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Preface

"From an early age we are taught how to read, to write, to interpret texts. But the efficacy of letters goes beyond their mere verbal meaning, and we should be attentive to the repercussions these legible forms (street signs) end up having on the landscape of the city - very especially on account of their creative and political potential (Freedman, 2008). The city presents itself to us full of messages, of elements that can turn out to be very attractive if we observe them from new, interdisciplinary, suggestive or creative standpoints."

(Heurta, 2010, p.73)

From I Like Cities; Do You Like Letters? Introducing Urban Typography in Art Education



The basis of this thesis is an interdisciplinary research project that includes collaborations between psychology, humanities and graphic design. ELIT (the Empirical Study of Literature Innovative Training Network) is an EU-funded network integrating methods within sciences and the humanities to produce knowledge on the cognitive operations involved in, and the impacts of, literary reading. This dissertation is jointly supervised by Prof. Helmut Leder (University of Vienna) and Prof. Massimo Salgaro (University of Verona) as part of an ELIT Cotutelle agreement, with the contents fulfilling the requirements of both universities.

Of the three research work packages outlined by the ELIT network, this project (Reading in the City: in everyday life; ESR3) falls under Work Package 1, which focuses on the fundamental processes that underlie literary reading. This utilises a combination of self-report, objective and online measures of cognitive processing, and also takes into consideration individual differences with regard to literary reading, i.e., age, gender, reading habits, *et cetera*. ESR3 focuses on eye-tracking to study the presence and quality, and aesthetic dimensions of natural reading in everyday lives.

A number of questions aim to be explored through this research:

What is the prevalence and effects of reading experiences in the visual exploration of an environment?

What features of text in urban environments might affect attentional demands?

How do these experiences systematically differ between perceivers?



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English Abstract

Text is everywhere, our urban everyday lives are flooded with textual elements- it is almost, if not, impossible to walk through a city without reading. Reading text is a key requisite in our daily affairs and considered one of the most outstanding features that make us human. Despite this, the sheer number of reading experiences encountered by an individual on a daily basis is often overlooked and so little is known about how reading is meaningfully embedded in our lives. The objectives of this dissertation are thus to measure and understand the activities and cognitive processes of literary readers, particularly concerning aesthetic reading experiences in everyday contexts. This is divided into three main sections.

In (1) the broader concept of ‘urban aesthetics’ is considered through a scoping review, and thus also where the study of text/reading fits within this. This can identify possible elements that were overlooked or should be investigated further with regard to text signs, but also in future field/lab studies within this urban, everyday context. Within the broader concept of ‘everyday aesthetics’, the future of text reading was also considered regarding how aesthetics could enrich the investigation of text. The studies in (2) involve mobile-eye tracking during free exploration walks in city streets to look at natural reading experiences. Combined with methods gathered from museum studies and predictions from models of aesthetic experiences (see Leder et al., 2010; Pelowski et al., 2011; 2016; 2018), this tests the predictive effect of aesthetic value on viewing behaviour of text stimuli. Following on from the designs of studies in (2), but with a different take on ‘reading in real life’, the studies in (3) look at another natural experience with everyday reading, with a focus on the interplay of familiarity/beauty with contextual information (text/image content), to assess what is more important for memory/evaluations of book covers.

Taking all three sections together, different approaches are undertaken to investigate graphic/textual elements in everyday life, to gain a wider understanding of aesthetic engagements (with reading) in everyday settings.

Text ist allgegenwärtig, unser städtisches Alltagsleben ist überflutet von textlichen Elementen - es ist fast, wenn nicht gar unmöglich, durch eine Stadt zu gehen, ohne zu lesen. In unserem Alltag ist das Lesen von Texten ein Schlüsselerlebnis, und Lesen gilt als eines der herausragendsten Merkmale, die uns zu Menschen machen. Trotzdem wird die schiere Anzahl der Leseerfahrungen, denen der Einzelne täglich begegnet, oft übersehen, und es ist tatsächlich recht wenig darüber bekannt, wie das Lesen sinnvoll in unser alltägliches Leben eingebettet ist. Ziel dieser Dissertation ist es daher, die Aktivitäten und kognitiven Prozesse von Lesern zu messen und zu verstehen, insbesondere im Hinblick auf ästhetische Leseerfahrungen in alltäglichen Kontexten. Sie gliedert sich in drei Hauptabschnitte.

In (1) wird das umfassendere Konzept der „urbanen Ästhetik“ mithilfe einer systematischen Literaturanalyse betrachtet, und liefert damit Informationen, wo die Untersuchung von Text/Lesen in dieses Konzept passt. Dadurch können mögliche Elemente identifiziert werden, die in Bezug auf Textzeichen übersehen wurden oder weiter untersucht werden sollten, auch in zukünftigen Feld-/Laborstudien in diesem städtischen, alltäglichen Kontext. Im Rahmen des umfassenderen Konzepts der „Alltagsästhetik“ wurde auch die Zukunft des Textlesens im Hinblick darauf betrachtet, wie Ästhetik die Untersuchung von Text bereichern könnte. Die Studien in (2) beinhalten die Augenbewegungsmessungen durch mobile Geräte während freier Erkundungsgänge in den Straßen der Stadt, um natürliche Leseerfahrungen zu untersuchen. Kombiniert mit Methoden aus Museumsstudien und Vorhersagen aus Modellen ästhetischer Erfahrungen (Leder et al., 2010; Pelowski et al., 2011; 2016; 2018) wird die prädiktive Wirkung des ästhetischen Wertes auf das Betrachtungsverhalten von Textstimuli untersucht. Anknüpfend an die Designs der Studien in (2), aber mit einem anderen Blick auf das „Lesen im wirklichen Leben“, betrachten die Studien in (3) eine weitere natürliche Erfahrung mit dem alltäglichen Lesen, mit einem Fokus auf das Zusammenspiel von Vertrautheit/Schönheit mit Kontextinformationen (Text/Bildinhalt), um zu verstehen, was für die Erinnerung/Bewertung von Buchcovern wichtiger ist.

In allen drei Abschnitten zusammen werden verschiedene Ansätze zur Untersuchung grafischer/textlicher Elemente im Alltag untersucht, um ein umfassenderes Verständnis der ästhetischen Erfahrung (beim Lesen) im Alltag zu gewinnen.

I testi sono ovunque, la nostra vita quotidiana nel mondo urbano è inondata di elementi testuali: è quasi, se non del tutto, impossibile, camminare in una città senza leggere. La lettura di testi è un requisito fondamentale nelle nostre attività quotidiane ed è considerata una delle caratteristiche più importanti che ci definiscono esseri umani. Ciononostante, spesso si trascura l'enorme numero di esperienze di lettura incontrate da un individuo ogni giorno e poco si sa di come la lettura sia diventata parte integrante delle nostre vite. L'obiettivo di questa tesi è quindi quello di misurare e comprendere le attività e i processi cognitivi dei lettori, in particolare per quanto riguarda le esperienze estetiche di lettura in contesti quotidiani. La tesi è suddivisa in tre sezioni principali.

Nella sezione (1) viene esaminato il più ampio concetto di “estetica urbana” attraverso una *scoping review*, e in che modo lo studio del testo/della lettura si inserisce in questo contesto. In tal modo è possibile individuare eventuali elementi che sono stati trascurati o che dovrebbero essere approfonditi sia in relazione ai segni testuali, sia in futuri studi sul campo o di laboratorio all'interno dell'abituale contesto urbano. Nell'ambito del concetto più ampio di “estetica del quotidiano”, è stato preso in considerazione anche il futuro della lettura dei testi, per capire come l'estetica possa arricchire l'indagine sul testo. Gli studi nella sezione (2) prevedono l'utilizzo di un *mobile-eye tracking* durante l'esplorazione libera a piedi delle strade cittadine per osservare le esperienze di lettura naturali. In combinazione con i metodi acquisiti dagli studi museali e con le previsioni generate dai modelli di esperienze estetiche (vedi Leder et al., 2010; Pelowski et al., 2011; 2016; 2018), si verifica l'effetto predittivo del valore estetico sul comportamento visivo rivolto a stimoli testuali. Partendo dal design utilizzato negli studi della sezione (2), ma con un approccio diverso alla “lettura nella vita reale”, gli studi nella sezione (3) esaminano un'altra esperienza di lettura naturale nel contesto di tutti i giorni, con particolare attenzione all'interazione tra familiarità/bellezza e informazioni contestuali (contenuto del testo/immagine), per valutare cosa sia più importante per ricordare/valutare delle copertine di libri.

Considerando tutte e tre le sezioni, vengono intrapresi approcci diversi nell'indagare gli elementi grafici/testuali nella vita quotidiana, per ottenere una comprensione più ampia delle esperienze estetiche (e di lettura) che permeano la vita di tutti i giorni.

1. Introduction

“We have at our disposal in our cities a genuine museum woven together with the threads of the alphabet.”

(Heurta, 2010, p. 72)

Text is everywhere, our cities are flooded with written material—reading is an inevitable part of walking through any city. Reading text is thus a fundamental necessity in everyday life. Moreover, language/reading is also considered one of the distinctive features that make us human (Cook, 1988; Jean, 1992; Luef & Marin, 2018; Robinson, 2009), and reading, in most instances, is unavoidable. Despite this, the reading experiences we are confronted with in our daily undertakings often go unnoticed and so our understanding of the extent to which reading is meaningfully embedded in our lives is limited. It is important to note that the focus here is not on literary text, but day to day experiences with any sort of reading material, on a micro-level. As such, this dissertation research aims to gain a wider understanding of aesthetic engagements with text in everyday urban contexts and thus reconceptualising reading.

My PhD project explores aesthetic experiences related to everyday reading. In the first chapter, I begin with a theoretical perspective of text reading and urban everyday aesthetics (Chapter 1: Theoretical perspectives). This involved a scoping literature review of urban components considered for aesthetics and wellbeing (Chana, Dehove, et al., subm.). Doing so provided an overview of urban aesthetics research in which I could identify reading material as an urban aesthetic component and what research previously was conducted on aesthetic reading experiences in urban environments. Alongside this, I also explored text reading specifically (Mendhakar, Chana et al., in prep), discussing future directions and how the incorporation of aesthetic methods could enhance the investigation of text. In the second chapter, I then carried out studies in everyday settings to explore natural reading behaviour with high ecological validity (Chapter 2: Field study investigations). These studies involved mobile eye-tracking during free exploration walks in city streets to look at natural reading experiences and the influence of aesthetics on memory (Chana et al., 2023). In the third chapter, I conducted laboratory experiments to investigate reading experiences systematically in more controlled settings (Chapter 3: Lab-based investigations). This included other everyday examples of reading experiences. In exploring book covers, I focused on contextual information (text/image), to assess what is more important for memorability and aesthetic evaluations of book cover content (Chana, Mikuni et al., acc.). The natural reading experience was further explored regarding how eye-movement behaviour differed according to print vs. various digital reading platforms (Mendhakar, Sierak et al., in press).

In this introduction, I will first provide an overview on what is meant by reading in the context of this dissertation. I will then outline the three main sections. The discussion will elaborate on how these three sections and the respective studies within them contribute to the wider understanding of aesthetic engagements with reading in everyday settings. Under the umbrella term of environmental aesthetics, Figure 1 provides a visual framework of my doctoral thesis and the included research papers. Together, these sections, with the corresponding first-author and co-author papers, demonstrate a holistic approach to understanding reading as an aesthetic experience. This approach recognises its embeddedness in everyday environments, and by integrating insights from psychological and environmental aesthetics, shifts the perspective on what constitutes reading.

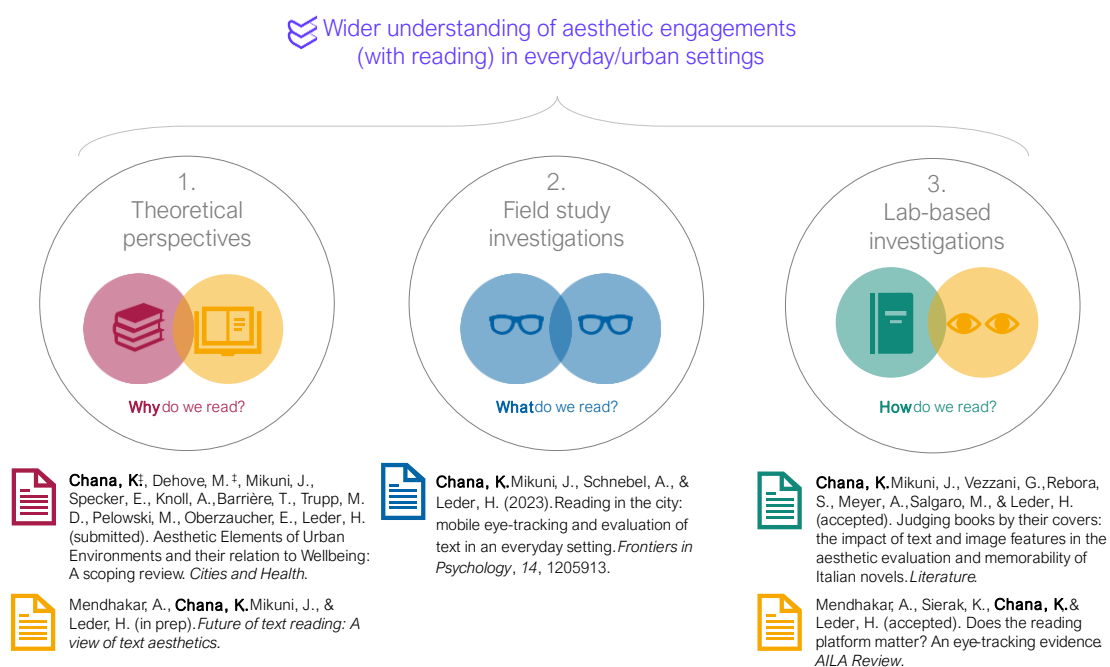


Figure 1. Graphical structural overview of the thesis and associated publications

1.1. Environmental Aesthetics

“Living in a visually stimulating environment is a source of enjoyment for many and it’s not surprising that creative individuals will ‘colour our city’ with images and ideas.”

(Chamberlin, 2018, vii.)

Environmental aesthetics is a multifaceted discipline that does not stem from a single origin but instead draws reference from an array of sources. The research appeal of the aesthetics of the environment stems in part from responses to ecological issues, reflecting on increased appreciation of

aesthetic values of our surroundings. In many ways, it functions as “applied aesthetics”, where aesthetic principles are integrated into everyday life and practical objects, ranging from clothing, vehicles, buildings, and even human behaviour. However, all aesthetics can be considered applied to an extent. Even the fine arts, which is traditionally linked to aesthetics, has practical aspects: something is created, evokes an effect, and may serve a purpose. Yet, this practical aspect is often overlooked in favour of the immediate emotional or sensory experience of aesthetics.

Environmental aesthetics, traditionally defined as the study of the aesthetic qualities of natural and built environments (Berleant, 1992), serves as a rich framework for examining how sensory experiences and perceptual responses to environments shape our engagements with texts. By incorporating empirical aesthetics¹, we can analyse how the visual, auditory, and tactile elements of both urban and everyday environments influence reading behaviours and the broader aesthetic experience of texts (for further elaboration, see §1.3). Understanding reading through the lens of environmental aesthetics allows us to expand the definition of reading beyond its traditional focus, considering instead the interactive, sensory, and emotional experiences that texts evoke in various environments (not limited to literary context).

My research, including this thesis, aims to engage a wide range of readers, including psychologists, linguists, practitioners. More importantly, it seeks to reach those who are inquisitive about their environment in ways that encourage and inspire them to explore/consider new ways of understanding its significance and complexities.

1.2. An understanding of reading

“Before there was reading there was seeing.”

(Visible Language, *The Journal of Visual Communication Research*, p.1.)

This research challenges and extends the conception of reading, by exploring urban text, visual stimuli and digital interactions as forms of reading without the confinement of pages within a literary book. Thus, in other words, it extends reading beyond words on a page. While traditional definitions of reading typically focus on ‘literary reading’ (see Salgado, 2021), the concept of reading addressed in this dissertation diverges from this position.

¹ Empirical aesthetics, situated at the intersection of psychology, neuroscience and philosophy, seeks to understand how individuals engage with and experience beauty and art through systematic, scientific enquiry (see Tinio & Smith, 2014) (see also §1.2.2.).

At its core, reading is an automated process of comprehension which includes deciphering characters or symbols, recognising them as words and then inferring their meaning (Findlay & Gilchrist, 2003). Whilst the role of affect and emotional reactions to text (e.g., Koopman & Hakemulder, 2015) ought not to be disregarded in the reading process, the emphasis here is placed on reading as a cognitive act and as an extension of 'looking'. However, as Kuiken and Jacobs (2021b) note, reading is more of an 'anachronism' in that it no longer fully captures the range of activities involved in engaging with literary material in modern contexts. This is particularly evident as the scope of what is considered as literature broadens to encompass not only traditional written material such as 'narrative texts' (for elaboration on literary texts and 'literariness', see Koopman & Hakemulder, 2015), but also other media such as film, theatre and television (Kuiken & Jacobs, 2021a), and other text forms, such as urban text (e.g., Chamberlin, 2018; Chana et al., 2023; Ferdous, 2015; Levy, 1978) and digital content (e.g., Herrmann et al., 2021; Khoo, 2021; Kuijpers et al., 2021; Oliver et al., 2021). The evolving landscape of cultural artefacts challenges the traditional notion of reading, which is increasingly inadequate in describing the complex, multi-dimensional engagements people have with narrative and aesthetic content today. In rethinking the definition of reading from a cognitive science approach (and addressed in the succeeding sections), this thesis therefore embraces a more inclusive perspective that includes visual and environment factors and contends that such an approach offers a richer understanding of reading behaviour related to the principles of environmental aesthetics.

The aforementioned framework of environmental aesthetics facilitates the expansion of what is meant by reading. The aesthetic experience is not restricted to artworks or specific aesthetic objects (Berleant, 1992; Leder et al., 2004; Pelowski & Akiba, 2011) and instead is deeply embedded in our everyday experiences (Berleant, 1992), including how to interact with urban environments and during day-to-day activities. This view broadens our conception of reading to emphasise engagement with our environment, an environment which encompasses texts, signs, and images, and therefore in itself becomes a multimodal text that requires a degree of interpretation. In this light, reading the environment indeed also involves the way one navigates in an urban space, exploring built environments through linguistic and verbal elements. Urban signage, advertisements, even architectural features and company logos are all elements classified as environmental text that can be read and decoded to understand the world around us (Gorter & Cenoz, 2008; Landry & Bourhis, 1997).

1.2.1. Visual reading and perceptual processing

“Each letterform skeleton of the Latin alphabet activates a different basic visual feature or combination of basic visual features of perception.”

(Zender, 2019, p. 70)

Central to the broader understanding of reading is the notion of *visual reading*, where reading constitutes the simultaneous processing of both text and image. In this section, I outline how reading builds upon cognitive and perceptual frameworks of visual objects. Further, I outline how visual reading goes beyond the traditional linguistic approach to include the dynamic interaction of both text and visual elements.

Visual reading, albeit a linguistic task, is fundamentally grounded in perceptual processes (Zender, 2019). In psychophysics, seminal works of Weber (1834) and Fechner (1897) explain that perception follows quantifiable laws, such as sensitivity to stimulus intensity. Such principles are crucial for understanding typographic legibility and visual clarity in reading environments (Legge & Bigelow, 2011). The notion put forward by von Helmholtz (1867), that perception involves unconscious inference, suggests sensory input is interpreted rather than passively received, and this concept is further supported by modern reading research (Dehaene, 2009). Further, Gestalt psychologists argue that holistic perception is organised by innate principles such as proximity, similarity and figure-ground distinction (Wertheimer, 1923), which helps structure how readers process typographic composition and integrate text and images (Lupton, 2014). Fechner’s (1860) work on visual aesthetics, revealing how visual features like balance and preference affect attention and comprehension, laid the groundwork for understanding how design and composition influences reading (Walker, 2001).

Marr’s (1982) computational model of vision² aligns with these theories and describes vision as an information processing system (for summary, see Bruce & Green, 1992). Marr’s three stages can be likened to the way typographic and visual elements are processed in reading, from preliminary analysis of letterforms and spatial organisation to the eventual recognition of an integrated visual-textual construct. These perspectives collectively highlight that visual reading is not limited to symbolic interpretation and instead entails a holistic perceptual process through which the brain synthesised input from linguistic and non-linguistic channels. Visual perception acts as a central framework for how visual information is

² Marr’s (1982) model includes three stages: the primal sketch, where basic shapes and edges are detected; the 2½D sketch, where surfaces and spatial orientation are derived; and the 3D model, where full object recognition occurs. These stages mirror how readers move from low-level typographic detail to higher-level linguistic meaning.

acquired, processed and interpreted in the act of reading. These foundational insights inform our understanding of the reading process, but also a theoretical basis for the evaluation of typographic design, layout, visual legibility, *et cetera*.

Alongside theoretical models, the history of alphabetic form also supports a perception-based view of reading (Zender, 2019). Most alphabetic systems (with exceptions such as Hangul³) evolved organically as opposed to being deliberately designed. Letterforms were shaped by the materials and technological constraints of their time. For example, angular cuts in clay gave rise to cuneiform, pens produced rectilinear shapes seen in Hebrew, brushes encouraged the fluidity seen in Arabic, and stone inscriptions led to serified Roman capitals (Sutton & Bartram, 1968; Jean, 1992, Robinson, 2009). The introduction of Gutenberg's movable metal type in the 15th century, replicated handwritten irregularities in blackletter typefaces and catalysed mass literacy (Ruder, 2018). As literacy spread, the need for visual consistency in letterforms increased. Unconventional shapes were discouraged in favour of stable, familiar forms that aided learned visual recognition patterns and thus facilitates reading (Noordzij, 2019). This stabilisation over time has been described as the emergence of an 'international basic form', whereby typographic heritage has been shaped by centuries of use and human visual comfort (Frutiger, 1989).

These insights into perceptual constraints are further supported by neuroscience. The visual cortex is organised into feature-detecting modules that are sensitive to basic shapes (e.g., curved, diagonal, horizontal, vertical) and forms the foundation for object recognition (Bruce & Green, 1992). These features, which are also apparent in early letterform detection, are perceptually salient and attract attention with minimum effort due to their simplicity (Treisman, 1985). This supports the idea that the legibility of letterforms, and consequently the processing of words in the act of reading, aligns with neurologically efficient visual processing (see also Turker et al., 2023).

