone App Icons

Colour and shape appear to play different roles in app icon design, while also interacting with one another to enhance the information conveyed to consumers about the app. Colour, on the one hand, appeared to play a crucial attention-grabbing role in app icon design, through its use as colour coherence and contrast. Moreover, it is useful for categorisation and brand and function identification, particularly when the colours used are associated in the app market as already relating to particular kinds of apps, such as the colours for instant messenger app icons being white, blue, and/or green.

Colours not only operated alone but also worked together, with their symbolic meanings complementing each other to enhance the values consumers could interpret about the app. For example, blue and white co-occurred in security app icons. White's symbolic meaning of cleanliness complemented blue's symbolic meaning of competency and trustworthiness that, together, portrayed security apps using these colour combinations in their icon as competent in cleaning the user's smartphone of software bugs or viruses.

Shape, on the other hand, arguably plays a more defined role in conveying information about what the app is and what it can do. Apps used tangible objects and

animals to draw on relations with their functions and purpose in the physical world to signal the capabilities and functional value of the app. Squares and circles specifically related to structures we identify in our environment to communicate the app's ergonomic value and encourage consumer engagement. Shape's encoding of the app's function was enhanced and elaborated by colour's aesthetic values that also express the app's quality of performance (e.g. trustworthiness, competency, cleanliness, etc.). Moreover, as the shape is often featured in the foreground with a visual colour contrast to the background, these figures may engage more consumer attention in the app store and therefore carry more informative meaning about the app. These cases demonstrate how colour and shape can work together to convey meaning and collaborate in app icon design as parts of a visual language.

The combination of colours, shapes, and text enhanced the meaning and messages app icons could convey about the app to potential customers. For example, in security apps the shape of a shield was used as the main object to convey a figurative message that suggests security apps can defend users against software bugs and viruses. The synergetic effect of the shield shape and blue and white colours allows the app to communicate a persuasive message to consumers about the type of app it is, what is does, and how well it performs. An app's name and description was also found to guide the interpretation of an app icon's colour and shape choices to attain more salient messages about the app. How many informative cues smartphone users need in order to interpret and understand what the app is and what it does could be tested in a series of more controlled experiments; the nature of which is described in more detail in the concluding section (§6).

5.2. How does colour and shape in smartphone app icons impact smartphone user attitude and behaviour?

The second aim of the thesis was to observe whether colour and shape in smartphone app icons have any impact on the attitude and behaviour of smartphone users to develop research on virtual products and online stores that has been less widely studied than physical products and offline stores (Oswald, 2012). As studies suggest that many purchase decisions are made on the basis of the product's appearance (its colour and shape in particular), the impact of these visual semiotic elements on consumers were measured by the amount of downloads and evaluations an app receives from smartphone users instore and in a user response study, which are discussed in their respective subsections (§5.2.1 & §5.2.2).

5.2.1. The Impact of Colour and Shape on Download Rates

There did not appear to be a connection between the use of particular colours or shapes in app icons and the amount of app downloads. Previous literature suggests that advertisements that contain figurative messages (including symbolic, iconic, and indexical meanings), are more likely to be appreciated by consumers (Van Mulken, Le Pair, & Forceville, 2010; Littlemore & Pérez-Sobrino, 2017). Indeed, Burgers et al. (2016) found that apps that had visual metaphor in their icons were downloaded and appreciated more than apps without visual metaphor in their icons. However, despite the expectation that figurative associations of colour and shape may be connected with higher download rates, they did not reliably impact the download rates of apps in the Google Play Store according to the corpus analysis conducted in study 1.

The category or function of an app, however, was more connected with download rates, such that popular app categories and functions were indicated by higher downloads. Apps from Communication and Social categories and the instant messenger function were downloaded the most overall. The colours and shapes used in the icons of apps with these popular categories and functions were therefore more likely to receive higher download rates. For example, white, blue, and green colours, and speech bubble and phone shapes, were often used in instant messenger apps and were also the colours and shapes downloaded the most.

It was expected that the commonality of squares and circles in app icon design might build consumers' familiarity with these shapes and thus increase their appeal and chances for the app being downloaded more. However, squares and circles were not downloaded as much as speech bubbles and phones, unlike frequent colours also being downloaded more due to their relation with popular app functions. The lower download rates squares and circles received may have been due to a number of reasons: (1) they had limited associations with a desirable app function; (2) their basic geometric nature may not have elicited evaluations that excited smartphone users; and (3) their commonality in app icons may have meant that they were overlooked by smartphone users who were accustomed to browsing the app store. However, these frequently occurring shapes did have a practical role that arguably improves the ergonomic value of the app.