Letterforms are therefore visual objects and, like images and all seen objects, are processed through bottom-up mechanisms, where low-level features are detected and combined into letters with stored activation patterns (Grainger et al., 2008, see also Underwood, 1998). Letterform silhouettes, for example, are so deeply embedded in the subconscious of the reader that even slight deviations can interrupt recognition and readability (i.e., fluency of reading) (Frutiger, 1980; Wehr & Weppich, 2004; Zenker, 2019). Though readability involves various typographic and layout factors (e.g., line length, size,

³ Hangul is a Korean script and is a rare example of a consciously designed alphabet. It was created in the 15th century by King Sejong and scholars to represent phonemes logically and visually (Sampson, 1985).

spacing), legibility (i.e., the ability to distinguish one letterform from another) remains a crucial element (Beier & Oderkerk, 2019).

Building upon the foundations of visual perception and cognitive processing, the more broadly defined conception of reading is increasingly characterised by the integration of both text and image. The visual reading process therefore is a multimodal experience that demands continuous interpretation of both text and image, with this combination in any environment shaping our understanding on a deeper cognitive level (Kress & Van Leeuwen, 2020; Liu, 2013). Given that text and image are processed simultaneously (Rayner, 1998; Rayner et al., 2001), reading becomes an integrated system where visual and textual information work in tandem to create meaning. This is particularly relevant for the broader conceptualisation of reading, where images and text in everyday scenarios (e.g., viewing advertisements or signage) demand parallel processing to enhance comprehension and emotional engagement. In such settings, textual cues work alongside visual cues in the environment, such as landmarks or colour-coded routes (Bauer & Mayer, 2008; Harland, 2015; Huerta, 2011; Lynch, 1960) to facilitate urban navigation.

In sum, visual reading draws upon the fundamental processes of perception, which shape how typographic and visual forms are interpreted. Rooted in historical evolution of typographic forms and neurobiological mechanisms of visual perception, the act of reading engages both symbolic and perceptual systems. As such, the design of text and image is not only a cultural product but also a cognitive concern. Understanding how the brain processes text and image together is essential for effective, legible reading, and creating meaningful reading environments/experiences.

1.2.2. Aesthetic reading

“Visual compositions that value aesthetics over ease of communication.”

(Chamberlin, 2018, p. 151)

Visual aesthetic processing, a central concern in empirical aesthetics⁴, offers another important lens through which to understand reading. Aesthetics is broadly defined as how we perceive, experience and derive pleasure or meaning from sensory stimuli (for overview, see Huston et al., 2015; Shimamura & Palmer, 2012; Tinio & Smith, 2014). Although traditionally studied in visual art⁵, this provides a framework for understanding the processing and responses to a range of aesthetic stimuli (see Leder et al., 2004;

⁴ The field of empirical aesthetics was founded by Gustav Fechner with the seminal work *Vorschule der Aesthetik* (1897). For further elaboration and translation, see Leder and Pleines (Leder, 2014)

⁵ The term was devised by Baumgarten (1750) in *Aesthetica* referring to studying the ‘art of thinking beautifully’ or *ars pulchre cogitandi*.

2011; Pelowski et al., 2011; 2017; Skov & Nadal, 2020; Zimmerman, 1966), including textual materials and other objects in our urban everyday environments (e.g., Chana et al., 2023; Gartus & Leder, 2014; Knoll et al., 2024; Leder et al., 2022; Grasso et al., 2024; Specker et al., 2024).

In empirical aesthetics, studies often include an evaluation of aesthetics pertaining to the stimuli at hand. This evaluation is often related to cognitive or affective components of the aesthetic judgement, encompassing dimensions such as beauty, liking, pleasure and preference, to name a few (see Augustin et al., 2012; Jacobsen, 2006; Knoop et al., 2016; Leder et al., 2005). This field of research has also provided fertile ground for theorising how cognitive and affective systems interact during the aesthetic experience (for overview, see Vartanian, 2014), which is especially relevant for aesthetic reading where readers not only comprehend text but engage with it on emotive, sensory and reflective levels.

Aesthetic reading could be considered a multimodal experience, where visual design and linguistic features coalesce in the act of literary engagement. Aesthetic properties influence not only appreciation but also cognitive processing. For example, the layout, typographic density, and even the aesthetic appeal of a book can prime readers' expectations and influence the depth and tone of engagement (Jacobs, 2015; 2017; 2023; Salgaro et al., 2018; 2021). Typography and colour, alongside narrative form and stylistic markers, constitute key variables in the reader's aesthetic experience (see also Page et al., 2017). This aligns with broader findings in empirical aesthetics demonstrating the significance of visual properties in shaping attention, fluency, and affect.

One of the most influential models in empirical aesthetics is the model of aesthetic processing proposed by Leder et al. (2004). This outlines five sequential stages of aesthetic processing: perceptual analysis, implicit memory integration, explicit classification, cognitive mastering, and evaluation. This model emphasises the interplay between sensory input and higher order cognition. Though developed in relation to art and other visual aesthetic stimuli, this framework is highly applicable to reading, where visual presentation and narrative complexity similarly demand a layered processing. In the context of reading, this model suggests that aesthetic appreciation of text could arise from more than surface-level comprehension, incorporating memory, expectation and individual meaning-making processes.

Evolutionary theories of aesthetics, such as those proposed by Nadal and Gómez-Puerto (2022), contribute a complementary perspective by situating aesthetic behaviour within the framework of human development and adaptation. They argue that the capacity to create and respond to art—including narrative forms like literature—may have evolved to support social cohesion, emotional regulation, and cognitive flexibility. This evolutionary lens implies that the human sensitivity to aesthetic elements in text,

such as narrative rhythm or symbolic resonance, could be rooted in adaptive functions (see also Robinson, 2009).

Neuroaesthetics provides further empirical grounding by identifying neural systems in the brain involved in aesthetic perception (e.g., Vessel et al., 2022, see for example Kathofer et al., 2025). Chatterjee and Vartanian (2014; see also Vartanian & Chatterjee, 2022) describe an ‘aesthetic triad’, comprising of sensory-motor, emotion-valuation, and meaning-knowledge systems, to describe the processes and underlying brain mechanisms in aesthetic experiences. Aesthetic reading, therefore, may activate brain regions responsible for linguistic comprehension, but also for affective and embodied responses. These systems would work in tandem during reading, implicating both low-level perceptual input and high-level interpretation, and thus revealing the deeply integrated nature of this experience. Within this broader neuroaesthetic paradigm, the Neurocognitive Poetic model (NCPM; Jacobs, 2015) offers further nuance by suggesting that literary reading engages both fast, affective-perceptual processing and slower, reflective-cognitive mechanisms (see also Tilmatine et al., 2024⁶). This dual-route model supports the idea that the aesthetic reading experience is shaped by visual and stylistic dimensions of texts, highlighting the interaction of linguistic form, emotional resonance, and narrative interpretation with cognitive-affective processes.

Another complementary theoretical lens is the processing fluency theory (Reber et al., 1998; 2004), which posits that the ease of cognitive processing influences aesthetic liking. In art contexts, familiarity and fluency influence aesthetic preferences, with increased exposure leading to greater liking (Leder, 2001; Song et al., 2021; Zajonc, 1968). In literary contexts, this theory suggests that stylistic coherence, rhythmic language, and familiarity, can enhance reader engagement and enjoyment, even in the presence of textual complexity. Importantly, fluency does not imply simplicity and emphasises the alignment between readers’ expectations and the text structure. As such, visual configurations such as layout, typographic style and spatial arrangement, could enhance or hinder a reader’s experience, acting as mediators of aesthetic engagement (Jacobs & Kinder, 2017).

These empirical models provide a multidimensional foundation for analysing aesthetic reading. This advocates for reading as an aesthetic experience, shaped by perceptual ease, cognitive effort, and emotional resonance. Visual elements are not peripheral but integral to how text is processed and

⁶ Extending this framework, Tilmatine et al. (2024) further validate and refine the NCPM. Using behavioural metrics, eye-tracking, and fMRI, Tilmatine and colleagues explores how quantifiable textual features—such as perspective shifts or lexical pacing—influence affective immersion and comprehension. In re-analyses of reader responses to Stephen King’s *The Shining*, this demonstrates how stylistic and structural cues predict variations in reading behaviour and subjective aesthetic evaluation. These findings affirm that reading engages both emotional resonance and cognitive effort, shaped in part by visual-linguistic design.

enjoyed. This convergence of the sensory, affective and cognitive substantiates a robust framework for understanding and exploring aesthetic reading.

1.2.3. An investigation of reading

“We only see what we look at. To look is an act of choice. As a result of this act, what we see is brought within our reach.”

(Berger, 2008, p. 8)

Building on the shifting conception of reading, an expanded understanding of literary engagement requires both methodological and theoretical innovation. As the scope of what constitutes literary material continues to evolve, it becomes essential to employ empirical methods that can capture the multi-dimensional nature of literary experiences across various media. The broadening definition of literature to include not only traditional texts but also digital forms and other cultural artefacts highlights the need for flexible and inclusive models that address the complex interaction between genre, style, and figurative language (Kuiken & Jacobs, 2021a). These dynamic relationships, often resistant to empirical study, are crucial for advancing our understanding of how people engage with and derive meaning from a wide range of texts.

For many people, reading—in its increasingly varied forms—is the most frequent way in which vision is used actively. It is thus no surprise that the reading process has become one of the most heavily investigated topics empirically (for overview of empirical history, see Salgado, 2021). Empirical research, particularly with eye-tracking, has significantly advanced our understanding of how visual stimuli are processed, shedding light on the mechanisms behind visual reading (e.g., Huey, 1908; Javal, 1878; McConkie & Rayner, 1975; Rayner, 1998; Rayner et al., 2001; for overview, see also Bojko, 2013; Findlay & Gilchrist, 2003; Holmqvist et al., 2011; Płużyczka, 2018). Javal (1878), for example, demonstrated that reading is not a linear process but a dynamic interaction where eye movements track across both text and image stimuli as part of a coherent visual field (Kuijpers et al., 2021). Rayner and colleagues (Rayner, 1998; Rayner et al., 2001) investigated the simultaneous processing of textual and visual information, showing that gaze shifts between both types of stimuli. Eye movements adjust continuously to the cognitive demands of the reading environment, suggesting that reading is an integrated process where visual and textual elements work together to create meaning. These findings align with the earlier discussions of visual reading, where both typographic and perceptual elements play a role in constructing meaning through continuous processing.

The challenge of extending empirical methods to capture aesthetic function in literary engagement, and to address the multimodal conception of reading outlined in this thesis, has spurred advancements in psychometric and computational techniques. As research in this area continues to integrate neuroimaging, eye-tracking, and self-report measures, the field is poised to produce more nuanced insights into how literary experiences impact readers on both cognitive and emotional levels. Multi-method studies that triangulate behavioural, physiological, and experiential data are becoming more common, facilitating the validation of complex theoretical constructs (e.g., absorption, empathy) which are central to understanding the effects of narrative engagement (Jacobs, 2018; Jacobs & Lüdtke, 2017; Kuijpers et al., 2021; Lüdtke et al., 2021; Schindler et al., 2017).

However, these advances also expose the limitations of existing theoretical models. The integration of findings from diverse disciplines, including cognitive psychology, neuroscience and literary theory, remains a critical task. Recent research has, however, moved toward more accurate predictions of how specific literary characteristics such as form, genre, style and typeface influence reader engagement and response (e.g., Hakemulder, 2020; Jacobs, 2015, 2017; Kuijpers et al., 2014; Kuiken & Sopčák, 2021; Li et al., 2015; Lüdtke et al., 2021; Neis et al., 2023; Pickren et al., 2022; Tilmatine et al., 2024; Wimmer et al., 2023). This requires continuous refinement of empirical methods, the development of new technologies, and the fostering of cross-disciplinary collaboration (Kuiken & Jacobs, 2021a), an outlook that is adopted within this thesis.

1.3. Theoretical perspectives

“Language is a marvellous tool for communication, but it is greatly overrated as a tool for thought. Because we are constantly exposed to language, we believe that thinking verbally dominates our lives. Thinking visually, if it occurs at all, is hiding in the shadows.”

(Reed, 2022, p. 3)

Why do we read? Writing is a written form of communication which allows thoughts and acoustic information to be conveyed (Blohm et al., 2021), knowledge to be preserved (Jean, 1992) and historic records to be kept (Robinson, 2009). The development of written scripts, and therefore also reading, are well documented (Jean, 1992; Robinson, 2009). Nevertheless, aside from the informational and semantic transmission reported for traditional reading, in a range of contexts that constitute urban and everyday environments, why do reading experiences occur? Why are we drawn to text? Amongst one of the reasons outlined in the above sections, is aesthetics, as part of perceptual processing, i.e., when we consider

reading to be an aesthetic experience and thus text to be an aesthetic object. In the following section, I outline the impact of aesthetics on reading, using environmental aesthetics as the basic framework from which to explore these more theoretical perspectives.

Within environmental psychology, the notion of environmental aesthetics has two complementary strands: urban aesthetics⁷ and everyday aesthetics, which explore urban and everyday life through their aesthetic qualities (Berleant, 1992; Melchionne, 2013; Ratiu, 2021). However, environments can also be subdivided into natural and built environments. There is substantial research about natural environment aesthetics (Weber, 2006), or the aesthetics of nature, often drawing upon restoration theories as a reasoning for environmental preferences (Meidenbauer et al., 2020). Research regarding everyday aesthetics and urban aesthetics (i.e., aesthetics of the built environment), however, is comparatively scarce and less comprehensive (see Melchionne, 2013; Ratiu, 2021). This is particularly the case with reading and quantifying the number/nature of reading experiences that ensue within everyday (Hansen, 2024; Moran, 2005) and urban spaces (Chana et al., 2023). However, an overarching interest is also to gain a wider understanding of aesthetic research in urban built environments more generally (Chana, Dehove et al., *subm.*).

What is classified as everyday aesthetics is often contested but, in line with changing perspectives outlined in empirical aesthetics (e.g., Knoll et al., 2024; Leder et al., 2022; Leder & Pelowski, 2021; Lehtinen, 2019; Makino, 2018; Pelowski & Leder, 2022, p. 202; Ratiu, 2021; Saito, 2001; Specker, 2025; for further see §1.2.2.), often refers to objects that are not classified as fine art (Leddy, 2012; Melchionne, 2013). However, as opposed to a ‘catch-all’, in which every interaction falls under this rubric, Melchionne (2013) suggests everyday aesthetics is limited to the facets of life marked by commonly shared routines and habitual patterns, which we often perceive or treat in aesthetic terms. More specifically, this entails fashion, food, home, social interaction, and going out/errands. This leads to a definition that is as extensive as it is limiting. Nevertheless, everyday aesthetics alludes to ‘widely practised daily human activities’. As Melchionne (2013) notes, this “opens neglected aspects of our lives for further consideration”, which aptly also concerns daily reading experiences.

Moreover, in everyday aesthetics, the *environment* in which day to day activities take place are investigated. This includes but is not exclusive to indoor environments, such as the workplace or our homes, where the majority of our daily activities occur (Fekete et al., 2025). As such one can think about reading that ensues within our everyday settings, with focus on the naturalness of such experiences. In

⁷ As Ratiu (2020) notes, urban aesthetics encompasses a broad framework of both macro and micro perspectives to render cities in their entirety.

doing so, one can also reflect on how such reading experiences might change as these spaces, and how we use them, continue to evolve, and how the future of text reading could be determined by aesthetics (Mendhakar, Chana et al., in prep).

1.3.1. Theoretical perspectives: aesthetics of everyday text reading

“Text on a grand scale can inspire and motivate or it can simply brighten an ordinary day by making us smile.”

(Chamberlin, 2018, p.1)

The history of reading is inseparable from the material and aesthetic evolution of the text itself. From Greek and Roman classics to Vedas in Sanskrit and the South American Inca empire⁸, reading was deeply entwined with orality and rhetorical education (Robinson, 2009). In these early oral cultures, stories and knowledge circulated through performance, with meaning shaped by voice, memory, and communal reception (Ong, 1983). Yet, the limitations of oral transmission in preserving reliable records prompted the development of writing as a pragmatic solution (Jean, 1992). The transition to written forms not only altered the dynamics of reading, from shared orality to silent, individual interpretation, but also introduced new aesthetic considerations in how texts were *rendered*. Throughout medieval and early modern periods, printers and scribes played a crucial role in the aesthetic experience of reading. Early manuscripts, often copied by hand, were not merely repositories of content but regarded as objects of beauty. The Gutenberg Bible and Arabic translation of the Medici Gospels displayed in the Beinecke Library⁹, for example, were crafted with attention to script, illumination and layout (Beinecke Rare Book & Manuscript Library, 2025; see also Constable, 1962). Embellishments on manuscripts and the typographic innovations of early print meant that beauty and textuality were very much intertwined (Jean, 1992). The decision of bindings, of margins, of font, framed how a text was received, and these aesthetic decisions invited contemplation not only of meaning but of form. Within these belletristic traditions, visual and tactile configurations of texts contributed to its cultural and aesthetic value.

Modernism marked a turning point whereby conventional aesthetic criteria were disrupted, and more active interpretation was required, with the aesthetics of text being more internalised within

⁸ The Inca Empire in South America (1438 – 1533) had a spoken language called Quechua but did not use a written language, instead keeping records with a complex system of knotted strings known as ‘khipu’ (Beyersdorff, 2005; Robinson, 2009).

⁹ The Beinecke Rare Book and Manuscript Library in Yale holds one of 21 complete existing copies of the Gutenberg Bible and also a copy of the Medici Gospels in Arabic. The Gutenberg Bible was the first book in Europe to be printed using movable type by Johannes Gutenberg in Mainz, Germany in the 15th Century. The Arabic translation of the Gospels was printed at the Medici Oriental Press around the 1590s, and features Arabic typeface and woodcut designs in Baroque style.

language and structure. Texts were characterised by fragmentation, ambiguity and formal experimentation (Bradbury & McFarlane, 1991); and aesthetic value shifted from formal beauty to complexity, innovation, and emotional intensity. However, theories of reading such as reader-response criticism (Fish, 1980; Iser, 1978) reframed reading as a dynamic interaction between text and reader. Aesthetics was no longer embedded in the text itself but emerged through the reader's engagement. Rather than being passively received, beauty and meaning were seen as emergent, generated through interactions, expectations and responses to text. Aligning with post-structuralist ideas (Harari, 2019), this marked a significant turn where aesthetic value no longer resided solely in the material but in the affective and interpretative labour of the reader.

Wolfgang Iser's theory of reading foregrounds the aesthetic experience as a dynamic interaction between the text and the reader, where meaning is not merely extracted but rather actively constructed through the textual 'gaps'¹⁰ (Iser, 1978). This model emphasises the autonomy of the reader, whose interpretations are guided by the text whilst retaining subjectivity and imaginativeness. This view invites a broader consideration of reading as a cultural and cognitive act, and thus a more interdisciplinary approach. While literary theory emphasises the phenomenological and aesthetic dimensions of reading, cognitive science seeks to explain this experience in terms of mental processes, underlying neural mechanisms and perception (Grubbs, 2016; Hauptmeier et al., 1989; Kuiken & Jacobs, 2021a; Tucker, 2022). The convergence of these perspectives allows for a more comprehensive understanding of reading, not only as an interpretative act but reading as an experience deeply rooted in human perception, memory, and imagination.

Such a perspective invites a more expansive view of reading, one that intersects with developments in cognitive science and psychological aesthetics. Reading is increasingly understood as an embodied and multi-sensory experience that is shaped not only linguistic content (e.g., Mangen, 2008; Kukkonen, 2019; Toro & Trasmundi, 2024) but by visual and pictorial features of text presentation (Levie & Lentz, 1982; Schnotz, 2014; Schnotz & Bannert, 1999; Yu & Song, 2017). As digital and screen-based reading prevails, the parameters that govern visual design, such as font, typographic hierarchy, spacing, *et cetera*, influence the processing and affective engagement of the reader (Dyson, 2004; Mackiewicz, 2007; Mendhakar et al., 2024; 2025; Shaikh & Chaparro, 2016; Sanocki & Dyson, 2012; Tantillo et al., 1995).

Typography, once regarded as the domain of graphic design, is central also to interdisciplinary enquiries of how aesthetics shapes reading in terms of absorption, comprehension, fluency (Reber et al.,

¹⁰ Central to this framework, the notion of 'gaps' describes the textual indeterminacies which prompt the reader to use imagination to complete the meaning of the text (Iser, 1976/8).

2004), *et cetera*. In the fields of cognitive poetics, human-computer interaction, and neuroaesthetics, the design of textual interfaces can either facilitate or hinder key processes such as information retention, narrative transportation, and cognitive load management (Jacobs, 2015; Jacobs, 2023). The aesthetic quality of text, measured through fluency, symmetry, visual harmony, complexity, *et cetera* (for general aesthetics, see Palmer et al., 2013), can affect the readability, emotional resonance and subsequent evaluations.

Moreover, efforts to quantify aspects of text aesthetics have introduced new methodological tools, ranging from traditional readability indices (e.g., Mendhakar et al., 2025; Tilmatine et al., 2024) to more nuanced empirical methods, such as eye-tracking (e.g., Hoshi & Menninghaus, 2018; Płużyczka et al., 2024; Rayner, 2009) and neuroimaging (e.g., Citron & Zervos, 2018; Jacobs, 2017, 2018, 2023). This multitude of approaches reflect the growing recognition that text aesthetics is not an ancillary concern but instead forms an integral component of reading.

1.3.2. Theoretical perspectives: aesthetics of everyday urban environments

“Cities are formed as much by ideas as they are by things.”

(Sudjic, 2017, p. 27)

The city, albeit created from materials acquired or originating from nature, is designed and structured by human agency. Cities are connected to a growing research interest in wellbeing, which has emerged in conjunction with numerous findings of negative impacts of urban environments on mental and physical health (e.g., Bai et al., 2012; Krefis et al., 2018; Lederbogen et al., 2011; Von Szombathely et al., 2017). Therefore, it is essential to identify how urban environments affect general health and wellbeing, and how, through its design, any positive effects can be strengthened, while negative effects reduced.

One element that has been extensively studied in conjunction with wellbeing is the implementation of urban vegetation and greenspace, with positive effects on mood, emotions, restoration, *et cetera* (e.g., Beil & Hanes, 2013; Hartig et al., 2003; Tyrväinen et al., 2014; White et al., 2013, 2023). A key argument as to why urban greenspace has such a wide range of positive effects is evolutionary aesthetics: Since plants were highly relevant resources in our evolutionary past, we evolved an innate preference and positive physiological and psychological response to such environments (e.g., Hartig et al., 1996; Kaplan & Kaplan, 1989; Ulrich, 1983)

Yet urban environments predominantly are man-made, encompassing work by city planners, architects, sign-makers, and designers, thus the question arises as to how these spaces should be designed to trigger a similarly positive effect on our aesthetic perception. Another element that can therefore be studied in conjunction with the design of urban environments is aesthetics. Incidentally, in empirical aesthetics, there appears to be a growing interest towards studying the urban environment (e.g., Chana et al., 2023; Dehove et al., 2024; Felisberti, 2022; Gartus et al., 2015; Gartus & Leder, 2014, p. 2024; Kühnapfel et al., 2024; Mikuni et al., 2024; Mitschke et al., 2017; Rambhoros et al., 2025; Tinio & Leder, 2009).

The potential for aesthetics to improve our urban environments and make cities better places to live is two-fold. First, there is evidence suggesting that aesthetic experiences, gathered from man-made aspects within the environment, such as art (Clow & Fredhoi, 2006; Fancourt & Finn, 2019; Fekete et al., 2023; Mastandrea et al., 2019; Trupp et al., 2022), certain design elements and architecture (Channon, 2023; Mazumder et al., 2022; Zhong et al., 2022), or the built environment itself (Galindo & Rodriguez, 2000; Mastandrea et al., 2021; Mouratidis, 2021) can contribute to wellbeing. Second, aesthetic experience has also been suggested as an underlying causal mechanism for affective benefits, even of nature. Meidenbauer et al. (2020), for example, showed that environments rated high in aesthetic value positively influenced wellbeing, regardless of whether they were natural or man-made settings. Both rationales indicate aesthetics as a worthy framing for the study of wellbeing in the urban environment. As such, it is important to think about what features go into our environment, given that how the urban environment looks shapes our experiences (and ‘reading’) of the city – and so one could consider the design/aesthetics of the components that make up our cities and the extent to which wellbeing outcomes have also been investigated.

The urban reader is often cursed with an overabundance of visual noise, making sustained aesthetic engagement difficult amid the constant demand for attention. In modern-day environments, our urban spaces and cities are overly saturated with text. From signboards and advertisements to street signs and graffiti... readers navigate a gargantuan flow of visual and textual stimuli, which could result in a layered or fragmented aesthetic experience. In response to such overstimulation, some drastic interventions have emerged. For example, Thomas Demand’s *Embassy* artwork series explores themes of visual reduction and perception in highly controlled, minimalist environments (Demand, 2013). Similarly, São Paulo’s *Lei Cidade Limpa* (Clean City Law) banned outdoor advertisements in an effort to combat visual pollution and reclaim public space for meaningful visual engagement (Marketing Week, 2007). Although these represent more extreme measures, it is a reminder of the importance of urban text design,

especially as our cities continue to expand and given that these visual environments increasingly affect our health and wellbeing (Portella, 2016).

Text, however, is just one of the elements considered for its design in the urban environment, and there are many other components or ‘urban aesthetic objects’ which are also subject to exploration (Galindo & Rodriguez, 2000; Lynch, 1996). Therefore, in an effort to gain a deeper understanding as to how urban environments are explored through the lens of aesthetics, a scoping review was conducted to identify what components of the urban environment are studied and how they have been aesthetically evaluated (Chana, Dehove et al., subm.). Further, in an attempt to address any gaps in the literature (and given the extensive coverage of the urban environment in terms of wellbeing benefits), this review also investigated the extent to which wellbeing outcomes have been considered for aesthetic man-made components within the urban environment.

1.4. Field study investigations

“Navigating a city is a bit like negotiating a way through a library. Randomly stacked shelves ...to explore in a purposeful way.”

(Sudjic, 2017, p. 75)

What do we read? Empirical studies of literature focus on the reader and reading literary texts, with a large body of research conducted on the content of literary excerpts as well as towards typographic concerns of letterforms (e.g., Bigelow & Larson, 2016; Pelli et al., 2006; Sanocki & Dyson, 2012; Shaikh & Chaparro, 2016). Exploring such parameters becomes more crucial when one considers that most studies on reading occur in laboratory settings, viewing text on a screen. Such investigations prove useful for assessing viewing behaviour during reading, since stationary eye-tracking experiments allow for precise recording and assessments of ocular movement patterns (Bojko, 2013; Holmqvist et al., 2011). However, viewing behaviour has been consistently shown to differ according to the task at hand (see Land, 2006), and therefore such study designs are limited in what they can tell us about the execution of mundane everyday tasks, such as navigating a city.

Choosing where to direct our gaze is crucial to performing most of our daily tasks and is a decision made continuously with a typical rate of three eye movements per second (Cristino & Baddeley, 2009; Rayner, 1998). Research has explored how saliency guides our attention in scene viewing, with saliency models considering low-level and high-level features in predicting viewing behaviour (for overview, see Hayes & Henderson, 2021; Itti & Koch, 2001; Tatler, 2009; Torralba et al., 2006; Underwood,

2010). Visual attention is not allocated merely to the most salient regions but to areas in a scene that convey the greatest informational significance (Einhauser et al., 2008; Henderson & Hayes, 2018; Henderson et al., 2018; Itti, 2005; Kollmorgen et al., 2010; Peacock et al., 2020; Pilarczyk & Kuniecki, 2014; Torralba et al., 2006; Vö et al., 2019; Wu et al., 2014). This attentional guidance is further influenced by the observer's memory and prior experience, as well as the objectives of the task (Aivar et al., 2024; Droll & Eckstein, 2009; Henderson, 2011; Hollingworth & Henderson, 2002; Irwin & Zelinsky, 2002; Pezdek et al., 1989; Valuch et al., 2013).

And when navigating a city? The limitations of our vision mean that we require head movements to capture a wider snapshot of the visual field. This is further diminished in that a large body of research into perception utilised photographs of real-world scenes in lab-based settings, which does not emulate how the real-world environment is viewed naturally, since the scenes are static and depicted at a fixed angle. Foulsham et al. (2011) compared gaze behaviour for participants walking in a natural environment with a mobile eye-tracker and when they viewed video footage of the same environment. Although similar objects were fixated on in both conditions, differences were found in when and how these were viewed. This strengthens the need to use field investigations to capture the naturalness of viewing behaviour.

In the execution of naturally occurring everyday activities, eye movements are guided predominantly towards the objects and areas most significant to the given task. In a series of studies, Land and colleagues analysed eye movements with a head-mounted eye tracker amidst mundane everyday activities, including driving, sandwich/tea-making and a range of other leisure activities (see Land, 2006; Land & Tatler, 2009). The findings revealed how gaze is directed by the action in a top-down fashion, and with accordance to the task. For example, in sports, fixations are pre-emptive, moving to where a ball is expected to land rather than following the object itself. In a similar fashion, when walking along uneven ground, fixations are guided by future foot placements (Land & Tatler, 2009; Marigold & Patla, 2008; Patla, 2004; Patla & Vickers, 2003; Warren Jr., 1998) which are calculated two steps ahead (approx. 1 s); and also, by hazard avoidance (i.e., preventing collisions with other pedestrians or crossing the road) (Foulsham et al., 2011; Geruschat et al., 2003; Jovancevic et al., 2006).

For the most part, however, it is not a requisite to look directly where to step for safe locomotion—we do not spend the entirety of our time staring at the ground in front of us when walking. Instead, Patla (2004) coined the term 'travel gaze fixation' to refer to the tendency for gaze to drift ahead a short distance over the terrain, albeit unrelated to future footfall. In general, we make use of our surroundings to navigate while walking in two possible ways. First, we may use distant landmarks, i.e., fixate on a specific object/marker, and head towards it before selecting another and so forth. In this way,

these markers represent the most peripheral object discernible within the field of vision. Second, we can use the relative motion of objects as we move forward, aligning the ‘point zero of motion’, which indicates our direction of travel, with the next target along the path (Gibson, 1954).

Naturally, our gaze behaviour when walking differs according to the location, but also in relation to the goals when walking. This leads us to ask what the goals indeed are when walking. As described by Lynch (1960) in *The Image of the City*, walking is a means of “mapping with your feet”. In efforts to gain a wider understanding of our environments, it is therefore intuitive to consider the city itself as the location for investigation, particularly city streets. Investigating streets through field studies is valuable in that they serve as dynamic public spaces where social, cultural and spatial interactions unfold in real time. Streets are conduits for movement but also critical sites to observe everyday practices and behaviours that shape urban life. Moreover, this provides insights into what is looked at when walking freely, i.e., without a particular incentive or goal-oriented task.

Whilst a substantial amount of viewing behaviour is linked to the act of walking and foreseeing the potential pitfalls associated with this, there is a multitude of objects within a street environment that could capture our attention (see Chana, Dehove et al., subm.). Text that is present within urban scenes is one of these possibilities. Despite the visual system being selective as to which objects to attend to, research in scene viewing has demonstrated that text generally does draw visual attention (Cerf et al., 2009; Wang & Pomplun, 2012). Cerf, Frady and Koch (2009) found that, relative to objects of a comparable size and location, text and faces attracted more attention. Wang and Pomplun (2012) conducted a series of experiments to consider the attraction to text in images of real-world scenes, finding that gaze falls to areas where text is expected.

Nevertheless, to build a foundation for testing cognitive processes in laboratory settings that reflect behaviour in the real world, Benz and Meier (2008) and Oberzaucher (2017) emphasise the importance of grounding experimental research in observations from natural environments. In line with this, employing a field-based approach allows one to capture everyday behaviour with quantitative physiological data alongside questionnaires and subjective ratings to assess psychological responses (e.g., Dehove et al., 2024; Hutzler et al., 2007; Mikuni et al., 2024; Mitschke et al., 2017; Rubo et al., 2020). One specific example of such an approach is provided by Mitschke et al. (2017), where mobile eye-tracking was used to examine how aesthetic qualities in the environment guide visual attention. Whilst the primary focus remained on art-related stimuli and how viewers often attend to aesthetically salient objects, this study briefly noted participants’ viewing of textual elements. However, reading behaviour and the role of textual elements in everyday visual exploration was not specifically addressed.

Building on this, Chana et al. (2023) shift the focus from aesthetic salience to semantic engagement, i.e., the extent to which individuals engage with text relative to other elements. By directly comparing attention to textual content versus non-textual features during free-exploration¹¹ walks, these field study investigations seek to determine the prevalence of spontaneous reading experiences in daily life. In doing so, this contributes to a broader understanding of how written information competes with or complements aesthetic and perceptual features in guiding attention in real-world environments.

1.5. Lab-based investigations

“Seeing comes before words. It is seeing which establishes our place in our surrounding world; we explain that world with words, but words can never undo the fact that we are surrounded by it.”

(Berger, 2008, p. 8)

How do we read? In seeking to better understand the reading experience, it is important to ask *how* we read and how we can gain insight into the essential processes that underpin reading. I began to address these questions in §1.2. by linking reading to perceptual processing. It is therefore important to understand the visual system and how viewing behaviour occurs. Eye movements during reading are not smooth; rather, they consist of fixations and saccades. When we view our surroundings—or more specifically, when we read—we do not transgress from one letter to another in a linear fashion. Instead, the eyes ‘jump’, fixating on the centre of the word and then skipping to the next in a series of saccadic movements that allow for efficient information uptake (Rayner, 1998).

Ocular behaviour during reading is also influenced by a range of factors, including viewing distance, word frequency, word length, syntactic complexity, *et cetera* (Bojko, 2013; Just & Carpenter, 1980; Klein & Ettinger, 2019; Rayner, 1998). Importantly, individual words are read and processed differently than full sentences or whole paragraphs, particularly in terms of fixation patterns (Klein & Ettinger, 2019; Rayner, 1998; Rayner et al., 2011). We can measure metrics such as the number of fixations, total number of fixations, and the frequency of refixations, with notable differences depending on linguistic and visual features. Refixations, for example, are when one looks at text, looks elsewhere, and then looks back to the previously viewed text. This might be, for example, due to skim reading, which is more common when

¹¹ In free viewing, or free exploration, the participant is not given any task to perform but is merely encouraged to explore a visual scene. These tasks are typically used to highlight the influence of low-level or bottom-up influences on eye movements stemming from the visual scene itself. However, such effects are not stable over time (Tatler, Baddeley & Gilchrist, 2005), suggesting the presence of some internally motivated, top-down tasks generated by the participant. It has been suggested that humans seek to create a stimulating and pleasing environment for themselves (Berlyne, 1971) and that such behaviour might be biologically conditioned as a result of the positive sensations that such stimuli provide (Biederman & Vessel, 2006). If that is indeed the case, then the pattern of eye movements made while performing an aesthetic evaluation task might allow preferences to be predicted under free viewing conditions, allowing aesthetic preferences to be explored experimentally without the problems associated with conscious reporting of subjective preferences (Nisbett & Wilson, 1977).

encountering longer passages, or as a strategy to gain further clarity or deeper comprehension, particularly with complex or literary texts (Rayner et al., 2011).

Naturally, context, content, and complexity—both visual and semantic—affect viewing behaviour, including readability, legibility, and overall evaluation. Even when text is viewed only briefly, letters can still be recognised, words processed, and meaning extracted. In real-world visual exploration, however, the eyes take in multiple stimuli in quick succession. Yet, due to the organisation of our visual system, all stimuli within our line of sight cannot be processed simultaneously. Instead, fixations occur to singular objects one at a time, so that eyes focus on a small portion of the visual field and obtain sensory information of high resolution (Henderson & Hollingworth, 1998; Damiano & Walther, 2019). This suggests that attention—and by extension, memory—is selective.

The concept of ‘gist’ refers to the level of generalised coarse representation that can be attained from a brief glimpse of a scene (Rousselet et al., 2005). However, detailed scene representations, especially of a scene viewed in the real world, are built incrementally over time from a series of fixations as the eyes redirect focus from one object to another (Rousselet et al., 2005; Malcom et al., 2017). These processes allow for better understanding of how we visually engage with real-world environments, particularly those in which text and image co-exist.

Studies on visual attention to signage, for instance, revealed not only what people look at (Auffrey & Hildebrandt, 2017; Bauer & Mayer, 2008; Cerf et al., 2009; Cook, 2018; Nafisur Rahman & Mehta, 2020; Rahman & Mehta, 2018; Wang & Pomplun, 2012) but also prompt a deeper question of what reading actually is in such contexts. Often, these brief interactions with urban text, such as signs, posters, advertisements, might be better characterised as *micro-reading*. Deviating from conventional reading patterns, these text-based encounters may resemble object viewing, where text is processed more like images or graphical elements (Bauer & Mayer, 2008; Huerta, 2010, 2011). That is, attention to these signs may be drawn by their visual features rather than their linguistic content.

This reconciliation between text and image draws parallels with insights from empirical aesthetics (Chamberlain et al., 2020; 2022; Melmer et al., 2013), where several studies have examined how accompanying verbal information influences the aesthetic appraisal of artworks. For instance, Cupchik et al. (1994) examined how viewers responded to abstract figurative paintings under different conditions and found that the inclusion of interpretive descriptions enhanced participants’ assessments of the artworks. Building on this, Cupchik and Gebotys (1988) proposed that when viewers are presented with additional verbal information, their engagement shifts from passive observation to active interpretation, involving deeper cognitive processing to make sense of the artwork’s meaning. In a similar vein, Franklin

et al. (1993) highlighted the prevalence of verbal information (titles or explanatory text) as a key experimental tool used to examine how viewers make sense of visual stimuli. This work stresses the idea that verbal context is not merely supplementary but often shapes the interpretative frame through which an artwork is viewed. Leder et al. (2006) explore the notion of ‘interpretive tension’ suggesting that the combination of visual art and verbal cues (i.e., titles) can create moments of cognitive dissonance. Viewers may resolve this tension by mentally reconfiguring the visual elements to ‘fit’ with the new interpretive possibilities suggested by the text, ultimately arriving at a more coherent and meaningful understanding of the artwork. Consistent with these findings, Mullennix and Robinet (2018) demonstrated that the presence of titles significantly increased aesthetic evaluations of art. Descriptive titles improved the viewer’s experience depending on how congruent the information was with the artwork itself. This emphasises the role of verbal cues as cognitive scaffolds that guide perception, interpretation and emotional engagement with visual art.

This process aligns with fluency theory (Reber et al., 2004), which posits that aesthetic pleasure can emerge from resolving initial cognitive disfluency. When interpretative effort leads to a clearer and more coherent understanding, especially in the context of complex, ambiguous material, the resulting fluency can enhance not only comprehension but also evaluative and affective responses. Thus, whether in the context of art viewing or encounters with visual-textual environments such as in the case of signage, the integration of verbal information serves as both a cognitive scaffold and a catalyst for deeper engagement. These dynamics raise important questions about how viewers attend to and interpret text in real-world environments, particularly in contexts where text is not only communicative but also visually expressive. Examples such as product packaging (Mukai & Miyazaki, 2016; Schmitt, 1997; Velasco & Spence, 2019), labels (Bitgood, 2000), and advertising (Pieters & Wedel, 2004; Rayner et al., 2001) illustrate how textual content is filtered through its visual presentation, often under time pressure or in highly designed settings. Similarly, in media such as book covers or digital storefronts, text operates as part of a broader visual field, shaping both perception and decision-making in ways that extend beyond linguistic meaning alone (Spence, 2020; Hazlett et al., 2013; Jajdelska et al., 2019).

When text serves not only a communicative function but also a visual one, as is the case in visual-textual hybrids such as signage and book cover design, it could become part of the aesthetic reading experience itself. To explore this distinction in more depth, a lab follow-up sought to isolate visual aesthetic features from the semantic word content itself¹². Based on Chana et al. (2023), how familiarity

¹² Here, I refer to unpublished data that was used as the basis and study design for Chana, Mikuni et al. (accepted) in this thesis.

and beauty interact in guiding attention to signs was investigated, and how text may function visually when integrated into rich visual environments. The initial aim was instigated by the question of whether attention and memory for signage were primarily driven by what the signs say or by how they look. This concept was extended to another naturalistic context of reading in real life: an exploration of reading books and their covers.

In a world increasingly shaped by digital reading environments, the way we choose what to read is constantly shifting. From browsing physical bookshelves to scrolling through tile-format book covers online, this transformation potentially alters how readers engage with text, given the tangibility of books is replaced with screen-based browsing (Spence, 2020). A study by Gudiniavičius and Šuminas (2018) explored this shift using Lithuanian novels in a mock online bookstore, examining how visual and textual features influence book selection without the physical affordances of a traditional bookshop.

Book covers offer an ideal site for examining the notion of image reading. As Sonzogni (2011) outlines, book covers serve multiple functions:

- 1) Presenting visual content that allows potential readers to decide whether to read a book or not (within a brief span of seconds)
- 2) Impart information to the reader by:
 - a) Displaying the title and author
 - b) Summarising the text through images and words
- 3) Prompting the reader's memory regarding their existing knowledge of the text

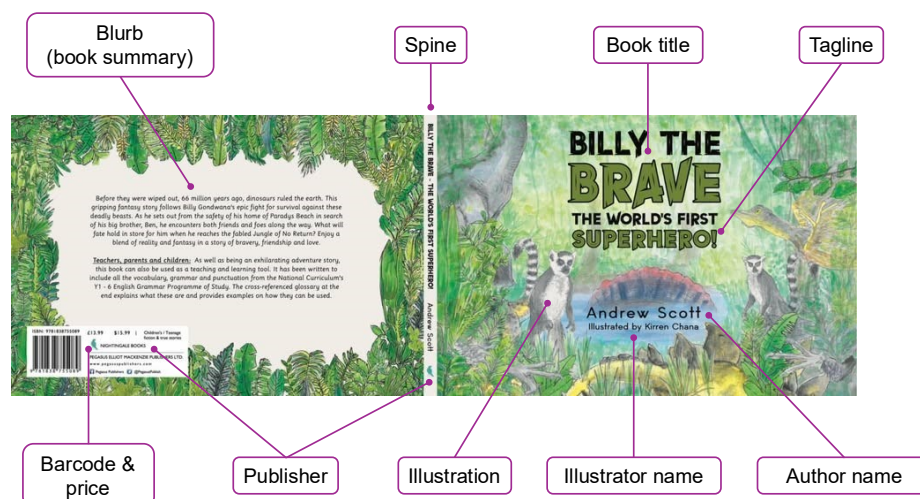


Figure 2. Visual and textual components of a standard book cover (Scott & Chana, 2023)

To better conceptualise this, Figure 2. illustrates the key components commonly found on a fictional book cover, each of which can act as an informational cue. These include semantic elements (e.g., title, author name, any taglines) and visual features (e.g., central images, colour palette, typography). Understanding how these elements function as cues in the reader's processing of the cover allows us to examine how they contribute to attention and memory. This allows us to examine whether memory and engagement are more strongly influenced by textual (semantic) content or visual (aesthetic) elements.

Chana, Mikuni et al. (acc.) therefore isolate two key components of book covers: the text (title and author) and the image (photographic or illustrative elements). This separation aims to understand how these visual and semantic features interact in guiding attention, supporting memory, and shaping evaluations. Moreover, given the ecological validity of book covers, the evaluation criteria extend beyond hedonic appeal and also includes economic, social and contextual value (Salgaro et al., 2018). This constitutes a major strand of the lab-based investigations into reading, by using image-text hybrids like book covers to explore how attention and memory function in real-world reading tasks.

The second strand focuses on the naturalness of reading behaviour across different platforms, with specific comparison made between print and digital reading. Given how central digital platforms have become to daily life and to everyday reading, it is important to understand whether, and how, reading behaviour shifts across formats. Eye-tracking provides a powerful tool to examine such differences, allowing us to compare natural reading patterns across print and screen. These measures (including fixation durations, regression rate and scanning strategies) offer insight into reading fluency, comprehension effort and even affective engagement with the text (see for example, Schuster et al, 2016).

Together, these lab-based investigations aim to enhance our understanding of real-world reading behaviours by isolating their underlying mechanisms. Field studies (§1.4.) provide ecological validity and highlight important real-life phenomena, but lab studies enable us to control for confounds and examine specific variables more precisely. Whether in the form of signage, book covers, or digital reading interfaces, these multimodal stimuli show that reading is not confined to linear text on a page but rather is embedded in rich visual environments where meaning is constructed through both language and design. Thus, these lab approaches contribute to building a fuller picture of how reading operates in the everyday world.



2. Projects

2.1. Theoretical perspectives

2.1.1. Theoretical perspective: Urban aesthetics and the future of text-based research



Chana, K.[‡], Dehove, M.[‡], Mikuni, J., Specker, E., Knoll, A., Barrière, T., Trupp, M. D., Pelowski, M., Oberzaucher, E., Leder, H. (submitted). Aesthetic Elements of Urban Environments and their relation to Wellbeing: A scoping review. *Cities and Health*.

My Contribution:

With shared first authorship of this paper, I contributed to various aspects equally with MD; see CRediT author statement below.

Kirren Chana: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration; **Margot Dehove:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration; **Jan Mikuni:** Conceptualization, Investigation, Writing - Review & Editing, Supervision; **Eva Specker:** Conceptualization, Investigation, Writing - Review & Editing, Supervision; **Anna Lena Knoll:** Investigation, Writing - Review & Editing; **Tristan Barrière:** Investigation, Writing - Review & Editing; **MacKenzie Trupp:** Conceptualization, Methodology, Investigation, Writing - Review & Editing; **Matthew Pelowski:** Resources, Writing - Review & Editing, Funding acquisition; **Elisabeth Oberzaucher:** Resources, Writing - Review & Editing, Supervision, Funding acquisition; **Helmut Leder:** Resources, Writing - Review & Editing, Supervision, Funding acquisition



2.1.1.1. Key findings



Graphical representation of components that constitute a typical urban environment which can be considered for aesthetics.