Although some colours and shapes connected with higher download rates through their use and association with popular app categories and functions, there

appeared to be no connection between the kinds of meanings conveyed and the amount of downloads received. With app research showing that consumers rely on multiple criteria to ease the app selection process (Gage Kelley et al., 2012; Gage Kelley, Cranor, & Sadeh, 2012; Dogruel, Joeckel, & Bowman, 2015), it is more realistic to suggest that consumers, whilst they may gather meaning from visual elements of an app icon to inform them about the app, it is the combination of these elements with other information about the app's category and function that consumers may find more informative that ultimately helps them to make informed purchase or download decisions.

Overall, while visual semiotic elements colour and shape might be said to act as informative tools in app icon design to help consumers identify the app's category, function, and ergonomic value, and contribute to the attention-grabbing and aesthetic value of the app, the function of the app specifically might be more influential for consumer's download decisions.

5.2.2. The Impact of Colour and Shape on Smartphone User Evaluations

Companies that provide desirable services to consumers increase their perceived value and, with effective marketing strategies, their visual presence in the app market. Consequently, the apps of these companies can consequently contribute toward popularising certain visual design characteristics in app icons. White and blue, for example, are perpetually used in the icons of apps that are downloaded more than

apps using other colours, which may primarily be due to their use in apps that have desirable functions in addition to the commercial success of social media company Facebook (which also owns WhatsApp and Instagram).

The commonality of white and blue in the app market means smartphone users are more likely to be exposed to and engaged with apps that have white and blue in their icons. Consumers find products they are familiar with more preferable to ones with which they are unfamiliar (Campbell & Keller, 2003). Heuristically, consumers may learn to recognise these colours as relating to apps that are desirable and that they are familiar with, trust, and use regularly. However, the higher frequency of certain colours and shapes in app icon design identified in the corpus (i.e. colours: white, blue, green, red; or shapes: squares or circles) did not elicit higher appeal ratings from smartphone users in the user response study.

It was also expected that atypical or infrequent colours identified in the corpus of app icons might elicit higher distinctiveness ratings from smartphone users, which was not the case in the user response study. While participants rated colours purple and orange as more distinctive than other colours presented to them in the study, the ratings still aired on the side of generic. Indeed, participants remained very reserved in their ratings between distinctiveness and genericity, and very appealing and not very appealing.

Another expectation was that if consumers had learned to recognise particular colours and shapes as being used in the icons for popular app categories and functions in the app market then these colours and shapes would receive higher typicality

rankings for their respective category in the user response study. The results revealed that the colours and shapes of app icons presented to participants in the user response study did not elicit strong responses with regard to their distinctiveness or appeal ratings, nor their category typicality rankings. There was no evidence of different forms (hard versus soft) making an impact on participant responses either.

There were many null results in study 2, meaning that the statistical power of the results is potentially an issue, which may be due to a number of reasons. Primarily, it might indicate the lack of impact colour and shape had on smartphone user evaluations in the user response study. This finding suggests that colours and shapes, when they are presented in this context with no other cues that would normally be seen on app icons (e.g. other shapes, objects, text, etc.), are not seen as signs in themselves by smartphone users. In other words, the fabricated app icons varying in colour and shape presented to participants perhaps lacked the appropriate context in which these icons could be considered as meaningful. Beasley and Danesi's (2010: 41) point that visual elements such as colours and shapes are not noticed as signs that convey meaning necessarily but rather as "complementary" or "decorative" aspects of a product (Beasley & Danesi, 2010: 41) goes some way to explain that colour and shape may not be considered informative enough signs to convey meaningful information when they are presented on their own with only a textual description portraying them as app icons. I therefore agree with Kress and Van Leeuwen (2011: 58-59) in that there are limits to how much colour and shape can be said to be signs on their own.

Moreover, the abstract nature of the experiment that involved presenting participants a combination of colours and shapes as app icons did not have enough contextual information to make them believable. Another limitation of the experiment was that it only tested a small selection of colours and geometric shapes, which limited the correspondences that could be made between study 1 and 2, particularly for different shapes that took the form of objects. If the user response study was replicated, there are a number of improvements that could be made with regards to its experiment design, of which some ideas are proposed in the following section as part of further research.

6. Conclusions and Proposals for Further Research

Exploring the roles colour and shape play in smartphone app icons has realised that colour and shape may have different communicative advantages in app icon design. Colour plays a more symbolic role in app icons, communicating affective values and cognitive associations in addition to serving as a practical attention-grabbing tool that can contribute to the aesthetic value of the app icon. Shape plays a role that is more useful in the identification of the app's category and function.

By considering colour and shape as visual semiotic elements individually and together, the thesis has shown how colour and shape can operate as part of a visual language in the context of the online app market. Analysing the use and meanings of colour and shape in app icons has demonstrated that visual characteristics including colour, shape, and form can all assist in the construal of desirable values associated with real world objects and conventionalised meanings that can be transferred onto an app to inform consumers of the qualities it possesses.