- We provide an overview of urban aesthetics research to be used as a tool for researchers to plan future studies.
- We identified ten urban component categories, which aesthetic/wellbeing dimensions are related to these categories, and the associated measures used.
- The most studied urban components were Urban Environment, Buildings, Streets and Squares, and a further 75.38% understudied components.
- We also highlight emerging trends (e.g., social media databases) and gaps (e.g., in terminology) that could be used to explore new research avenues.

2.1.1.2. Original Manuscript

(see next page)



Aesthetic Elements of Urban Environments and their relation to Wellbeing: A scoping review.

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Data availability statement: The datasets presented in this study and further information can be found in the following online Open Science Framework (OSF) repository: <https://osf.io/e6udp/>.

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Abstract

Urban environments present a range of potential benefits for wellbeing through their design and aesthetics. However, there is a lack of comprehensive overview on how the urban environment, particularly its designed man-made components, has previously been studied regarding aesthetics and wellbeing. To this end, we performed a scoping review to identify the breadth and depth of research on the topic by synthesising the evidence from pre-existing literature. Scopus, Web of Science and PsycINFO databases were searched, and papers were screened based on three concepts: *Urban (man-made) components*, *Aesthetics*, and *Wellbeing*. In total, 255 articles related to urban aesthetics were identified, 122 of which were also related to wellbeing. The results show the prevalence and diversity in man-made components, aesthetic dimensions, and wellbeing dimensions studied in relation to the urban environment; and provide an overview of the methods applied when studying such environments. Along with the synthesis highlighting trends found in urban research, a dataset (freely available on OSF) summarising extracted information is provided. This review and dataset offer: (1) guidelines for urban researchers in planning future studies (primary and secondary), and (2) the basis to assess the aesthetic and wellbeing potential of urban elements when designing our urban environments.

Keywords: Urban, Built Environment, Aesthetics, Wellbeing, Design, Scoping Review



Aesthetic Elements of Urban Environments and their relation to Wellbeing: A scoping review.

The majority of the world's population (55%) lives in cities and this proportion is expected to only increase further in coming decades—up to 68% by 2050 (United Nations, 2018a). This rapid growth of urban populations has led to a fundamental shift in many human activities and social structures, as well as in our everyday environment. The day-to-day setting for many humans now predominantly consists of (hu)man-made and built space. This 'urban environment'¹—from buildings, roads and pavements forming the surfaces and horizons for our actions, to parks, squares, and other public areas essential to meet or for respite—defines our daily experiences.

The role of the urban environment in shaping our experience and daily existence is an emerging topic for multiple domains. This has been explored, for example, in design (Hassen & Kaufman, 2016), social inclusion (Malek et al., 2021; Mirzoev et al., 2022), usability (Pinna et al., 2021), and walkability (Fonseca et al., 2022), using a range of methods. Another such domain is the aesthetics of urban environments, for which there has been a resurgence of scientific interest since the seminal works of the 1960s and 70s (see Berleant, 1992; Drew, 1960; Lynch, 1960; Weber, 2006). Despite this emerging cross-field collection of work, such studies are still disparate in terms of interdisciplinary awareness, and even more so regarding a thorough integration. Moreover, as urban environments also have a significant influence on our wellbeing (e.g., Von Szombathely et al., 2017), it is necessary to better understand which components of urban environments might make cities better places to live in. To this end, we conducted a scoping review with the aim of providing a first integrated overview of how the urban environment has been evaluated with regards to primarily aesthetics and secondarily wellbeing.

Text Box 1: What is a Scoping Review?

Scoping reviews and systematic reviews are both types of secondary research that synthesise evidence from pre-existing literature, however they serve different purposes. A scoping review maps the breadth and depth of available evidence on a topic – especially when the topic is complex, emerging or not yet well-defined. From this, key concepts and definitions are clarified, types of evidence and methodology are collated, and knowledge gaps are identified. Unlike other types of reviews, a scoping review has a more extensive focus and provides a comprehensive overview from a range of sources (e.g., primary research, non-empirical data, etc.) rather than in-depth analysis (e.g., no critical appraisal of the quality of individual studies is performed). Scoping review evidence can then be used for planning future research and guiding more focused systematic reviews or meta-analyses.

Systematic reviews, on the other hand, focus on more definite questions that are answered from the evidence obtained using a more stringent search protocol, in which data quality is assessed and results are compared, and then synthesised to inform practice or policy. Therefore, as a precursor to this, researchers may conduct a scoping review to gauge more about the literature on a particular subject and decide how to formulate a more refined research question.

For further explanation on the scoping review approach, see Munn et al., 2018; 2022.

The urban environment has a profound impact on human health and is connected to growing research interest in wellbeing. This interest has emerged in conjunction with numerous findings of negative impacts of city design, noise, pollution, urbanisation *et cetera* on emotional wellbeing, life satisfaction, mental illness, mortality, stress, and physical health (e.g., Bai et al., 2012; Grübner et al., 2017; Krefis et al., 2018; Lederbogen et al., 2011; Peen et al., 2010; Von Szombathely et al., 2017). One element consistently shown to have a positive impact on wellbeing is urban greenery. It has been demonstrated that greenspaces and vegetation positively impact heart rate (e.g., Tsunetsugu et al., 2013), mood (e.g.,

¹ A more precise definition of what constitutes urban environment in this paper can be found under 'Context' in section 2.1.



Tsunetsugu et al., 2013; Tyrväinen et al., 2014), restoration (e.g., Hartig et al., 2003; Stigsdotter et al., 2017), social interactions (e.g., Jennings & Bamkole, 2019; Kuo et al., 1998), and stress (e.g., Beil & Hanes, 2013; Tyrväinen et al., 2014). However, since implementing urban green spaces is not always feasible (see Boulton et al., 2018), other ways to design cities for wellbeing exist. Thus, there is a need to consider if and how other urban design aspects – namely, the look and feel of a city – could be implemented to make cities a better place, and especially to address the current demand to improve urban population’s health and wellbeing.

Cities and their features can be designed and assessed through the concept of aesthetics. Aesthetics refers to the evaluation or appraisal (e.g., beauty, liking, pleasure, emotions, etc.) of sensory objects or events². Although aesthetics is traditionally linked to art, other objects can also be aesthetically relevant (see Leder et al., 2004; 2011; Pelowski et al., 2017; Skov & Nadal, 2020; Leder et al., 2022), and the notion of aesthetics can be applied to objects in everyday urban environments, i.e., not traditionally categorised as art (Knoll et al., 2024; Specker, et al., 2024). In this regard, there is a growing interest in research on art and aesthetics towards studying the urban environment (Barrière et al., 2024; Brielmann et al., 2022; Burtan et al., 2021; Chana et al., 2023; Dehove et al. 2024a; Dehove et al. 2024b; Felisberti, 2022; Gartus & Leder, 2014; Gartus et al., 2015; Kühnapfel et al., 2024; Leder et al., 2010; Leder et al., 2016; Mazumder et al., 2022; Mikuni et al., 2024; Mitschke et al., 2017; Negami, 2020; Ruta et al., 2018; Tinio & Leder, 2009; Yang et al., 2024). Nevertheless, no work has been done to summarise this new input of evidence. A potential reason as to *why* aesthetics may be relevant for urban environments is evidence suggesting aesthetic experiences contribute to wellbeing. This includes, but is not exclusive to, art (Clow & Fredhoi, 2006; Fancourt & Finn, 2019; Fekete et al., 2022; 2023; Trupp et al., 2022), certain design elements and architecture (Channon, 2023; Zhong et al., 2022), or the built environment itself (Galindo & Rodríguez, 2000; Mouratidis, 2021).

Despite indications of the importance of aesthetics in studying urban environments, past literature is limited. First, previous review articles centred on the aesthetics of the urban environment tend to focus on very specific perspectives, e.g., only features of building exteriors (Nasar, 1994), only differences between artworks and everyday scenes (Nanay, 2018), or only referring to one aesthetic design model (Nia & Atun, 2016). Second, in part due to the diversity in the research fields studying urban environment features, there is presently no lexicon of how studied elements can be referred to, what has or has not been evaluated, or what measurement approaches have been taken. Finally, apart from a few empirical studies (e.g., Galindo & Rodríguez, 2000), there is a missing overview of what urban features have been studied in relation to both aesthetic experience and potential impacts on wellbeing. This lack of information has considerable consequences for research and policy, leading to less attention being paid to the impact of urban environments beyond that of greenspaces.

The present scoping review acts as an important first step to delineate and organise this topic, collating research across many fields to address the importance of aesthetics in the urban environment. Specifically, we aim to:

- (1) provide a comprehensive overview of how and which parts of the urban environment, particularly its man-made components, have been studied in the past in relation to aesthetics. This allows us to identify the main conceptual ideas and factors related to aesthetics in the urban environment as well as gaps in scientific research, which can provide avenues for future studies (Munn et al., 2018, see Text Box 1).
- (2) In tandem, we review how often and in what ways these articles addressed wellbeing benefits associated with aesthetic components. This way, we describe the potential link between

² A more precise definition of what constitutes aesthetics in this paper can be found under ‘Context’ in section 2.1.



aesthetic experiences and wellbeing within an urban context and provide an overview of the relationship between the urban environment, aesthetics, and wellbeing.

In line with these aims, the following questions and sub-questions were used to structure the scoping review:

RQ1: What is the present state of investigation on aesthetic components in the urban man-made environment?

RQ1a: Which urban man-made components have been investigated regarding aesthetics?

RQ1b: How were aesthetic outcomes evaluated and measured?

RQ2: What wellbeing outcomes are associated with aesthetically evaluated components of the urban environment?

RQ2a: Which aesthetic urban components have been investigated regarding wellbeing?

RQ2b: How were wellbeing outcomes evaluated and measured?

Methods

Protocol, Registration and Eligibility Criteria

We used the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews method (PRISMA-ScR; see Tricco et al., 2018 for further discussion) as a guideline. The protocol was made public on the Open Science Framework (documents were uploaded on November 28, 2022; https://osf.io/e6udp/?view_only=3017713bacef44ae890ab221e438a706 Link anonymised for peer review). The PCC framework (Population, Context, Concept; Peters et al., 2020) was used to identify the review objectives and eligibility criteria (see Table S1 in the Supplementary Material A for the full eligibility criterion).

P (Population). The review aimed to gain information about the aesthetic engagements with the urban environment more generally, as opposed to targeting patients or clinical samples. As such, we considered articles that discussed adult (18+) non-clinical populations.

C (Context). ‘Urban’ was defined as belonging to or relating to a town or city, or similarly developed areas with a density of man-made structures. Given the vagueness of the everyday use of the term ‘urban’, suburbs and peri-urban areas, neighbourhoods, residential settings, and regions surrounding a city were also included (see Duany & Talen, 2001). We included urban environments in towns or cities worldwide. Further, we included articles in which the urban environment was experienced either directly (e.g., in a field study) and/or indirectly (e.g., reproductions of the environment presented in laboratory, online, or virtual reality studies). The urban environments considered within the review were all public outdoor spaces. In contrast, private and indoor settings (e.g., care homes, interior design, museums) were excluded. Urban blue/greenspaces, focusing on natural elements and not man-made components, were also not considered given the extensive coverage of ‘urban green’ in existing literature.

C (Concept). Our three main concepts were urban man-made components, aesthetics, and wellbeing. For eligibility purposes, we defined these as:



(1) *Urban (man-made) components*. Within the urban context, we further focused on man-made components (referred to as urban components for the remainder of this paper). These were defined as sub-elements of the urban environment that were either: (a) a tangible object in the urban environment (e.g., art, monuments, signage, statues, etc.); (b) a non-tangible object in the urban environment (e.g., pollution, traffic noise, etc.), or (c) a formal property of a component's appearance or design (e.g., symmetry, complexity, etc.). As such, the urban components were not exclusive to the visual evaluation of the environment but could instead also include sound, smell, taste, and touch. Moreover, these urban components could already exist in the environment (e.g., buildings in a city) or could be manipulated/created for the purpose of the experiment (e.g., modified photos changing the architecture of buildings). Articles on greenspaces and natural environments were only considered if they were compared to or involved urban components; articles focusing only on nature/green spaces, albeit technically human-designed (e.g., landscaping, gardening), were excluded.

(2) *Aesthetics*. Articles included in the review were required to have a quantitative assessment or evaluation on an aesthetic dimension (i.e., a term used in relation to the cognitive or affective aspects of an aesthetic judgement). Articles solely about the creation of a component or that conducted an experiment without any mention of any aesthetic evaluation were excluded. With many ways to define the notion of aesthetics, we used very broad terms from the psychology of the art to define the initial concept of aesthetics (e.g., beauty, liking, preference; see Augustin et al., 2012; Leder et al., 2005). We included articles mentioning similarly relevant evaluations that could also be considered aesthetic, such as emotion, mood, etc.

(3) *Wellbeing*. Past literature highlights the multifaceted nature and complexity in agreeing upon a definition of wellbeing (Dodge et al., 2012). For example, the World Health Organisation (WHO) defines health more generally as “a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity” (WHO, 2006). Stone and Mackie (2013) proposed a more specific definition of subjective wellbeing, with the sub-categorisations of *evaluative*, *experienced* (hedonic), and *eudemonic* wellbeing. This encompasses the degree of life satisfaction, perception of meaning and purpose, emotional states (positive and negative), and effects linked to sensations, such as stress, pain, or arousal. To respect the objectives of the scoping review, we decided to adopt a broad definition of wellbeing combining all the facets described, and in doing so, concerning physical, emotional, psychological and social aspects.

Search

The main search was conducted via the electronic databases: Scopus, Web of Science, and PsycINFO. The first two databases were selected for their wide coverage of topics and multidisciplinary catalogues. PsycINFO, albeit a smaller database, was selected for its specialisation in behavioural and social science publications, aligning with many studies on aesthetic topics.

We conducted our database search using a syntax that addressed the three concepts identified with the PCC and their associated keywords/synonyms using Boolean operators (for full search syntax, see Supplementary Material B). The search strategy was developed and executed by the two first authors and further refined through discussion with the co-authors. A first search was run with the three concepts following the simple syntax: *Urban Environment AND Aesthetics AND Wellbeing*. A second search only addressed the first two constructs: *Urban Environment AND Aesthetics*. Splitting the search into two syntaxes ensured any articles that only dealt with urban aesthetics were not missed, while also including articles on urban aesthetics and wellbeing. Within our search filters, we only considered articles written in English and published in peer-reviewed journals between 2000 – 2022. The searches were conducted during October 2022 (for precise dates, see Figure 1). The flow chart, reported in Figure 1, details the



selection process (Search, Screening and Data Extraction) undergone to reach the final sample ($N = 255$) for which information was extracted.

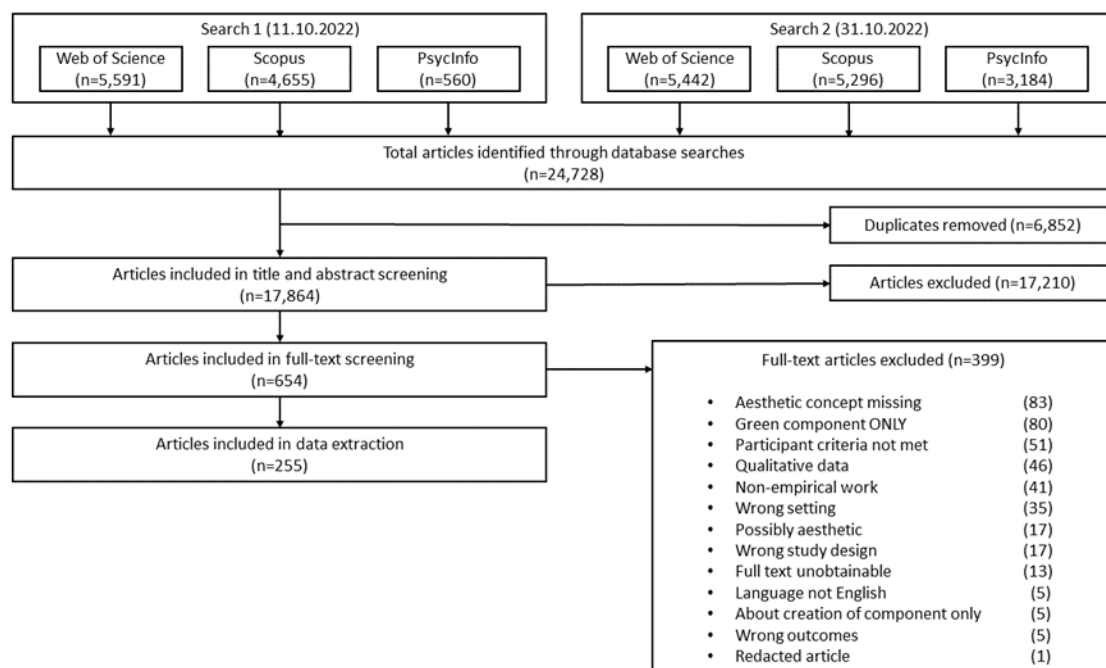


Figure 1. Flow diagram of methodological selection process

Screening

Covidence (<https://www.covidence.org/>), a specialist commercial software for conducting reviews, was used to screen the articles identified through the database searches ($N = 24,728$). At this stage, 6,861 duplicate articles were automatically removed, and the remaining 17,864 article abstracts were screened according to a predefined list of inclusion/exclusion criteria (for full eligibility criterion, see Supplementary Material A). Seven independent reviewers assisted with the screening in two steps: (1) title and abstract screening, and (2) full text screening (for further detail see Supplementary Material A). If the decision was made to exclude an article, justification was provided. While Figure 1 provides an overview of the reasons for exclusion, a more extensive report is available on OSF (https://osf.io/e6udp/?view_only=76fdff2e1935406dbbcd32b6551a857c, anonymised for peer review). In cases of doubt, the article was discussed between reviewers, with a final decision made with team consensus.

Data Extraction

A final sample of 255 articles was selected for the extraction phase. Data extraction was conducted by nine independent reviewers, six of whom had assisted with the previous screening stages. Each article was (1) extracted by one reviewer and then (2) double-checked by a second reviewer (for further detail, see Supplementary Material C). To address our research questions, we operationalised the three concepts identified in the PCC in the following way: (1) information about specific components were extracted for the Urban components concept; (2) information about specific dimensions were extracted for the Aesthetics concept, and (3) information about specific dimensions were extracted for the Wellbeing concept. Table 1 presents an overview of the extracted information, making the operationalisation of the three concepts into components and dimensions visible (further elaboration on



these terms is reported in the next section; for full description, see also Table S4 in Supplementary Material C).

Table 1. Overview of types of extracted information by section

Section	Extraction item
General Information	Title of article
	Lead author
	Year of publication
	Journal
	Aim of study
	Country/City where study is conducted
Methods – General	Total sample size
	Participants
	Sampling Methods
Urban Component (Concept 1)	Urban environment
	Urban component
	Form of component
	Sensory modality measured
	Types of engagement
	Component created/already existing
Aesthetics (Concept 2)	How aesthetic implemented in study design
	Aesthetic dimension(s)
	Method(s) to measure aesthetics
	Conditions/Groups
	Results
Wellbeing (Concept 3)	Was wellbeing assessed?
	Wellbeing dimension(s)
	Method(s) to measure wellbeing
	Conditions/Groups
	Results
	Aesthetic & Wellbeing link
General Notes	Notes

Data Items & Synthesis

To summarise the results after the data extraction, categories were created for the different components and dimensions. The full elaboration of how the categories were formed for the Urban components, Aesthetic dimensions and Wellbeing dimensions is found in the Supplementary Materials E, F & G. We provide a succinct summary below.

Regarding the Urban components, we refer to each urban element that was investigated in the extracted articles as components (e.g., bridges, buildings, colour, lighting, neighbourhoods, path distance, etc.). The extracted components were further grouped into 10 broader urban categories to aggregate the results (see Table 2). The creation of urban categories was guided by Gyurkovich and Pieczara (2021) and Papastergiou et al. (2023) (for further detail, see Supplementary Material E). For example, components which were conceptually close to each other, such as paths, sidewalks, streets, street surfaces, etc. were aggregated into the category ‘Pathways/Surface’.



Table 2. Urban component category description

Category	Description
 Accessibility	This category refers to the ease and efficiency of movement for people and goods within an urban area. This takes into consideration various modes of transport, traffic management systems, and overall infrastructure accessibility. This also includes investigated factors such as proximity to elements within the urban environment, walkability, visual accessibility, etc.
 Amenities	This category relates to amenities and services that contribute to the functionality, or include desirable features, within urban spaces. This includes benches, rubbish bins, playgrounds, sports/leisure facilities, etc.
 Architectural Elements	This category contains both the individual components and materials that make up buildings or structures. These architectural elements serve as the basic building blocks of architectural design, ranging from windows, façades, arches, columns, etc. Additionally, the category includes a diverse range of substances and materials utilised in construction, spanning traditional options like bricks and wood to contemporary materials such as concrete, steel, glass, and other composite materials.
 Buildings	This category contains different identifiable types of buildings, with a range of different purposes. Some common types of buildings include residential, commercial, industrial, skyscrapers, etc.
 Built Heritage	This category refers to the grouping of various buildings, structures or aspects with artistic, cultural, historical or symbolic importance within urban areas. This classification includes attractions, public art, landmarks, monuments, religious institutions, etc. Such elements could often be regarded as ‘classically aesthetic’ objects.
 Pathways/ Surfaces	This category includes the different surfaces and types of pathways or streets within an urban environment based on various characteristics and functions. This includes grouping streets based on their size, purpose, traffic flow and other features. We include alleys, arcades, residential roads, motorways, bike paths, pavements, etc. This also encompasses aspects related to the construction and configuration of ground surfaces, such as street layout, paved roads, path smoothness, etc.
 Properties	This category refers to the visible characteristics that contribute to the physical structure and appearance of components of the urban environment. These properties are akin to perceptual analyses or features (see Leder et al., 2004) that shape the formal or visual aspects of the urban landscape. This includes colour, complexity, contrast, fluency, symmetry, etc. Additionally, this addresses characteristics that define the spatial organisation and layout of elements within an urban environment. These properties include height, size ratio, proportion, etc.
 Quality	This category comprises various characteristics associated with the quality of the urban environment, including air quality, cleanliness, maintenance, pollution, soundscape, etc.
 Structural/ Infrastructure	This category refers to the physical and organisational structures and systems that support and enable the functioning of cities and urban areas. It encompasses a wide range of elements necessary for daily operations and development, including signage, lighting, walls, bridges, cranes, etc.
 Urban Space	This category refers to areas within urban space that can be large in scope or content, including the built environment on a broad scale, neighbourhoods, public open spaces, landscapes, etc. Additionally, this includes identifiable areas within urban space that have a defined sense of size, often a location related to a particular position or site. Examples of such areas include squares, plazas, urban parks, courtyards, etc.