However, while colour and shape in this regard can be said to be informative tools, they are less persuasive than expected and did not connect with download rates or positive evaluations from smartphone users. Colours and shapes that associate with popular app categories and functions are more likely to connect with higher downloads, such as white, blue, and green were used more by instant messenger apps than any other type of app and so received higher download rates through their association.

The results from the user response study in particular for both colour and shape indicate that smartphone users struggle to interpret colour and shape in app icons with regards to their distinctiveness, appeal, and category typicality when the design of the stimuli and the environment in which they are perceived is too distant from the context in which apps would normally be found. Therefore, there may be other factors that are more instrumental in affecting downloads and consumers' evaluation of an app, such as its category, function, and additional contextual cues (e.g. app name, description, reviews, etc.).

Further research could extend the current thesis' studies by analysing the use, meaning, and impact of app icons from a broader range of categories, in addition to addressing the mixed colours, lighting effects, and text in app icons. The user response study relied on responses from native-speakers of English, which could be extended by having non-native speaking participants rate the colour and shape of app icons in order to test for cultural variation in their responses. If the experiment was replicated, a preference rating for a colour spectrum would provide a more balanced insight into the effect colour preference (positive and negative) has on smartphone user's ratings for the appeal of app icon colours. Moreover, presenting participants with app icons that include more contextual cues such that they appear more realistic and believable to consumers might improve the experiment's design and provide more accurate results regarding smartphone user evaluations of app icons.

Due to the exploratory nature of the thesis, the conclusions reached here will benefit from a confirmatory approach in further studies. Three proposals for further research are detailed in the following discussion.

First, an ethnographical account from app designers would provide an insight into why they make certain choices with regard to the colours and shapes used in app icon creation, and their reasoning for arranging these choices to act in specific roles within icon composition. Although previous research has suggested that most designers rely on intuition and creative experience (Gorn et al., 1997), increasing accessible and easy-to-use design software means the specialist activity is becoming more widely available to the general public (Kress & Van Leeuwen, 2006). Establishing how practitioners navigate the meaning potential of visual design elements such as colour and shape may help to improve design quality and effectiveness in general, for both professional and amateur designers.

Moreover, research has documented that companies are becoming more adventurous and creative, introducing new ways in which consumers can *consume* their marketing and products (Rosa & Malter, 2003). Therefore, building collaborative relationships with large and small companies, their marketing departments, and individual advertising agencies could allow academics access to the creative minds in modern business and shed light on how these people – the creators of advertising and product marketing – harness visual and figurative language. Understanding the processes involved in making these choices during the design procedure can greatly enhance our knowledge for how we, as humans, conceptualise and manipulate

seemingly abstract elements, such as colour and shape, to produce resources that are informative, persuasive, and powerful.

Second, the thesis and its associated research fields of marketing and visual search, would benefit from further controlled, confirmatory experiments that serve to discern more specifically what cues smartphone users consciously consider and report, and subconsciously use, to inform their download choices when browsing the app store. Determining the reasons *why* and *how* design choices have an impact on consumers' perception, comprehension, appreciation, and purchase behaviour is a desirable goal for all marketing research. When presenting participants with these apps, it would also be interesting to test how colour and shape in app icons are decoded by consumers in order to determine what values consumers interpret from the app icon itself, and indeed which values and kinds of interpretations are more salient.

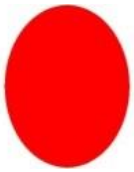
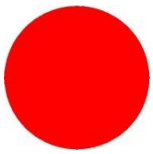
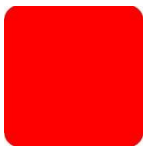
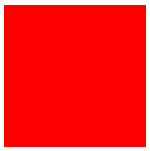
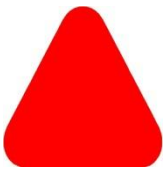
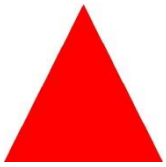
Future study should involve an experiment that engages participants in a search task in the Google Play Store or Apple App Store and asks them not only to report the cues they consciously consider to inform their purchase or download decisions (as previous studies have done), but also tracks what they look at and consider subconsciously using eye-tracking software and screen capture. This will extend app and visual search research by investigating what cues consumers use when selecting apps from the online market that also includes the visual impact of the app. Controlled experiments that give participants a task to select apps from the app store in real time should study specific sign systems and how they convey meaning. Indeed,

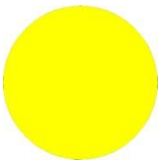
more confirmatory testing of colour and shape in visual search on mobile devices is required, in addition to computer monitors, before their effectiveness is confirmed (Ivory & Magee, 2009).