A similar process was used to group Aesthetic and Wellbeing *dimensions*. For Aesthetics, creation of *categories* was guided by Nia and Atun's (2016) aesthetic design thinking model (see Table 3; for further detail, see Supplementary Material F). We derived four *categories* for aesthetic *dimensions*: (A) Objective Urban Elements; (B) Organisational Attributes of Place; (C) Meaningful Attributes of Place; (D) Hedonic Response.

Table 3. Aesthetic dimension category description

Category	Description
(A) Objective Urban Elements	This includes dimensions that concern the perception or the sensation of concrete objective indicators. E.g., lighting, sound, colour, textures, etc.
(B) Organisational Attributes of Place	This includes dimensions regarding the configuration and image properties of the environment. E.g., harmony, proportion, symmetry, order, complexity, etc.
(C) Meaningful Attributes of Place	This includes dimensions that make the environment understandable and meaningful. E.g., coherence, openness, accessibility, mystery, safety, sense of place, etc.
(D) Hedonic Response	This includes dimensions related to observers' responses to the environment. E.g., arousal, enjoyment, liking, pleasure, preference, satisfaction, etc.

For Wellbeing, creation of *categories* was guided by Von Szombathely et al.'s (2017) conceptual model of health-related urban wellbeing (see Table 4; for further detail, see Supplementary Material G). We derived three wellbeing *categories* for wellbeing *dimensions*: (1) Urban Environment; (2) Citizens (Society); (3) Citizens (Individual).

Table 4. Wellbeing dimension category description

Category	Description
(1) Urban Environment	This includes dimensions related to external forces beyond the individual or group on an environmental level. These are specifically concerning the surroundings, such as crime, safety, security, etc.
(2) Citizens (Society)	This includes dimensions related to citizens on a group level. These are social aspects related to cohesion, community and the wider population, such as belonging, community engagement, etc.
(3) Citizens (Individual)	This includes dimensions related to citizens on a person level. These include mental, physical or emotional aspects of an individual's health, such as stress, restoration, walkability, etc.

Results

The results reported below are organised in accordance with the research questions. These results are based on the data extraction and synthesis presented in a final dataset. This final dataset (https://osf.io/e6udp/?view_only=6d79f244a4b64255ad81748abe6b0a14, anonymised for peer review), in a tabular file format, contains all extracted information (for an overview, see Table 1; for full list, see Table S4 in Supplementary Material C). Supplementary Material D contains basic demographics of the final sample of articles (years and journal of publication), locations of the studied environments, the type and sample size of the studied population, as well as the methods of recruitment. Data were analysed in R



Studio (Posit team, 2022; version 2022.12.0.353). The code used for the data analysis is available on the OSF repository (https://osf.io/e6udp/?view_only=4810c054d0e84b04be943f85386edd72, anonymised for peer review).

Which urban man-made components have been investigated regarding aesthetics? (RQ1a)

Across 255 research articles, we identified 524 individual urban components. We reported how often the components were studied, finding 75.38% of urban components were only investigated once across the extracted articles. This indicates a large variety of urban components studied. This is further reflected in that components that were investigated more than once (i.e., 24.62%) also have low frequencies and each are only reported in a small portion of articles. Out of the individual urban components, the most investigated were the Urban Environment (as a whole) (5.58%), Building (2.42%), Street/Road (1.90%), and Square (1.58%)³.

The 524 individual urban components were further grouped into 10 urban categories (see Table 2; for further elaboration see Supplementary Material E). The proportion of urban components within each category is reported in Figure 2. A full list of the urban components organised per urban category is also available in Table S10 of Supplementary Material E. The most investigated urban category across all articles was Urban Space (in broad terms)⁴ (16.42%), followed by Accessibility (13.79%), Amenities/Facilities (12.00%), Pathways/Surfaces (10.42%) and Properties (10.42%).

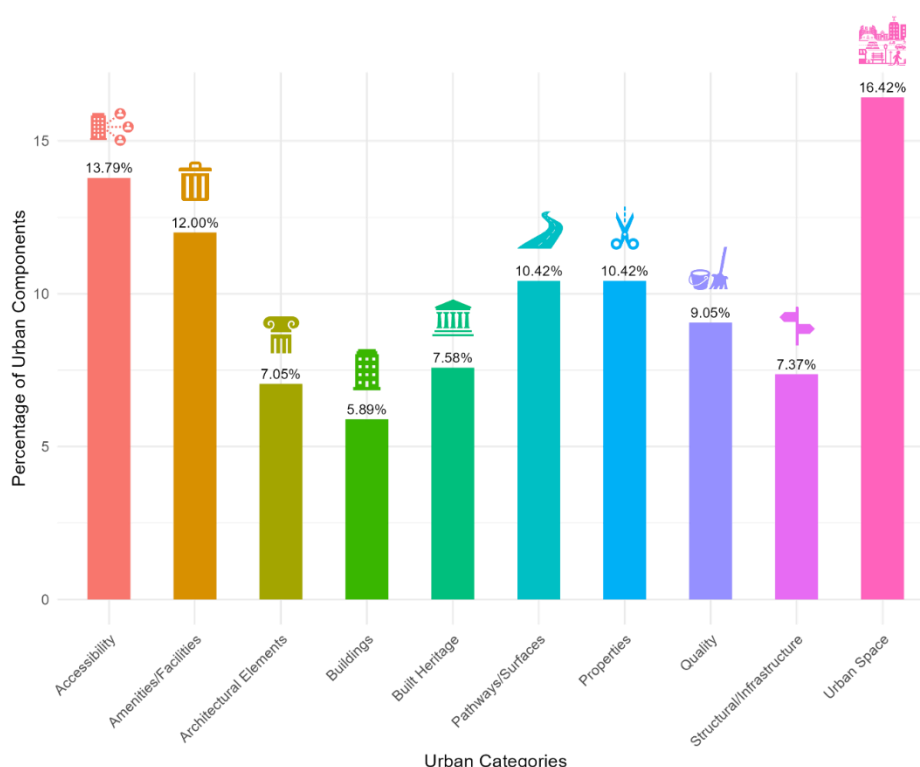


Figure 2. Proportion (%) of urban components per urban category across articles.

³ The percentages were calculated by dividing the frequencies for each individual urban component by the sum of frequencies. By frequencies, we mean the number of articles that investigate the given component. By sum of frequencies, we account for all the 524 components studied across all the 255 articles. For example, the urban component 'Urban Environment (as a whole)' had a frequency of 53 and the sum of frequencies for all the urban components is 950. Then, $53/950 \times 100$ is equal to 5.58%. All calculations of percentages were performed similarly. The sum of frequencies is reported at the end of the corresponding supplementary tables (S7, S8, S9, S10, S11, S12, S13, S14) in the supplementary materials.

⁴ Some category names have the same or similar names as some individual components. For example, the individual component called Urban Environment (as a whole) is an item falling into the broader category called Urban space (in broad terms). For more information, refer to Table 2 in the main manuscript and the Table S10 in Supplementary Material E.



How were aesthetic outcomes evaluated and measured? (RQ1b)

A total of 438 individual aesthetics dimensions were identified (for full list, see Table S12 in Supplementary Material F). The most frequently reported aesthetic dimensions amongst all articles were Preference (6.94%), Pleasure (4.20%), Beauty (2.74%) and Complexity (2.74%). These small percentages indicate variety in the aesthetic dimensions investigated, which is also reflected in that 60.05% of the aesthetic dimensions were only reported once across articles. The 438 aesthetics dimensions were further aggregated into four overarching aesthetic categories: Objective Urban Elements (4.52%, 46 individual dimensions such as Architecture Aesthetics, Luminosity and Colourfulness), Organisational Attributes of Place (19.45%, 97 individual dimensions such as Complexity, Harmony and Maintenance), Meaningful Attributes of Place (42.21%, 218 individual dimensions such as Interest, Openness and Comfort) and, Hedonic Responses (33.82%, 77 individual dimensions such as Preference, Pleasure and Beauty).

Lastly, we identified not only *which* aesthetic dimensions were investigated, but also *how* these were assessed. Aesthetics was evaluated by a wide range of measures ($n = 131$; for full list, see Table S10 in Supplementary Material F). The most frequent measure was Likert-type scales (35.59%), used over three times more frequently than the second measure (Semantic Differential scales; 9.52%). Forced Choice and Eye-Tracking were used 6.52% and 3.01% of the time respectively. We also note 74.05% of the measures were only reported once. We observe a bias towards self-report methods (i.e., the first three listed above, 51.63% in total). We also reported which measures were used in relation to specific aesthetic dimensions (see Table S11 in Supplementary Material F). For example, 'Visit Preference' was assessed with four different measures (Duration, Frequency, Geo-tagged Image Frequencies, Likert Scale) whereas 'Instagram-worthiness' was only evaluated via frequency measures.

Which aesthetic urban components have been investigated regarding wellbeing? (RQ2b)

Of the 255 articles in our final sample, approximately half ($n = 122$, 47.84%) specifically addressed wellbeing. Although both aesthetics and wellbeing were included within these articles, the two concepts were not necessarily linked. To account for this, we reported whether there was a direct association (i.e., an inferential statistical result linking aesthetics and wellbeing). More than half of the articles had such an association ($n = 67$, 54.92%). Since our research aims were not to systematically assess aesthetic or wellbeing effects of urban components, positive or negative effects of wellbeing are not reported, and statistical results are not analysed, but rather at a descriptive level the proportion of relatedness between aesthetics and wellbeing is reported.

The urban components (organised by urban categories) that were studied in the articles investigating urban aesthetics and reporting wellbeing are shown in Figure 3. The most frequently reported urban categories were Urban Space (22.91%), Pathways/Surfaces (13.30%), Accessibility (13.05%), and Amenities/Facilities (12.56%). A full list of urban components identified in wellbeing-related articles is available in Table S11 in Supplementary Material E. Further, to identify which urban components are more associated with wellbeing, we also compared the quantity of urban components between aesthetic and wellbeing-related articles (for elaboration, see Figure S4 in Supplementary Material E).

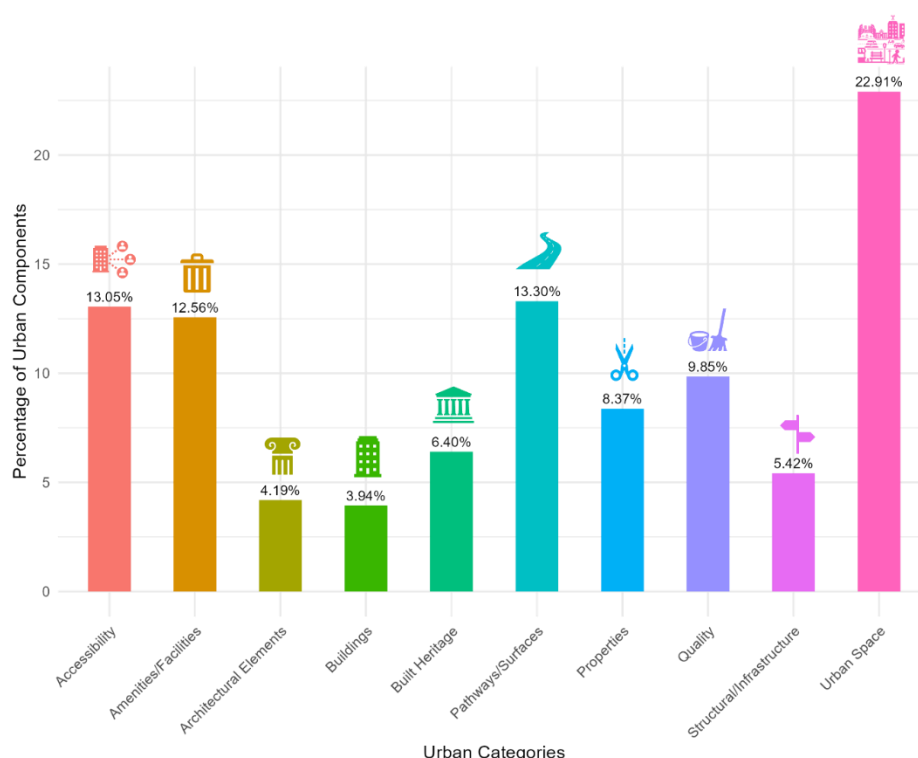


Figure 3. Proportion (%) of urban components per category across the articles that measure a wellbeing dimension.

How were wellbeing outcomes evaluated and measured? (RQ2b)

A total of 81 wellbeing dimensions were identified (see full list in Table S15 of Supplementary Material G). The most frequently reported wellbeing dimensions amongst all articles were Restoration (14.13%), Safety (12.72%), Stress (6.71%), and Happiness (4.95%). Similar to aesthetic dimensions, there is high variety within the wellbeing dimensions investigated. Out of the wellbeing dimensions, 55.56% were only reported once across articles compared with 60.05% of aesthetic dimensions.

The 81 wellbeing dimensions were further aggregated into three overarching wellbeing categories (for further elaboration, see Supplementary Material G): Urban Environment, Citizens (Society), and Citizens (Individual). Using this categorisation, 70.32% wellbeing dimensions fall within the Citizens (Individual) category ($n = 56$, e.g., Restoration, Stress, Happiness), 23.67% within the Urban Environment category ($n = 16$, e.g., Safety, Security, Crime Safety), and 6.01% within the Citizens (Society) category ($n = 9$, e.g., Social Cohesion, Social Stimulation, Social Activity).

Lastly, we also reported *how* the wellbeing dimensions were investigated. Wellbeing dimensions were assessed by a wide range of measures ($n = 77$, for full list, see in Table S16 in Supplementary Material G). The most frequent measure was Likert-type scales (29.84%), followed by the Perceived Restorativeness Scale (PRS) (10.47%), Semantic Differential scales (5.24%), and the Positive and Negative Affect Schedule (PANAS) (3.66%). Again, this shows a bias towards self-report methods. The wide variety of assessing wellbeing is reflected in 79.22% of the measures only being reported once. We also reported which measures were used in relation to each specific wellbeing dimension (see in Table S17 in Supplementary Material G). For example, 'Health' was a wellbeing dimension evaluated with three different measures (Likert Scale; SF-12v2 Health Survey; Standard Morbidity Ratio (SMR)), whereas 'Resilience' was only evaluated via the Resilience Scale (RS 11).



Summary

To provide a comprehensive overview, extracted information was organised by urban categories, with a focus on the top five most frequently reported items for each section (i.e., urban components, aesthetic dimensions, aesthetic measures, wellbeing dimensions, wellbeing measures) (see Table 5). Where multiple items with the same frequency (n) exceeded the first five items, we reported the first items at this level in alphabetical order. The ellipsis (...) is used in the table to indicate the number of items continues beyond that reported within the table, with the total amount reported at the end of each section. The full list of items for each section is available in Supplementary Materials E (Urban Components) and H (aesthetic dimensions, aesthetic measures, wellbeing dimensions, wellbeing measures).

For clarity, we provide an example of how to read Table 5: We found that 120 articles identified at least one urban component (out of a possible 43) that fell under the category 'Urban Space'. Further, within this urban category, 279 aesthetic dimensions were identified (see "Total Items" in Table 5), with preference being the most frequent, identified in 33 articles (see the reported n in Table 5). The other columns (urban components, aesthetic measures, wellbeing dimensions, and wellbeing measures) and rows (urban categories) can be interpreted similarly. However, each column is not tied to the next and should be looked at individually. Further, whilst the aesthetic dimensions and measures were directly linked to specific urban components, the wellbeing dimensions and measures were not. This means the number of articles reported for wellbeing in each category accounts for when components in that urban category appear in the same article than that of the wellbeing concept (but does not necessarily mean that the specific components are assessed on wellbeing dimensions/measures).



Table 5. Summary of data extracted according to urban categories

Urban Components			Aesthetic Dimension		Aesthetic Measure		Wellbeing Dimension		Wellbeing Measure	
	<i>Item</i>	<i>n</i>	<i>Item</i>	<i>n</i>	<i>Item</i>	<i>n</i>	<i>Item</i>	<i>n</i>	<i>Item</i>	<i>n</i>
 Accessibility (n = 56 articles) ^a	Traffic	7	Preference	21	Likert Scale	18	Restoration	12	Likert Scale	27
	Parking Lots	5	Pleasure	7	Forced Choice	5	Safety	12	Electroencephalogram (EEG)	6
	Accessibility	4	Accessibility	5	Point Allocation Method	4	Stress	4	Perceived Restorativeness Scale (PRS)	5
	Car	4	Comfort	3	Semantic Differential Scale	3	Comfort	3	Forced Choice	3
	Distance	4	Complexity	3	Discrete Choice Experiment (DCE)	2	Health	3	Point Allocation Method	3
	...	...	...	...	...	...	...	...	...	...
	Total Items: 85		Total Items: 62		Total Items: 38		Total Items: 30		Total Items: 24	
 Amenities (n = 49 articles) ^a	Seating	12	Preference	18	Likert Scale	19	Safety	10	Likert Scale	16
	Street Furniture	8	Pleasure	6	Forced Choice	5	Restoration	9	Electroencephalogram (EEG)	6
	Playground	7	Accessibility	3	Semantic Differential Scale	5	Stress	4	Perceived Restorativeness Scale (PRS)	3
	Café/Restaurant	6	Aesthetics	3	Point Allocation Method	4	Security	3	Point Allocation Method	3
	Bench	5	Attractiveness	3	Frequency Measure	3	Comfort	2	Semantic Differential Scale	3
	...	...	...	...	...	...	...	...	...	...
	Total Items: 65		Total Items: 64		Total Items: 25		Total Items: 25		Total Items: 19	
	Façade	12	Preference	18	Likert Scale	19	Safety	9	Likert Scale	7
	Architecture	10	Complexity	13	Semantic Differential Scale	9	Restoration	4	Market Basket Analysis	2



 Architectural Elements (n = 48 articles) ^a	Building Façade	3	Pleasure	9	Forced Choice	5	Happiness	2	Perceived Restorativeness Scale (PRS)	2
	Architectural Elements	2	Beauty	8	Eye-tracking	3	Agoraphobia	1	Senior Walking Environmental Assessment Tool (SWEAT)	2
	Concrete	2	Familiarity	5	Point Allocation Method	2	Anxiety	1	Sliding Scale	2
	...	...	...	...	...	...	...	...	...	...
	Total Items: 39		Total Items: 125		Total Items: 31		Total Items: 12		Total Items: 13	
 Buildings (n = 36 articles) ^a	Building	23	Preference	6	Likert Scale	18	Safety	6	Likert Scale	13
	House	5	Beauty	5	Forced Choice	2	Restoration	4	Binary Comparison	1
	Commercial Building	2	Liking	4	Frequency Measure	2	Health	2	Forced Choice	1
	Industrial Building	2	Accessibility	3	Geo-tagged Image Frequencies	2	Mental Wellbeing	2	Perceived Restorativeness Scale (PRS)	1
	New Building	2	Arousal	3	Point Allocation Method	2	Relaxation	2	Restorative Components Scale (RCS)	1
	...	...	...	...	...	...	...	...	...	...
	Total Items: 26		Total Items: 65		Total Items: 21		Total Items: 8		Total Items: 7	
 Built Heritage (n = 51 articles) ^a	Graffiti	4	Preference	13	Likert Scale	22	Safety	7	Likert Scale	13
	Historic Building	4	Beauty	6	Semantic Differential Scale	4	Restoration	6	Electroencephalogram (EEG)	6
	Sculpture	4	Pleasure	6	Forced Choice	3	Relaxation	4	Semantic Differential Scale	4
	Fountain	3	Interest	5	Frequency Measure	3	Stress	2	Point Allocation Method	3
	Monument	3	Accessibility	4	Eye-Tracking	2	Affect	1	Preference Evaluation	2
	...	...	...	...	...	...	...	...	...	...
	Total Items: 48		Total Items: 100		Total Items: 30		Total Items: 21		Total Items: 12	



 Pathway/ Surfaces (n = 61 articles) ^a	Street/Road	18	Preference	21	Likert Scale	25	Safety	16	Likert Scale	29
	Path	9	Pleasure	8	Semantic Differential Scale	10	Restoration	8	Electroencephalogram (EEG)	6
	Sidewalk	8	Liking	7	Forced Choice	5	Stress	6	Neighbourhood Environment Walkability Scale (NEWS)	3
	Streetscape	4	Attractiveness	6	Frequency Measure	4	Walkability	5	Profiles Of Mood States Scale (POMS)	3
	Bicycle Paths	3	Interest	6	Discrete Choice Experiment (DCE)	2	Comfort	3	Semantic Differential Scale	3
	...	...	...	...	...	...	...	...	...	...
	Total Items: 56		Total Items: 119		Total Items: 35		Total Items: 31		Total Items: 22	
 Properties (n = 51 articles) ^a	Colour	12	Preference	15	Likert Scale	23	Safety	8	Likert Scale	14
	Size	6	Pleasure	8	Semantic Differential Scale	6	Restoration	7	Semantic Differential Scale	11
	Curvature	3	Complexity	7	Forced Choice	5	Being Away	3	Perceived Restorativeness Scale (PRS)	5
	Shadow	3	Beauty	6	Eye-tracking	3	Fascination	3	Blink Rates	2
	Brightness	2	Liking	6	Entropy Value Calculation	2	Relaxation	2	Frequency Measure	1
	...	...	...	...	...	...	...	...	...	...
	Total Items: 70		Total Items: 100		Total Items: 27		Total Items: 16		Total Items: 8	
 Quality (n = 41 articles) ^a	Sound/Noise	7	Preference	11	Likert Scale	17	Safety	7	Likert Scale	16
	Soundscape	6	Pleasure	9	Semantic Differential Scale	5	Restoration	5	Point Allocation Method	3
	Traffic Noise	6	Calmness	4	Point Allocation Method	3	Walkability	3	Int. Physical Activity Questionnaire (IPAQ)	2
	Human Sounds	5	Liking	4	Dichotomous Response	2	Affect	2	Positive & Negative Affect Schedule (PANAS)	2
	Cleanliness	4	Aesthetics	3	Forced Choice	2	Attention	2	Preference Evaluation	2



	...	...	...	...	...	...	...	...	...	
	Total Items: 53		Total Items: 95		Total Items: 30		Total Items: 22		Total Items: 16	
 Structural/ Infrastructure (n = 41 articles) ^a	Signage	13	Preference	16	Likert Scale	19	Safety	9	Likert Scale	9
	Lighting	10	Complexity	5	Semantic Differential Scale	6	Stress	3	Electroencephalogram (EEG)	6
	Advertisements	5	Harmony	4	Eye-tracking	4	Restoration	2	Binary Comparison	1
	Bike Infrastructure	2	Pleasure	4	Forced Choice	2	Security	2	Directed Attention Test	1
	Crane	2	Beauty	3	Frequency Measure	2	Anxiety	1	Forced Choice	1
	...	...	...	...	...	...	...	...	...	...
	Total Items: 39		Total Items: 67		Total Items: 19		Total Items: 14		Total Items: 14	
 Urban Space (n = 120 articles) ^a	Urban Environment (as a whole)	53	Preference	33	Likert Scale	65	Restoration	31	Likert Scale	65
	Square	15	Pleasure	18	Semantic Differential Scale	16	Safety	23	Perceived Restorativeness Scale (PRS)	16
	Park	14	Attractiveness	15	Forced Choice	8	Stress	17	Semantic Differential Scale	12
	Neighbourhood	11	Beauty	14	Frequency Measure	4	Happiness	8	Electroencephalogram (EEG)	6
	Landscape	6	Complexity	12	Neighbourhood Environment Walkability Scale (NEWS)	4	Relaxation	6	Neighbourhood Environment Walkability Scale (NEWS)	5
	...	...	...	...	...	...	...	...	...	...
	Total Items: 43		Total Items: 279		Total Items: 66		Total Items: 54		Total Items: 57	

Note. ^aThe total *n* is the number of articles that investigate components within this category



Discussion

This scoping review gives an outline of literature on aesthetic components of the urban environment and their relation to wellbeing. Given the sheer scope of the review, we only report on a selection of the specific results and trends, providing examples and recommendations. We therefore prompt the reader to consult the more extensive tables in the supplementary materials for a holistic overview.

In this discussion, we propose more concrete recommendations for future primary and secondary research based on the findings and execution of the present scoping review. For primary research (i.e., original articles where data is produced by the authors), we provide suggestions to enable researchers to either build upon existing work or address underexplored areas. This, in turn, would foster a more cohesive understanding of the field and further identification of research gaps. For secondary research (i.e., where pre-existing data is re-used), we highlight the challenges encountered during our review process to ensure any future literature reviews on the same topic proactively address these concerns.

Finally, we explain how the information extracted for this review can be used as a tool intended to serve both researchers and urban planners alike. This dataset contains all extracted information (for an overview, see Table 1 and for full list, see Table S4 in Supplementary Material C). This information is freely available for future research (e.g., the development of systematic review questions or meta-analyses) and design (e.g., identification of aesthetic urban elements that have the potential to impact wellbeing) purposes.

Recommendations for Future Primary Research

Study underrepresented⁵ urban components

Overall, there was variation within the urban categories as well as the individual urban components studied, indicating a relatively wide breadth but not necessarily depth of study (i.e., each category or component is only represented by a few articles). This calls for more research on individual components that are minimally investigated within these broader categories (see Table S10 in Supplementary Material E). For example, art and other similar cultural elements within the ‘Built Heritage’ category, that would be considered as typically aesthetic objects, appear to be underrepresented. From the perspective of art and aesthetic research, it is expected that such stimuli is researched more, however only accounts for a small proportion of studied urban components within our review findings.

Additionally, building materials (e.g., concrete, glass, timber, etc.) were also identified as components that could be of interest in future research. Despite their extensive usage and prominent role in the appearance and development of urban environments (for an overview, see Strappini et al., 2024), they are an underrepresented aspect within the ‘Architectural Elements’ category. Furthermore, specific urban components within the ‘Structural/Infrastructure’ category related to signage, such as information boards (Budner, 2016), posters (Johannes et al., 2021), signboards (Wang et al., 2010), and other wayfinding objects (Hunter & Askarinejad, 2015), were only investigated once in reviewed articles. Similar to art, signage, and other textual elements can play an important role on visual attraction (e.g., Chana et al., 2023), warranting further investigation.

⁵ Underrepresented denotes various aspects (components, dimensions, methods, etc.) that were reported less frequently within our extracted articles. To make these more easily identifiable, we provide the lists of the most underrepresented results (i.e. reported in only one research article and therefore counted as a frequency score of ‘1’) in the Supplementary Materials (OSF: https://osf.io/e6udp/?view_only=2968c37e3c55499ea670cf259a0fbd8e). For the aspects that arose more frequently, a visual summary is available in Table 5 and an interpretation is available in Supplementary material I.



During our identification of urban components, we noticed a possible emerging trend regarding the modalities of the urban components being investigated. Despite a large proportion of urban components studied within the visual domain (arising in 188 out of 255 articles), the auditory domain is also gaining popularity (arising in 25 of the 255 articles). This is further reflected in the appearance of various noises, sounds, and urban soundscapes as components studied (see Table S10 in Supplementary Material E). Although visual stimuli are dominant within the field of psychology, and especially within art and aesthetic research, the urban environment is experienced with all the senses. However, the olfactory domain, for example, was only present in two extracted articles (i.e., Engel et al., 2018; Sinda et al., 2022). It would be interesting to see a further shift in research on urban soundscapes and stimuli in other sensory domains, given that all the senses can have a profound effect on us.

Study underrepresented⁵ aesthetic dimensions

To ascertain which aesthetic dimensions ought to be implemented in future research (as 60.05% of the aesthetic dimensions were rather underrepresented, see Supplementary Tables S12 & S18 in Supplementary Materials F & H), we identified 42 underrepresented dimensions that had previously been regarded within a list of aesthetic responses to the urban environment (Nia & Atun, 2006; see full list in Supplementary Material F “Underrepresented Dimensions”). From this, we notice certain groups of terminology (e.g., related to colour and sound properties, sense of place and belonging, atmosphere, etc.) could be fruitful to study further in relation to the urban environment.

As a further example, Meaningfulness as an aesthetic dimension only appeared in two reviewed articles (Davies et al., 2014; Hunter & Askarinejad, 2015). However, in categorising our aesthetic dimensions into groups, the category ‘Meaningful Attributes of Place’ (from Nia & Atun, 2016) suggests there are many more dimensions related to the meaningfulness of the urban environment, albeit not with the specific wording; for example, ‘Place Attachment’, ‘Sense of Identity’, ‘Historical Importance’. From this, we propose researchers should use dimensions that fall under the category ‘Meaningful Attributes of Place’ in evaluations of the urban environment to better capture the concept of meaningfulness. This conceptualisation and inclusion in future research might be of particular importance given that meaningfulness of aesthetic experiences is a suggested mechanism for wellbeing impacts (Trupp et al., 2023; 2024) and contributes to overall aesthetic experiences (Leder et al. 2004; Pelowski et al. 2017).

Study underrepresented⁵ wellbeing dimensions

For wellbeing, we identified dimensions relating to social aspects are the most underrepresented. Social engagements are important for mental health, especially in terms of interactions with the urban environment (e.g., Lauwers et al., 2020). However, our review revealed some specific social dimensions (e.g., Belonging, Community Engagement) were systematically underrepresented across urban categories (see Table S20 in Supplementary Material H). Given the argument that cities are becoming more densely populated, and density correlates with health concerns such as loneliness (Bower et al., 2023; Ochnik et al., 2024; Carnegie et al., 2022), perhaps community and social interactions/cohesion ought to be explored further.

Increase real-world representation

In looking at the methodology of our reviewed articles, we identified some studies that are more representative of the real world (i.e., the urban environment). For example, the number of articles identified with direct engagement with the urban environment (e.g., natural and field studies; $n = 52$ of the



255 articles)⁶. Although psychology experiments often take place under highly controlled laboratory conditions, direct observations in naturalistic or field environments provide the highest forms of external validity. Since this is still a small proportion in our dataset, we recommend more studies are conducted in ecologically valid settings to complement the internal validity of laboratory experiments (Schmehl & Oberzaucher, 2014).

The representativeness of the real world is also exemplified in the use of large databases, which may complement the variability in the environments captured in fieldwork. As opposed to predefined image stimuli set by researchers themselves, databases with many images offer more avenues to represent diverse urban locations worldwide and thus increase external validity. The following were used in the articles analysed: Scenic-Or-Not (Seresinhe et al., 2015; 2018; 2019), Place Pulse 2.0 (Larkin et al., 2021; Zhang et al., 2018a), or even Google Street Images (Joglekar et al., 2020; Kawshalya et al., 2022; Larkin et al., 2021; Loodin & Thufvesson, 2022; Takizawa & Kinugawa, 2020).

Additionally, we note a trend to using a number count (e.g., number of images per location) as indicator of preference in relation to geo-tagging, photo classification, and use of social media. For instance, we identified Flickr (Havinga et al., 2021; Langemeyer et al., 2018; Seresinhe et al., 2018), Instagram (Wan et al., 2021; Zasina, 2018) and TripAdvisor ratings (Kourtiti et al., 2021c). This kind of methodology seems to be becoming more apparent in studying everyday environments (e.g., Alexander, 2013; Knoll et al., 2024; Leder et al., 2022; Petersen & Martin, 2021; Vissers & Wagemans, 2022). This is also reflected in the use of Ecological Momentary Assessments (EMA; see Scott et al., 2018 from the reviewed articles). Such methods balance both the ecologically valid design while also obtaining representative responses due to the large samples. This is perhaps the beginning of such a trend, and such designs/methods ought to be further encouraged when considering the urban environment, a complex environment that is difficult to transcribe in a laboratory setting.

Echoing this, we also note the emergence of studies using Virtual Reality (VR) (e.g., Jeon et al. 2021; Kim & Kim, 2019; Luo et al., 2022; Mouratidis & Hassan, 2020; Nasar & Cubukcu, 2011; Pals et al. 2014; Park et al. 2020; Ryu et al. 2007; Shi et al., 2020; Xiangmin et al., 2022). As this approach provides more immersion while keeping the experimental control of a laboratory setting, we recommend future research to continue implementing this approach to explore experiences of spaces (see Newman et al., 2022).

Incorporate more physiological measures

This scoping review identified similarities and differences in the types of measures used to assess aesthetic and wellbeing dimensions. In exploring the measures used within the extracted articles to assess aesthetic and wellbeing dimensions, we identified a strong bias towards Likert-type scales, forced choice and semantic differential scales. This is most probably a reflection of psychology as a field (see Chan, 2008), where self-report measures are used predominantly in study designs (~50% in our extracted articles). In turn, this also meant fewer instances of physiological measures were reported in the present data, and might be considered more in future studies, especially to target wellbeing and physical health. For example, measuring heart rate (HR) or electrodermal activity (EDA) could be useful in the assessment of traffic safety, stress, risk avoidance, alertness (see Park et al., 2020 from our review), which is imperative to day-to-day interactions with urban transport systems and traffic.

⁶ We found 163 articles reporting only indirect engagement (e.g., laboratory, online, or virtual reality), 44 articles reporting only direct engagement (field, natural), 8 articles reporting both direct and indirect engagement, and 48 articles with no specific engagement. Note that these numbers do not add up to 255 as we have cases in the data where we found more than one type of engagement per article; therefore, $n = 52$ includes 44 articles with direct engagement and the 8 articles with both direct and indirect engagement.



Use more targeted standardised questionnaires

Aesthetic dimensions were often assessed with varying Likert scales and extensive semantic differential scales (see also section 4.1.5), resulting in many underrepresented⁵ dimensions. For example, Llinares et al. (2014) evaluated the urban space in general on a series of unique adjectives (e.g., chaos, childish, exotic, frivolous, luxury, romantic, seductive, vitality, etc.), which make their frequency of occurrence very low as they are very specific terms. This calls for more discussion to create consensus as to which dimensions, or at least consistent phrasing of them, are used in self-report assessments addressing the urban environment and aesthetics. Using the same scales would help to make research findings more comparable in general and would also help when performing meta-analyses.

This review highlights standardised questionnaires which are targeted to the urban environment and include aesthetic dimensions that could be used in this regard: City Relatedness Scale (CRS; Lämmle et al., 2022); Keep America Beautiful Litter Index (KAB; Budruk & Manning, 2006); Perceived Environmental Aesthetic Qualities Scale (PEAQs; Subiza-Pérez et al., 2021); Urban Public Space Evaluation (UPSE; Xu et al., 2023). Furthermore, the following standardised questionnaires were used to assess wellbeing dimensions, e.g., the Perceived Restorativeness Scale (PRS; Hartig et al., 1991); the Spielberger State-Trait Anxiety Inventory (STAI; Marteau & Bekker, 1992), Senior Walking Environmental Assessment Tool (SWEAT; Cunningham et al., 2005), and Neighbourhood Environment Walkability Scale (NEWS; Saelens et al., 2003).

Use specific terminology tailored to the urban environment

Echoing the diversity in aesthetic dimensions (see point 4.1.2.), discordance regarding which terminology ought to be used is raised within empirical aesthetics generally (see Jacobsen, 2006; Augustin et al., 2012). This becomes more imperative in exploring the aesthetics of urban environments. For example, the term ‘preference’ is commonly used within empirical aesthetics and arises frequently within our extracted articles. However, when asking about preference, this is often a relative judgement *for* something, and, most of the time in aesthetics research, the preference is for an aesthetic stimulus such as art. Conversely, preference for something in an urban environment is more varied (e.g., colour preference, destination preference, environmental preference, image preference, living preference, preference for safety, visit preference).

As aforementioned (4.1.6.), consensus in terminology across fields of research, and also within disciplines, allows for better comparisons. However, it is recommended that the aesthetic dimensions used are tailored towards the urban environment. For instance, place attachment instead of attachment or neighbourhood satisfaction instead of satisfaction. Additionally, other terms such as homeliness, liveliness, cleanliness, etc., directly address environmental aesthetics and would not necessarily be used across broader research on art and aesthetics. This increased specificity in terminology better addresses specific research questions and targets the complexity of the urban environments, by incorporating environmental factors that influence aesthetic evaluations.

Reduce geographic bias

Our review is limited by a bias in geographical locations of the urban environments studied, generally carried out in the Global North: mostly within Europe and some in China (see Supplementary Material D). It remains unclear why this bias arises within our extracted articles, but this may represent the location of research(ers). Reports of world urbanisation prospects indicate increases in urban populations and urbanised regions – with the majority of this growth in Asia, Africa and other geographic regions within the Global South (United Nations, 2018b). Future researchers should therefore look more broadly at urban environments across the globe to fully capture world urbanisation.



Recommendations for Future Secondary Research

Identify dimensions as aesthetic or wellbeing

The disparity in terminology is construed by the lack of distinction between aesthetic and wellbeing. During data extraction, it became apparent that articles often do not ‘separate’ between aesthetic and wellbeing evaluations but combine these in more sweeping assessment of the urban environment. For example, studies using semantic differential scales list emotion-related adjectives for aesthetic evaluation, some of which overlap with wellbeing, such as happiness (Llinares et al., 2014) and comfort (Wan et al., 2020). Similarly, the Neighbourhood Environment Walkability Scale (NEWS; Saelens et al., 2003) includes sub-items concerning attractive elements (i.e., aesthetics-related) and crime (i.e., wellbeing-related).

Other examples, like the aforementioned 'Preference for Safety', combine aesthetic (preference) and wellbeing (safety) terms, which causes ambivalence as to whether this is regarded as an aesthetic or a wellbeing dimension. This makes it difficult to quantify the terms used across studies when aesthetic and wellbeing dimensions are recorded separately. A suggestion for how to counter this is to look at how the papers are framed (see also section 4.2.2.) and use this to decide whether a term should fall under aesthetics or wellbeing. To facilitate this process for future research, this information was included within our data extraction⁷ (see also section 4.3.).

Link urban components to wellbeing

In our review, we noticed two different approaches within the 122 articles that considered wellbeing: either (1) directly targeting the impact of the urban environment on wellbeing as the main aim; or (2) directly targeting the aesthetics of the urban environment whilst also looking at additional wellbeing measures. However, the way in which we conducted our data extraction was always centred on aesthetics, and not wellbeing, given the framing of our aim and research questions. We therefore did not target articles that looked at the urban environment and wellbeing *without* aesthetics, which would be useful to account for this framing bias.

Furthermore, within the articles addressing wellbeing, more than half showed a link between aesthetics and wellbeing (i.e., with inferential statistics, see section 3.3). This indicates that there is a large proportion of literature finding relationships between aesthetic components and wellbeing outcomes, either positively or negatively. However, although this finding sounds promising, we addressed wellbeing and its relation to each article as a whole. Since wellbeing evaluations were not tied to a specific urban component, it is difficult to link back the effects of both aesthetic and wellbeing to one single urban component. This approach was taken since wellbeing was a secondary focus of this review.

Additionally, we did not explicitly evaluate (positive/negative) results or methods and therefore cannot capture specific components targeting wellbeing and quantify their effects. Future researchers should link wellbeing dimensions to the urban components to provide the most comprehensive overview of the interplay between the three PCC concepts: Urban Environment X Aesthetics X Wellbeing. Importantly, our review highlights enough material for future systematic reviews or meta-analyses, which include many sensory domains, to provide substantial evidence that the aesthetics of the urban environment can (positively) influence wellbeing, and which specific urban components are relevant for both aesthetics and wellbeing.

⁷ Our dataset includes information regarding the framing of the research articles (aesthetics or wellbeing focused), if a statistical link between aesthetics and wellbeing was reported, and further notes on theoretical background (see section 4.3. and OSF manual

https://osf.io/e6udp/?view_only=6d79f244a4b64255ad81748abe6b0a14 [Link anonymised for peer review](#)).



Isolate study designs for systematic reviews

Given the purpose of the scoping review to map a wide range of literature, there was substantial diversity in study designs extracted from our reviewed articles (see dataset in OSF, https://osf.io/e6udp/?view_only=6d79f244a4b64255ad81748abe6b0a14 Link anonymised for peer review). For example: (1) sampling methods and sample sizes vary greatly across the articles, from less than 100 participants, to large samples over 1000, and some studies in which no participants were included at all; (2) there are some instances of case studies and longitudinal studies; (3) not all studies provide results of an aesthetic or wellbeing effect, and a range of statistical methods were used when results were present in the articles. Whilst this extracted information provides a record of possible ways to conduct research on urban aesthetics and wellbeing, these studies are not methodologically equal and therefore large comparisons cannot be obtained. In the construction of a systematic review or even a meta-analysis, researchers should isolate the articles of interest according to one or several of these aspects (Myung, 2023).

Be mindful of researcher bias

We acknowledge that the findings and recommendations from this scoping review could be potentially biased by our scientific background: the search terms were based on a conceptualisation of aesthetics deriving from psychological research, which could exclude terms from other disciplines more tailored towards investigating/assessing the urban environment. Despite these initial search terms, the review findings show how aesthetic dimensions already established within empirical aesthetics are used, but also what else ought to be considered as an aesthetic dimension, especially when concerning the urban environment.

Furthermore, the articles that were included may also be limited by the scoping review search protocol given the search only captured peer-reviewed literature in the past two decades, English language and used only three databases, which in turn could contribute to the Global North bias (highlighted in section 4.1.8.). Nevertheless, it limits the breadth of which kind of urban environments are included in our review. We recommend that our scoping review acts as a starting point for those interested in urban aesthetics and wellbeing, encouraging the use of our dataset to begin exploring various avenues in more depth. At the same time, we remind the reader that whilst this paper and additional materials stem from a stringent empirical approach, the information in grey literature and qualitative research is prolific and should not be disregarded (Oberzaucher, 2017; Richer et al., 2017).

Urban Aesthetics and Wellbeing Dataset

The final contribution of this scoping review is a dataset with all the information extracted from the reviewed articles (https://osf.io/e6udp/?view_only=6d79f244a4b64255ad81748abe6b0a14 Link anonymised for peer review). This dataset is in a tabular file format, where each article is represented by one or multiple rows and the reported information is structured into different sections (see Table 1 and Table S4 in Supplementary Material C). We provide more information about this structure and how to use the dataset in a manual on OSF.

We offer this dataset since extracting the relevant information from a multitude of primary research into a useable, compatible structure ultimately results in a substantially large file that is too extensive to report in full within this research article. Thus, whilst other aspects of the dataset may prove interesting, in this paper, efforts were made to synthesise the collected data with focus on research questions and the core concepts. Moreover, this includes other information related to the quality of the articles and that may prove noteworthy to urban researchers and those in other related disciplines. For example, information



pertaining to study design, sample size, geographical context, etc. that can be looked at more precisely according to research interest.

We recommend using this dataset during the elaboration of future research questions (e.g., to identify components or measures to incorporate in designing new studies). Whilst we condense the information into a comprehensible format within this article, using the full dataset allows future researchers to shape/tailor the data and select the specific information that they need. Furthermore, we recommend urban planners and designers use this review dataset to appraise the aesthetic and wellbeing potential of the urban elements that they incorporate into the construction of attractive urban spaces with added health benefits. It can be used to justify why a component, or a measure should be included in the design of city (i.e., present factual evidence from citeable research to support pre-existing ideas from urban planners) and in study designs of researchers. Thus, one can search for specific objects of interest (e.g., benches, artwork, etc.) and filter the articles of relevance in the dataset, using the extracted information or the relevant citations, toward aesthetic or wellbeing benefits in the urban environment.

Conclusion

In seeking to provide a comprehensive overview, we collated quantitative literature from a diverse combination of research fields that outlines how aesthetics in the urban environment is important, how it has been studied and how it may relate to wellbeing. We found vast divergence in the types of urban components that held aesthetic value, what type of aesthetic value they held, and the impact this could have on city dwellers. However, in this plethora of literature, we identified several clusters that we think are relevant for researchers with growing interests in urban aesthetics and its implications. Further, the results highlight the terminology used in such aesthetic/wellbeing-related evaluations, which can be used by researchers, designers, and planners alike to ensure greater consensus cross-disciplinarily.

The dataset provided can be used by researchers, designers and urban planners alike. The information can be used by researchers to pinpoint research gaps or areas to consider assessing more comprehensively in the development of further research questions and study designs for both primary and secondary types of research. This would be a step towards fully capturing the assessment of environmental perception and addressing more factors that could contribute to the aesthetic experience of the urban environment. Additionally, the aesthetic and wellbeing potential of urban components can be backed with evidence from citeable sources when planning the future designs of urban spaces with attractive and health-related benefits.

With the sheer number of articles identified, this scoping review supports our initial premise: to make the urban environment better for its inhabitants, the aesthetics of cities should be considered. However, these articles stem from various research fields that do not seem to foster interdisciplinary exchange, leading to a fragmented research landscape. Therefore, what one can ascertain from this manifold of studies is limited. This review marks a first step to bringing together research from disparate fields in a condensed format, because this is needed to provide a bigger picture of how to make our cities more aesthetically pleasing, optimise our wellbeing and, fundamentally, better places to live.



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2.1.2. Theoretical perspective: Everyday aesthetics and the future of text reading



Mendhakar, A., Chana, K., Mikuni, J., & Leder, H. (in prep). *Future of text reading: A view of text aesthetics*.