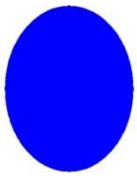
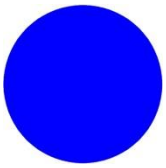
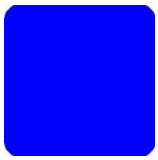
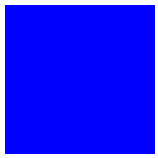
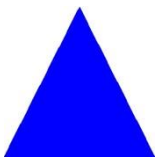
Third, in order to establish whether more conventional visual design in app icons (e.g. blue, white, and shields in security apps) or distinctive visual design effect download rates, a longitudinal study should test whether a change in colour, shape, or other visual elements can influence a subsequent change in download rate. A series of experiments could investigate whether subtle changes in the visual characteristics of the same app icon alter the consumer's appeal and appreciation of the virtual product, and which of these characteristics are most effective (i.e. that elicit more positive evaluations, or alter perceptions considerably in favour of the product).

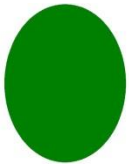
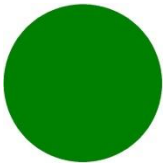
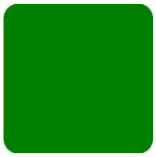
7. Appendices

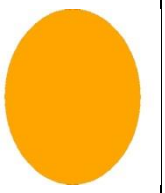
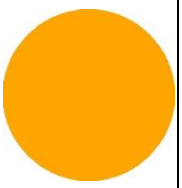
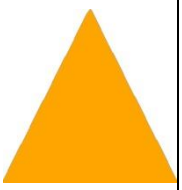
7.1. Details of Stimuli Design

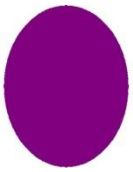
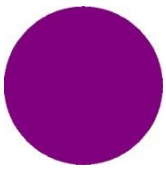
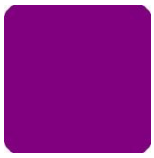
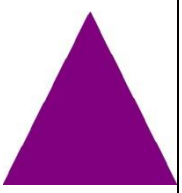
Appendix 1: Details of Stimuli Design						
Colour	**RGB value**	**Hexa-decimal (#) value**	**Geometric Shape**	**Form***	**Visual Represent-ation****	**Code**
Red	255, 0, 0	#FF0000	Oval	Soft		Rd_Ov
			Circle	Soft		Rd_Ci
			Square	Soft		Rd_SS
				Hard		Rd_SH
			Triangle	Soft		Rd_TS
				Hard		Rd_TH

Colour	RGB value	Hexa-decimal (#) value	Geometric Shape	Form*	Visual Represent-ation**	Code
Yellow	255, 255, 0	#FFFF00	Oval	Soft		Yw_Ov
			Circle	Soft		Yw_Ci
			Square	Soft		Yw_SS
				Hard		Yw_SH
			Triangle	Soft		Yw_TS
				Hard		Yw_TH

Colour	RGB value	Hexa-decimal (#) value	Geometric Shape	Form*	Visual Represent-ation**	Code
Blue	0, 0, 255	#0000FF	Oval	Soft		Bl_Ov
			Circle	Soft		Bl_Ci
			Square	Soft		Bl_SS
				Hard		Bl_SH
			Triangle	Soft		Bl_TS
				Hard		Bl_TH

Colour	RGB value	Hexa-decimal (#) value	Geometric Shape	Form*	Visual Represent-ation**	Code
Green	0, 128, 0	#008000	Oval	Soft		Gr_Ov
			Circle	Soft		Gr_Ci
			Square	Soft		Gr_SS
				Hard		Gr_SH
			Triangle	Soft		Gr_TS
				Hard		Gr_TH

Colour	RGB value	Hexa-decimal (#) value	Geometric Shape	Form*	Visual Represent-ation**	Code
Orange ***	255, 165, 0	#ffa500	Oval	Soft		Or_Ov
			Circle	Soft		Or_Ci
			Square	Soft		Or_SS
				Hard		Or_SH
			Triangle	Soft		Or_TS
				Hard		Or_TH

Colour	RGB value	Hexa-decimal (#) value	Geometric Shape	Form*	Visual Represent-ation**	Code
Purple	128, 0, 128	#800080	Oval	Soft		Pu_Ov
			Circle	Soft		Pu_Ci
			Square	Soft		Pu_SS
				Hard		Pu_SH
			Triangle	Soft		Pu_TS
				Hard		Pu_TH

* Hard forms = straight and angular lines and edges
Soft forms = round and curved lines and edges
**Soft square template (appendix 2) and soft triangle template (appendix 3)
*** Orange values (color-hex, 2018)

7.2. Soft Square Template

Source: square-rounded-xxl (iconsdb.com, 2018)

7.3. Soft Triangle Template

Source: triangle-with-rounded-corners (iemoji.com, 2018)

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