My Contribution:

AM proposed the concept of the paper. AM and I contributed to the literature review, and I selected papers related to typography, design, and aesthetics. AM wrote the article, creating the main body of work. I contributed to the writing of the original manuscript and revisions. HL supervised the conceptualisation, and JM and I helped with the development of the paper. All authors provided feedback on the consecutive versions.

2.1.2.1. Key findings

- Text has evolved through major technological revolutions, fundamentally reshaping how we generate, store and engage with written content.
- Aesthetics and the perceived beauty of text plays a significant role in how readers experience and interpret written material.
- Research shows that the visual presentation of text directly impacts reading perception and user engagement.
- As digital reading tools advance, there is growing emphasis on incorporating text aesthetics to enhance future reading experiences.

2.1.2.2. Original Manuscript

(see next page)



Future of text reading: an aesthetic point of view

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Abstract

Text reading is arguably the most ubiquitous task people perform. From initial stone carvings to the invention of word processors and widespread internet adaptation, text has undergone multiple revolutions in generation, storage, and dissemination (Robinson, 2009). Today, digital tools have made information readily accessible, fundamentally transforming the way we engage with text. With the rise of digital reading devices, on-screen text has become increasingly dynamic and easily modifiable, improving readers' comprehension and engagement. Text typography, beauty, and aesthetics are integral to the reading experience, as reflected in major investments by publishing industries in customised reading tools. Prior research has demonstrated that text aesthetics significantly influence readers' perception (Jacobs, 2015; Larson & Picard, 2005; Kirschenbaum, 2006; Deloux, 2003). As reading is a complex activity, it should be tailored to individual reading behaviours and preferences. This paper established a foundational perspective on text aesthetics and proposes a comprehensive framework to guide future multi-disciplinary research on text customisation. Further, pressing areas for exploration are highlighted within the field of text aesthetics for reading.

Keywords: Text, aesthetics, reading, digital, perception



Future of text reading: An aesthetic point of view.

Text reading is arguably one of the most ubiquitous tasks in modern life. From ancient stone carvings to the invention of word processors and the widespread internet adaptation, text has undergone multiple revolutions in its generation, storage and dissemination (Robinson, 2009). Modern digital tools have introduced an era where we have constant access to information, fundamentally transforming how we interact with text. Every text revolution has not only transformed how we interact with text but has also shaped our perception of its beauty and aesthetics.

Text aesthetics refers to the visual and structural elements of text that influence its readability, engagement and emotional impact. These elements include typography, layout, and design, which collectively shape the reader's experience. While much research has focused on the functional aspects of reading, such as to comprehend grammar and interpret meaning, the aesthetic dimensions of text remain underexplored. Yet, aesthetics plays an important role in facilitating comprehension, improving engagement, and evoking emotional responses. Text compositions have an inherent beauty and style associated with them that determines the aesthetics of a reading activity (Page et al., 2017). The beauty and style associated with texts acts as a medium for the prototypical aesthetic judgement (Jacobsen et al., 2004; Jacobsen & Beudt, 2017; Knoop et al., 2016), which facilitates comprehension.

For example, Knoop et al. (2016) demonstrated that readers attribute higher aesthetic value to texts that are 'beautiful', 'imaginative', or 'suspenseful'. These aesthetic qualities were related to more immersive and engaging reading experiences, suggesting a functional role for literary aesthetics in enhancing comprehension and emotional involvement. Similarly, Larson et al. (2017) identified measurable improvements in reader experience when texts were aesthetically optimised. For instance, enhanced performance on creative cognitive tasks and decreased activity in the corrugator muscle, which is typically associated with frowning, suggesting a more positive and fluent reading state. Mendhakar et al. (2025) provide a complementary perspective, showing that the use of text mining-powered graphic organisers significantly improved comprehension among EFL readers, though it did not directly enhance aesthetic appreciation, highlighting a possible boundary between functional and aesthetic textual enhancements.

The importance of text aesthetics has grown in the digital age, where dynamic and customisable text formats have become the norm. Understanding how aesthetic elements influence reading is particularly relevant for designers, educators, publishers and researchers, who aim to create more engaging and accessible reading materials. This paper explores the role of text aesthetics in reading, focusing on its historical evolution, measurement and impact on reading behaviour. By synthesising existing research, this paper provides a framework for understanding text aesthetics and offers practical insights for future text tools and approaches to text aesthetics in reading.

Historical evolution of text and reading

Text has been a cornerstone of human communication for centuries, from rock carvings on walls to modern digitally rendered texts on screens (Brumm et al., 2021; Robinson, 2009). The first major revolution was associated with text production in the 1450s with the introduction of movable types by Johannes Gutenberg, which enabled mass production and standardisation of text (Kinross, 2004). This innovation transformed the accessibility and aesthetics of text by making it more uniform and widely available.



The second shift came in the 1860s with the invention of the typewriter. This further streamlined text production and introduced new possibilities for text aesthetics (Maimon, 2020). Handwritten texts, which were often labour intensive and inconsistent, gave way to printed texts that were more legible and standardised. The emergence of word processors and personal computers in the 1960s initiated a transformative period in which information became accessible at all times and locations, reforming how text was produced, preserved and retrieved.

The late 1990s saw the widespread adoption of the internet, which introduced new possibilities for text digitisation and interactivity. Digital texts have tried to emulate traditional print formats on paper but have also introduced dynamic features such as hyperlinking, multimedia integration, and customisable layouts. These developments have significantly influenced how we interact with text, making it more accessible and adaptable to individual preferences. With each revolution, the perception of text and its beauty has evolved, underscoring the importance of aesthetics in shaping the reading experience. In modern life, for many individuals, text and reading activities are implemented in daily practice, and it is even hard to avoid them (Brinkmann et al., 2023; Chana et al., 2023).

Digital revolution and text aesthetics

The digital revolution has fundamentally transformed how we read, introducing unprecedented convenience, flexibility, and interactivity. This proliferation has brought about significant changes in reading behaviours, with numerous advantages over traditional print, including accessibility, storage, customisation, immersive experience, hyperlinking and multimodal integration (Solak, 2014; Baron, 2017). However, even with the multitude of advantages of digital texts, the supremacy of one over the other is debatable (O'Toole & Kannass, 2018; Mangen et al, 2013; Kurata et al., 2017; Singer & Alexander, 2017; Ebrahimi 2016; Taj et al, 2017; Baron, 2015) and these changes also brought new challenges such as information overload and distraction (Colliot, 2022; Dobler, 2015; Kurelović, Tomljanović & Davidović, 2016). Nevertheless, publishing houses are investing billions of dollars to develop the next iteration of the digital texts. This includes utilisation of machine learning-powered text tools to cater for the fast-changing reading behaviour of young adults. These reading tools assist traditional reading behaviour and add an array of untapped textual possibilities to improve reading (Kuhn & Hagenhoff, 2017).

One of the most significant contributions of digital technology to text aesthetics is the ability to manipulate font parameters dynamically. Typography, which encompasses the design and arrangement of text, plays a central role in text aesthetics. Fonts are categorised into groups based on their style and purpose, such as serif and sans-serif fonts. Serif fonts, with their decorative elements, are often associated with better readability in print, while sans-serif fonts are preferred for digital displays due to their clean and modern appearance (Mackiewicz, 2007; Bernard & Mills, 2000). The amalgamation of machine learning tools and artificial intelligence has made digital text more fluid and manipulable on demand in terms of its aesthetics, such as font, text size, screen contrast, line spacing, and other design choices. These online text aesthetics opens new avenues to improve the reading metrics such as readability of text, comprehension, experiences associated with reading etc.

Font as an example of text aesthetics

The text has an inherent style and beauty, studied as text typography. These textual parameters are manipulated by changing size, shape, colour, and dimensions to form specific text fonts (see Dillon, 2002 and Dyson, 2004 for extensive reviews). Fonts intended for continuous reading are specifically design to ensure that letterforms are as legible and easy to read as possible. Type designers recognise the importance of distinctiveness but emphasise the uniformity of letters (e.g., Carter, Day, & Meggs, 1985; Cheng, 2005). The classical goal of type design is to achieve harmony and balance between individual



forms. Within words, a letter should never stand out; it should cohere with neighbouring letters to better form a word unit and sub lexical units. Type designers constrain the shape of individual letters within a font so that they are related in weight, contrast, and stress, or axis of the letter (Walker, 2008).

In type design, the characters within a single font are aligned using a set of standardised guidelines, including the baseline, x-height, cap height, ascender and descender line, (Baines & Haslam 2005). Although these measurements differ slightly across various fonts, they remain within a limited range, which can cause fonts of identical point size to look either bigger or smaller (Pelli et al., 2006).

Thousands of fonts have been created by manipulation of the above textual parameters (Pollatsek & Treiman, 2015). These fonts are grouped based on similarities in style, structure or purpose dependent on the specific projects ensuring visual consistency and coherence. The popular font grouping describes either serif or sans-serif type among others (Mackiewicz, 2007; Moriarty & Scheiner, 1984; Tantillo et al., 1995; O'Donovan et al., 2014; Shaikh et al., 2006). Serif typefaces are designed for decorative purposes to have better readability and letter recognition while sans-serif fonts are clean and modern, ideal for digital displays (Bernard et al., 2001; Mackiewicz, 2007; Tantillo et al., 1995).

Measurement of text aesthetics

The measurement of text aesthetics has also evolved with the advent of digital tools. Measuring text beauty and aesthetics while reading helps researchers understand how textual elements impact the reading behaviour and how it can be improved. Aesthetic elements such as size, colour, shape, and dimensions can significantly impact readability, comprehension, and emotional engagement. By quantifying these effects, researchers can identify best practices for optimising text presentation.

Various methodologies and metrics are used to measure text aesthetics. Typographic principles, such as font size, spacing, and alignment, are often evaluated using assessments of readability and user feedback. In other cases physiological measures, such as eye tracking (Rello & Marcos, 2012; Hoshi & Menninghaus), facial electromyography (Cacioppo et al., 1992; Dimberg, 1990), emotion (Meyer & Turner, 2006; Ong et al., 2011), mood (Isen, 1987) and event-related potentials (Li et al., 2015), are reported in tandem with reading metrics to estimate the aesthetics perception of text (Doyle & Bottomley, 2009; Juni & Gross, 2008; Karnal et al., 2016; Hyndman, 2016; Sanocki & Dyson, 2012). The reading metrics described includes variables such as reading speed, reading comprehension, reading experience, readability, immersion, comfort of reading, etc. The use of eye-tracking provides insights on how readers interact with text, uncovering patterns of where the eyes focus and underlying cognitive processes (Jacobs, 2015). Self-reported measures, such as surveys and interviews, capture subjective perceptions of text aesthetics, offering insights into reader preferences and emotional responses.

These methods provide a comprehensive framework for evaluating the relationship between text aesthetics and reading behaviour. It can be inferred that the cognitive-affective responses to aesthetic stimuli (i.e., text) are often manifested as a facilitated aesthetic reading experience (Jacobs, 2015; Hoshi & Menninghaus, 2018). By combining objective and subjective data, researchers can gain a deeper understanding of how aesthetic elements are received by a reader and thus influence the (aesthetic) reading experience.

Impact of text aesthetics on reading behaviour

Improving text aesthetics holds the key to significantly enhancing the reading experience, influencing various aspects of reading behaviour. These improvements in reading behaviour associated with text aesthetics are often described with respect to factors such as readability, comprehension, reading



experience, immersion and comfort of reading. This section provides a comprehensive analysis of the relationship between text aesthetics and some of these parameters.

Readability

Readability encompasses various aspects, but this article will limit its scope to the presentation form (e.g., typographical features) rather than including content for our purposes. In this context, readability refers to the ease of recognising the characters of the text. Responsive design for fonts serves as a fundamental approach for digital displays, considering the many screen sizes that exist today. As a result, responsiveness has gained significant popularity in design, notably in web design and typography (Pamental, 2014). Marko Dugonji introduced responsiveness of font sizes in 2013, where the size of the fonts dynamically changes based on the distance between the user and the text. This concept allows for size-specific adjustments to type designs, drawing inspiration from the practices of metal type printing over the past 500 years (Wölfel & Stitz, 2015).

While early digital typefaces predominantly utilised single-master designs and abandoned size-specific optimisations due to the limitations of pixel grid resolution (Mills & Weldon, 1987), the advent of phototype marked a resurgence of typefaces optimised for specific settings.

Building upon this notion, Wölfel and Stitz (2015) created a type design that adapted letterforms based on external conditions, an approach that goes beyond traditional responsible typography. This allows the text to adjust dynamically in response to physical factors such as viewing angle, obstructed sightlines, or other challenges faced by readers. For example, when a reader has difficulty in focusing, the letter shapes can be modified to improve legibility under those specific conditions.

Ease of reading

Readers often prefer a comfortable setting and an uninterrupted experience while engaging with text (Foroughi et al., 2015). This preference is influenced by various factors, including the ease of page-turning, seating posture, and the way a reading device is held (Liu, 2005). Biedert et al. (2010) have explored the use of gaze-based controls for page-turning and scrolling, enabling users to navigate content with minimal physical effort and read extended passages without interruption. Similarly, Rosenberg (2005) developed a gaze-responsive system to assist users in resuming their reading after interruptions. This system incorporated a reading place marker that could be adjusted when the reader's gaze shifted away and automatically removed when their focus returned to the specific section of the text.

Integrating such features can greatly enhance the reading experience by offering improved comfort and uninterrupted engagement (Chu et al., 2004; Pearson et al., 2013). These advancements illustrate the potential of gaze-based interactions in optimizing reading interfaces and creating a more immersive experience. Additionally, research by various authors (Nguyen et al., 2015; Rendl et al., 2016; Slyper et al., 2010; Olberding et al., 2014) has shown that combining smart devices with digital tools can significantly enhance user engagement.

Pace of reading

One of the goals of reading is to increase reading speed, which is commonly measured by the reading rate, representing the number of words read per minute. However, it is crucial to consider comprehension alongside speed, as faster reading is only beneficial if it does not compromise understanding. To investigate the grasp and processing of written language, Rapid Serial Visual Presentation (RSVP) was introduced (Forster, 1970; Aaronson & Scarborough, 1977) to improve reading. The popularity of RSVP led to the development of the product named Spritz® (Castelhano & Muter, 2001). The primary objective of



Spritz® is to optimise text consumption, particularly in limited display spaces such as smartwatches, by accelerating reading speed. The unconventional method of Spritz® presents one word at a time instead of the traditional line-based presentation. Proponents claim that this precise placement of words aligns them exactly where the brain naturally produces a vivid and enjoyable reading experience. This approach aims to streamline text consumption while maintaining or even enhancing comprehension, revolutionising the way we engage with written content.

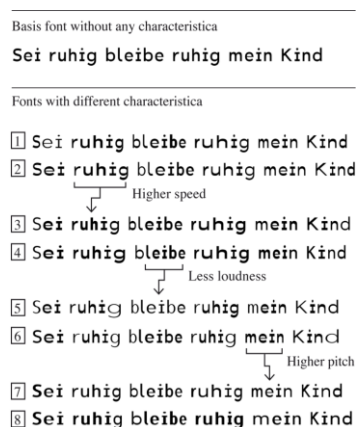
Reading comprehension

Reading comprehension refers to the capacity to read text, process it, and derive its intended meaning. Various methods can enhance comprehension, such as employing grammar and spell checkers to prevent poorly constructed sentences and typos.

The universal usage of emoticons guides us towards another approach to improving comprehension. It involves converting additional features unrelated to text (prosody, emotions, etc) via a visual representation.

Voice-driven typing was demonstrated by Wölfel et al. (2015) as WaveFont. Figure 1 shows a representation of voice-driven typing. This feature enables the text to alter a character's shape based on acoustic properties. Loudness is depicted by the vertical stroke, pitch is conveyed through the horizontal stroke and width reflects the speed. This phoneme-grapheme-based adaptation allows us to capture spoken utterance's characteristics better and preserve individuality within the written text. This strategy is beneficial for subtitling and online transcription industries. Additionally, it can depict intonation and accentuation in language learning materials and guide singing techniques. Please refer to Wölfel, Schlippe, and Stitz (2015) for a more comprehensive technical explanation of Wavefonts.

Figure 1. WaveFont: a visual representation of different speech characteristics (adapted from Wölfel & Schlippe, 2015).



Immersion and absorption

In this context, immersion is a profound mental engagement with something, encompassing a broader scope beyond its association with virtual reality. In the realm of written information, immersion is primarily established through narration. However, additional elements can contribute to immersion, such as ambient lighting (Flettermann, 2002), presentation size (Nijdam, 2006), etc.

Additional research findings (Nijdam, 2006; Wölfel et al., 2013; De Silva & Haddela, 2013) showed that a responsive colour environment can convey emotions and enhance the sense of immersion in addition to



text. The changing lighting conditions may correspond to the emotion in the currently read paragraph, where sadness is represented with yellow and happiness with blue.

Similar findings were reported by Sanchez et al. (2015), who worked with visual, auditory and tactile cues while reading literature. Their findings highlighted that auditory signal has facilitatory effects with visual cues when synchronised effectively. Supporting these claims, studies by Hill and Wölfel (2017) have concluded that auditory signals, only when aligned perfectly with visual information, have an additive effect and can contribute by making the narrative structure more malleable and fostering an increased sense of absorption and immersion.

Interactive reading

The text has moved from static symbols to an interactive essence with the introduction of the digital representation of text. Augmented text can adapt dynamically to reader inputs, such as gaze-controlled interactions (Biedert et al., 2010; Sharmin et al., 2013; Menges et al., 2017; Werchan et al., 2022), touch-based actions, or immersive book features (Bailey, 2019; Papoutsaki et al., 2015; 2017). Functions like gaze-driven page turning, scrolling, and interactive images have proven effective in enhancing the reading experience (Rosenberg, 2005). These approaches demonstrate the potential for leveraging gaze-based interactions and other external inputs from the readers to optimise reading interfaces and promote a more immersive and uninterrupted reading experience (Ngyuen et al. 2015; Rendl et al. 2016; Biedert et al. 2012; Jermann et al. 2010; Chen et al., 2019). While there have been multiple isolated research reports in this domain, a few dedicated projects that promote interactive reading have also been published which includes eyeBook (Biedert et al., 2009), iDict (Hyrskykari, 2006) and AdeLE (Mödrtscher et al. 2006) have garnered research attention.

Future Challenges to Overcome

The transition from traditional print to digital reading has brought about significant changes in how text is presented, perceived, and consumed. Multiple studies highlighted in this paper have been showcased as conference papers, prototypes, and artworks, demonstrating the potential of innovative methods to transform text presentation for larger audiences. With these methods, changing how text is presented and perceived is possible, particularly as we are witnessing a gradual shift from reading on paper to reading on screens. This shift is driven by the increased consumption of news, entertainment, and information through computers, tablets, and smartphones.

Nevertheless, this shift does not necessarily imply that digital devices have surpassed the advantages of print. Despite the advantages of digital reading, such as accessibility and interactivity, paper-based technologies continue to dominate in certain domains, particularly in publishing. Major publishing houses have embraced the digital reader trend and invested heavily in developing digital reading solutions. These efforts aim to replicate the tangible elements of printed books in digital formats, ensuring a comparable, if not superior, reading experience (Burstyn & Herriotts, 2010; Lahey et al., 2011; Watanabe et al., 2008). With the advent of faster microchips and machine learning algorithms, present-day digital reading solutions can more than mimic text on screens. Coupled with text mining tools, digital text can achieve functionalities that were previously impossible with physical books (Prensky, 2013; Reinking et al., 1998; Rideout et al., 2010).

Challenges: Research community

Despite these advancements, several challenges ought to be addressed to realize the full potential of text aesthetics in digital reading. One of the primary challenges lies in the research community, where



introducing innovative text presentation methods requires a multidisciplinary approach. However, collaborative research in text augmentation has been limited, and fields such as typography, cognitive science, and digital design must work together to develop new frameworks and methodologies. Professionals like software designers, engineers, and artists can work collaboratively to create new ideas unburdened by tradition and preconceptions. Such collaboration is essential to push the boundaries of what is possible in text aesthetics.

Challenges: Libraries and toolkits

Another challenge is the lack of comprehensive and user-friendly libraries and toolkits that can facilitate the widespread adoption of aesthetic optimisation tools. These libraries should offer accessible applications for content preparation, generation and easy distribution. For instance, the development of a gaze-based responsive library (Biedert et al., 2010) deployed as an open-source web application has sparked a multitude of research in gaze-based interaction. Expanding such initiatives can enable researchers and developers to explore new possibilities in text aesthetics, making it easier to integrate these advancements into practical applications.

Challenges: Developers

Developers also face challenges in adapting to the evolving demands of augmented text representation. Developing new text elements is a deeply ingrained practice that has evolved over centuries, but the shift to digital media requires adaptation and re-evaluation. It is crucial to educate developers and content creators about the new possibilities and encourage them to explore new ways of utilising these advancements for positive purposes. Mere adaptation may not be sufficient; authors, for instance, need to learn how to craft interactive stories with animation and audio, which can be challenging when adapting existing narratives. This requires not only technical expertise but also a willingness to experiment with new storytelling formats.

Challenges: Companies

Large institutions, such as publishing houses and technology companies, are often cautious when it comes to the implementation of new technologies that might hinder their business models. However, key publishers, such as Kindle Direct Publishing (KDP), Pearson, and Penguin Random House are beginning to recognise the future of innovation in text. These companies are gradually allocating significant portions of their budgets to develop and implement future technologies for text, ensuring that digital reading solutions remain competitive and user-friendly. Their investments highlight the growing importance of text aesthetics in shaping the future of reading.

Challenges: Sluggishness of users

Finally, readers themselves can be a barrier to the adoption of new technologies. Many readers are reluctant to invest effort in learning how to enhance their reading quality, a phenomenon associated with the “paradox of the active user” (Carroll & Rosson, 1987). This suggests that users often prefer to use systems without tutorials even if it means sacrificing long term benefits. To overcome this challenge, developers must design intuitive and accessible systems that minimise the learning curve while maximising the benefits of aesthetic optimisation. By creating user-friendly interfaces and providing clear value propositions, developers can encourage readers to embrace new technologies and improve their reading experiences.



In summary, while the digital revolution has opened new avenues for text aesthetics, overcoming these challenges will require a concerted effort from researchers, developers, companies and users. By addressing such barriers, the full potential of text aesthetics can be unlocked and create more engaging, accessible, and innovative reading experiences.

Summary

The advancements in digital technology has transformed how text is created, engaged with, and consumed. From the advent of word processors to the widespread adoption of digital devices, these advancements have introduced new possibilities for text presentation and interaction. Even though there are clear merits of digital tools over traditional paper-based formats, such as accessibility, interactivity, and customisation, their acceptance is not yet fully embraced. Nonetheless, reading remains a crucial skill that is used and mastered by people. Text data possesses a unique ability to integrate various data formats, allowing it to generate rich and meaningful communicative outputs. However, it also has inherent limitations that must be addressed.

By challenging the current status of text and developing newer interactions with it, the full potential of text can be harnessed, and the current drawbacks of reading can be overcome. The integrations of aesthetic elements into text design is not merely a superficial enhancement but a critical factor in improving readability, comprehension and engagement. These elements allow text to transcend its functional role, becoming a medium that evokes emotions, fosters immersion, and enhances the overall reading experience.

In essence, to expedite the changing sphere of reading, the benefits of augmentation must be apparent, the adaptation process must be minimally demanding, and the perceived comfort should not be diminished. People have varied experiences and expectation, implying their customisation to the individual user and their reading behaviour is the future direction we should focus on. Rather than pursuing a 'one-size-fits-all' solution for every use case, the aim should be to promote diversity, allowing different systems (often unconventional ones) to coexist alongside each other, much like other forms of media. Additionally, the purpose of the content might determine the viability of specific cases. The hardware infrastructure for digital reading is already widely accepted, making the introduction of new formats feasible through straightforward software updates rather than costly solutions.

The current status of text and its potential must be challenged by professionals in order to facilitate future development. Compelling solutions are required to unlock their full potential. By doing so, scenes, settings, characters, moods, emotions, and even the most minor actions within a story can be more vividly experienced. This offers a creative and innovative medium, enabling authors to enhance their narratives and unlock new avenues for literary expression.

In conclusion, the future of text reading lies in the seamless integration of aesthetics and functionality. By addressing the challenges outlined in this paper and fostering interdisciplinary collaboration, we can ensure that text continues to evolve as a dynamic and versatile medium. The thoughtful application of text aesthetics will pave the way for more inclusive, engaging, and innovative forms of communication in the digital age.



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2.2. Field study investigations

2.2.1. Field investigations: aesthetic reading experiences in urban everyday settings



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My Contribution:

The authors' contributions as requested in Frontiers in Psychology:

KC and HL contributed to the design of the study. KC and AS were responsible for data collection. KC and JM analysed and interpreted the data. KC, JM, and HL drafted the manuscript. All authors contributed to the article and approved the submitted version.

2.2.1.1. Key findings

- We provide first evidence for the prevalence of reading, with more fixations made towards text signs compared to other objects across two street settings.
- We investigated the relationship between viewing behaviour and the aesthetic qualities of text signs, but did not find that the more aesthetically valued texts yielded longer fixation times.
- The more aesthetically valued texts were better recognised in a memory performance task.

2.2.1.2. Original Manuscript

(see next page)



Reading in the city: mobile eye-tracking and evaluation of text in an everyday setting.

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Data availability statement: The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: <https://osf.io/ajr48/>.

Ethics statement: Ethical approval was not required for the studies involving humans because ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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Abstract

Reading is often regarded as a mundane aspect of everyday life. However, little is known about the natural reading experiences in daily activities. To fill this gap, this study presents two field studies ($N = 39$ and 26 , respectively), where we describe how people explore visual environments and divide their attention toward text elements in highly ecological settings, i.e., urban street environments, using mobile eye-tracking glasses. Further, the attention toward the text elements (i.e., shop signs) as well as their memorability, measured *via* follow-up recognition test, were analysed in relation to their aesthetic quality, which is assumed to be key for attracting visual attention and memorability. Our results revealed that, within these urban streets, text elements were looked at most, and looking behaviour was strongly directed, especially toward shop signs, across both street contexts; however, aesthetic values were not correlated either with the most looked at signs or the viewing time for the signs. Aesthetic ratings did however have an effect on memorability, with signs rated higher being better recognised. The results will be discussed in terms aesthetic reading experiences and implications for future field studies.

Keywords: Book covers, Fiction, Memory, Cognitive studies, Aesthetic evaluation, Reading behavior



Reading in the city: mobile eye-tracking and evaluation of text in an everyday setting.

In everyday life, perception is a powerful tool that guides us through our complex environments and, by controlling our attention, directs us toward relevant, interesting events and objects ([Bruce et al., 2003](#); [Clarke et al., 2013](#)). In a figurative sense, the way in which people engage with and assimilate their surroundings requires what can be regarded as ‘reading the city,’ highlighted in *The Image of the City* ([Lynch, 1960](#)) to denote how the urban environment is perceived ([Silva Gouveia et al., 2009](#)). This also includes the ability to locate and deduce meaning from visual elements in everyday settings (i.e., taking notice of directions or road signs while navigating toward a destination), i.e., ‘everyday reading.’ Reading thus extends beyond the literary context and instead could be considered more a cognitive sub-skill of visual exploration and understanding the environment.

In a narrower sense, and also as the essence of signs for reading, text in today’s urban environments is omnipresent - it is almost, if not, impossible to walk through a city without reading. Reading text can be regarded as one of the most outstanding features that make us human, and in most cases, when we are exposed to text, cannot be avoided ([Jean, 1992](#); [Robinson, 2009](#)). From a literary perspective, reading involves decoding characters or symbols, identifying them as words, and subsequently interpreting their meaning ([Findlay and Gilchrist, 2003](#)). As such, it is clear that reading text is a key requisite in daily affairs, and our urban civilizations are inundated with written information, so much so that we are perhaps gripped by its consumption ([Robinson, 2009](#)).

Nevertheless, despite the importance and relevance of reading in our daily lives, the sheer number of reading experiences encountered by an individual on a daily basis in ecologically valid settings (e.g., street environment, etc.) is often overlooked, and little is known about how reading is meaningfully distributed in our lives. A possible reason could be the difficulties of performing such observational studies in highly ecologically valid settings, which requires many resources (e.g., devices to measure participants’ attention, inviting participants to a testing place with enough experimenters, etc.). However, although this is a challenging task, it is important to describe and understand how people actually divide their attention in a natural context, as the testing contexts here (e.g., well-controlled laboratory, complex urban street environments) might play a crucial role.

In the current paper, through two field studies, we present a first step to bridge this gap. Specifically, we investigated *how* people divide their attention to readable objects of any kind, while they freely walked around an urban street environment, and specific reading occurrences (i.e., toward shop signs), using mobile eye tracking devices to record eye movement patterns of participants. Furthermore, we also aim to investigate *what* is important for text to capture one’s attention. More specifically, we focus on how aesthetic values in texts in everyday life affect our perception in terms of attention measured *via* viewing time (e.g., do more beautiful signs receive longer looks than less beautiful ones?) as well as its memorability (e.g., do people remember more beautiful signs better than less beautiful ones?).

In the following section, we first provide a general overview of how reading/reading behaviour in everyday life has been studied in psychology and in other fields. Secondly, we argue how visual aesthetic qualities can be related to and impact reading. Finally, we present two field studies in which we assess the relationships between real-world scene-perception, reading behaviour, aesthetic appreciation, and memory.



Studies of everyday reading in the field of psychology

The decision of where to look is imperative in the undertaking of many everyday activities. With an average of three fixations made per second ([Cristino and Baddeley, 2009](#)), this is a task we must do incessantly. Naturally, our gaze is guided by our surroundings and potential obstacles when walking, in relation to the principal goals of locomotion; i.e., to walk safely from one location to another ([Warren, 1998](#)). However, when people are able to walk freely in a space with no obstructions, there is a possibility for gaze to fall upon other items that are present within the peripheral field. In the context of urban settings, this can be guided by the intention of walking along a city street (e.g., leisure, shopping, orientation), or even a lack of purpose. The latter is apparent for the flâneur, a person who wanders aimlessly, ‘mapping their surroundings with their feet’ as a means of creating a ‘meaningful experience with the city’ ([Elkin, 2017](#)). At first, it seems such an act would result in one becoming lost in a metropolis, but in fact [Lynch \(1960\)](#) noted it is a rarity to be completely disoriented within built environments. This is arguably since legibility and wayfinding are important features in city design, to the extent that we are bombarded with a myriad of wayfinding devices. These are information systems with textual and graphic sign elements that contribute to our identity with (sense of belonging), understanding, and experiencing of the city ([Lynch, 1960](#); [Bauer and Mayer, 2008](#); [Huerta, 2010](#); [Harland, 2015](#); [Clark et al., 2017](#)).

In fact, there have been a few studies where researchers examined how people divide attention toward texts compared to the other components. For example, research in scene viewing has demonstrated that text generally does draw visual attention. [Cerf et al. \(2009\)](#) found, relative to objects of a comparable size and location, text and faces attracted more attention. [Wang and Pomplun \(2012\)](#) conducted a series of laboratory experiments to consider the attraction to text in images of real-world scenes. They found text drew more attention than non-text objects and control regions. Furthermore, in the field of marketing, print advertisements also highlight brand, pictorial and text elements as key to capturing attention, with text arguably being the most central ([Ogilvy, 1985](#); [Belch and Belch, 2001](#); [Pieters and Wedel, 2004](#)).

It is worth noting, however, that such laboratory-based studies lack ecological validity. Indeed, laboratory experiments are important to assess the impacts of target factors while controlling confounding factors. However, to understand how people are dividing their attention to objects in urban scenes, the ecological validity in the testing setting seems to be crucial. In a laboratory setting, one might have looked at still images containing a limited number of items while seated. Yet, the actual interaction with visual stimuli in natural (i.e., real life) urban scenes is obviously far more complex. In a natural urban scene, there are not only multiple forms of text present, but also the text contends with a multitude of objects for attention, while the observers are moving around with more physical freedom and flexibility - a setting very different compared to that of a well-controlled laboratory study. Further, as aforementioned, while study participants tend to engage in specific tasks in a laboratory, actual pedestrians can have very different purposes for engagement in urban settings, which can also impact where, what, and how to search the environment ([Droll and Eckstein, 2009](#)). As such, the results delivered from oversimplified situations in a laboratory setting probably do not reflect the actual behavioural patterns in a real-life setting.

Hence, although past literature demonstrates the potential of text to capture our visual attention more than other components, in order to describe how the text attracts our attention in a real urban environment, it is quite important to observe natural behaviour in a highly ecologically valid setting, which has been rarely assessed in the past literature. In the present paper, we tackle this limitation by conducting field studies in real urban settings, using mobile eye-trackers to describe participants’ visual attention, and assess how people divide their attention toward text elements in a real urban environment amongst the other visual elements.



Aesthetic viewing in everyday settings

The matter of *what* determines the attentional guidance to text remains a topic up for debate. In relation to attentional processing, image-related features that are highly salient (i.e., colors, contrast, etc.) capture attention in a bottom-up fashion ([Janiszewski, 1998](#); [Itti and Koch, 2001](#)). For example, the text element's relative size is a possible saliency feature that captures attention in this way ([Janiszewski, 1998](#); [Pieters and Wedel, 2004](#)). However, such studies do not provide a complete overview and often ignore some features from the reading literature. One candidate not addressed so far is the aesthetic quality of the text elements. Like any other designed visual object, text elements can elicit different aesthetic experiences, such as beauty.

Aesthetics¹ have been shown to influence how we direct our attention in our environment, with aesthetic liking eliciting longer viewing time ([Shimojo et al., 2003](#); [Holmes and Zanker, 2012](#)). On this basis, our sense of beauty guides what we experience by determining where we tend to look – and what binds our looks. This is in line with research which argues that visual attention is not necessarily directed to low-level features,² but toward task-related areas in a scene that provides the greatest meaning or informational value ([Itti, 2005](#); [Torralba et al., 2006](#); [Einhäuser et al., 2008](#); [Kollmorgen et al., 2010](#); [Pilarczyk and Kuniecki, 2014](#); [Wu et al., 2014](#); [Henderson and Hayes, 2018](#); [Peacock et al., 2020](#)). From this perspective, considering that the aesthetic experience provokes complex psychological processes, such as meaning making and memory integration ([Leder et al., 2004](#); [Pelowski et al., 2016](#) for review), it seems theoretically plausible to postulate that texts, which are high in aesthetic experience, might also capture our attention more.

Similar findings are shown in other domains of research. For example, preferred faces and artworks have been shown to bind visual attention ([Shimojo et al., 2003](#); [Leder et al., 2016](#)). Such studies have implemented a free-viewing paradigm, which involves looking at stimuli without a specific task, and have shown that aesthetically preferred objects (as indicated in follow-up evaluations) bind visual attention. Using this design, images were presented of natural everyday scenes that depicted two people, with the more attractive faces evoking longer looks ([Leder et al., 2010, 2016](#)). Similar effects had also been shown for artworks ([Goller et al., 2019](#); [Mikuni et al., 2022](#)), or more beautiful images ([Mitrovic et al., 2020](#)) of the visual aesthetic sensitivity test.

Interestingly, the attention toward stimuli that are high in aesthetic experience has been demonstrated not only in the laboratory but also in a field study with a more comparable situation to that of our study. [Mitschke et al. \(2017\)](#) examined viewing behaviour, in an outdoor natural environment, during a free exploration walk along a canal pathway containing art/aesthetic objects, e.g., graffiti or sculptures. Similar to the findings from laboratory studies, individual aesthetic evaluations (i.e., liking, interest) of objects within the natural setting were positively correlated with the total fixation durations. Thus, even in such an everyday environment, in which there are many visual stimuli, and subsequently great individuality/variability in viewing behaviours, the beauty of objects played an important role in how people direct their looks.

In this light, perhaps also viewing behaviour in everyday reading could be related to aesthetic quality/preference. Accordingly, in the present study, we assess how subjective aesthetic quality of the text elements and viewing behaviour (i.e., amount of divided attention, viewing time) are related.

¹ [Shimamura \(2012\)](#) states aesthetics has generally been associated in regard to art inducing an emotional response. However, this encompasses more than artworks and in the broader sense refers to an array of objects that can be considered for their beauty. Further, [Baumgarten \(1750\)](#) notes the physical features of an object can elicit a sense of beauty, which comes about as a result of an aesthetic experience.

² With regard to the conspicuousness of viewing scenes, research has explored image saliency with regards to how low-level features (e.g., colour, contrast, luminosity, orientation, etc.) predict viewing behavior (see [Einhäuser and König, 2003](#); [Itti, 2005](#); [Tatler, 2009](#); [Hayes and Henderson, 2021](#)).



Real world memory and visual attention

An essential purpose of text is the preservation of information ([Jean, 1992](#); [Jaderberg et al., 2016](#)), therefore it is not only what text people look at in natural scenes that is of interest, but also whether they remember it. Despite its fundamental functions in urban environments, research exploring memory and vision is rarely carried out in environments with greater visual complexity. This is despite the intuitive suggestion that more natural stimuli will have a stronger memory trace when viewed for greater lengths of time ([Irwin and Zelinsky, 2002](#); [Melcher, 2006](#)). As such, the question of what enhances the memorability of the texts remains open and warrants further investigation.

Past studies have suggested attending to elements of a scene is essential for the encoding of a representation ([Hollingworth and Henderson, 2002](#)), meaning it is possible that longer looks give rise to improved memory. Following our arguments from the previous section, it seems plausible to postulate another relationship between aesthetic quality and texts elements; that is, if longer looking times are found for more aesthetic and more beautiful objects, and longer looks enhance the memorability of the items, then higher aesthetics might result in higher memorability (e.g., when one finds a text element more beautiful, it would be remembered better than less beautiful ones). Accordingly, we also assess how the subjective aesthetic quality of the text element and its memorability are related in the present study as well.

Present study aims and hypotheses

The current paper focuses on the engagement with reading the environment in a naturally-occurring urban street setting. We especially aim to study viewing behaviour toward text in an everyday setting, given that previous studies (in labs/real-world scenes) suggest text inevitably captures attention, yet were lacking ecological validity. Owing to the situation of carrying out studies in natural outdoor environments, it was not feasible to actively control/manipulate the testing environment in the current studies. As such, an exploratory approach was undertaken with broader objectives in order to describe natural reading behaviour in an ecologically valid setting and its relation to aesthetic value.

In the present paper, we set three distinct research questions: (1) What is the prevalence of reading? (2) How does viewing behaviour correlate with the aesthetic qualities of text? (3) What are the effects of text differing in aesthetic quality on memory? We addressed these questions in the two studies with the following hypotheses corresponding to each research question: (1) As shown in the past literature, in real-world walks in urban environments, more fixations would fall toward signs and text compared to the other visual objects in the testing environment; (2) In evaluating the major visual elements for aesthetic preferences, more aesthetically valued texts also yield longer fixation times; (3) Based on the reported relationship between aesthetic experience and viewing time as well as between memorability and viewing time in the past literature, we hypothesise that more aesthetically valued texts are better recognised.

To address our three research questions and test our three hypotheses, two field studies in different urban street environments were conducted. Study 1 considered viewing behaviour of text across a section of the Mariahilferstraße shopping street in the 6th district of Vienna. This section forms the beginning of a pedestrianised shopping area which is popular amongst tourists and locals. Mariahilferstraße is a very busy shopping street, with a greater number of shops, advertisements, and buildings with busy traffic. The street is also lined with trees and largely pedestrianised, therefore there is presumably a higher propensity to view nature and people. It can therefore be considered as an everyday urban environment, which can be found in many different cities and countries, and in which various forms of text, as well as a variety of other objects, have the potential to capture one's attention. Such testing



environment was especially suitable to test our first research question: What is the prevalence of reading *amongst other available objects*? The first study also served as a proof of concept, that our methods can reasonably be employed to test our hypotheses. Study 2 also considered the viewing behaviour of text across a section of the Siebensterngasse, wherein the circumstances were thought to be quite different than in Study 1. The second street represented a supposedly more mundane street, in that it is not pedestrianised and comprises a selection of shops, cafes, and public transport representative of the average Viennese street (see [Furchtlehner and Lička, 2019](#); [Furchtlehner et al., 2022](#)), and thus also a higher propensity to view traffic and people as a reflection of the specific street (e.g., [Geruschat et al., 2003](#)). By conducting similarly structured field studies with two urban streets, which differ in terms of street characteristics and available objects, we aim to also test the generalizability of reading behaviour, and to report, if any, possible differences as a reflection of the specific street.

We note our focus in the present studies is on reading behaviour in the street environment in general (e.g., attention toward advertisement, traffic/shop signs etc.). However, especially to examine the relationship between viewing behaviour/memorability and aesthetic quality in texts, we explicitly focus on the shop signs. This decision was made, as in our testing streets, there are a variety of shop signs, which would result in a variety of aesthetic qualities in texts, while there seem to be less variety in other types of texts.

Study 1

Materials and methods

Participants

A sample of 39 participants (26 female, 13 male; Mage = 24.25, SDage = 3.60, range: 19–32 years) were recruited via the University of Vienna. The average height of the participants was 172.35 cm (SDheight = 8.66, range: 155–187 cm, two missing due to recording issues). One participant used a wheelchair, however could not be included in the eye-tracking analyses due to data loss (detailed further in Data Preparation section). All participants included in the analysis had normal or corrected vision and were native German speakers. Anonymity was guaranteed with the use of personal identifiers, and participants received monetary compensation (10 €). The study corresponds with the ethical standards of the Declaration of Helsinki and the ethical regulations at University of Vienna. For more detail regarding participant information refer to OSF.3

Apparatus

The Pupil Labs wearable eye-tracking headset (Pupil Core) was utilised to track the eye movement patterns of the participants during their walk. The portable glasses are equipped with three adjustable cameras to record each of the participants' pupils (Eye Camera, 200 Hz, 192x192px) and the outer environment (World Camera, 30 Hz), to monitor where individuals are looking. The eye-tracking data was collected on a Windows Microsoft Surface Pro 4 tablet, running the software EyeRecToo (see Santini et al., 2017a; Reitstätter et al., 2020). Calibration was administered with a single ArUCo marker with a spiral movement pattern, as suggested in CalibMe (Santini et al., 2017b). This uses numerous calibration points, with the spiral movement allowing the wearer to change the spatial distance and head angle for better gaze estimation within a mobile setting.

Setting

A 250 m section of Mariahilferstraße was chosen for the eye-tracking path. The start point was set at Mariahilferstraße 31 (48.2004918,16.3573532; 6,924 + 6X Vienna) and the endpoint was set at



Mariahilferstraße 7 (48.20118,16.359881; 6,926 + C2 Vienna), where the ‘BIPA’ drugstore is located, which marks the point at which the street begins to curve so that further road traffic and more distant landmarks at Museumsquartier can be seen (see [Figure 1](#)). Further, although this part of Mariahilferstraße is not completely pedestrianised, only one small side street (Königsklostergasse) without any specific road markings fell within this 250 m path, which meant there would be minimal traffic interfering with the eye-tracking path. Given this portion of the street is on a slope, participants walked both uphill and downhill, as it was not apparent which direction was best or would elicit better/different viewing behaviour.



Figure 1. OpenStreetMap image, depicting the eye-tracking route along Mariahilferstraße 31 to 7 in Vienna’s sixth district. The images denote the start (A) and finish (B) positions along the eye-tracking path.

All recordings took place when the street was less busy and the majority of stores were still closed. It is, however, noted there was extensive construction work on the opposite side of the street, which progressively moved further within the testing section of interest and could potentially have caused a marked difference in viewing behaviour. Though, given this was a field study and external variables cannot be controlled, this was accepted as another distractor as there were many other facets that meant there was variation in the street conditions for each participant (i.e., different people, new graffiti).

Eye-tracking procedure

Testing took place in 2 week blocks across two waves, in June and September 2021. Eye-tracking data was collected across all days during this period (Monday to Sunday, between 8 am-10 am) to cover any notable differences to the environment across the span of a week. The general street setting was the same during this timeframe, but four particularly noticeable changes within the environment occurred: (1) escalation of construction work, (2) one store that had been vacated, (3) billboard advertisements that had been replaced, (4) prominent graffiti across the external wall of the Starbucks store (see [Supplementary Table S1](#) for detailed descriptions). Participants were tested in two blocks but testing



was stopped abruptly after 39 participants due to extensive construction work, which meant further testing was not feasible.

Upon arrival at the testing site, participants scanned a QR code with their mobile device to read the information sheet and electronically provide informed consent. Participants then provided an identifier and anonymized demographic information. After completing this, the eye-tracking glasses were set up and adjusted. Once the eye-tracking glasses were calibrated, participants were led to the starting point and given verbal instructions. Since this was a free-viewing paradigm, participants were not given a specific task and instead were instructed to walk along the path at their natural pace. This method was chosen since eye movements are influenced by the task at hand ([Buswell, 1935](#); [Land and Tatler, 2009](#)). Therefore, without a specific task instruction, we expect viewing behaviour will be as natural as possible. They were informed they could move their head freely without restrictions and to raise their hand should they require help/feel discomfort at any point during the walk. The instructions were chosen to be as unconstrained and natural as possible, but to still ensure all participants would walk along the same path. As such, participants were unaware of the true purpose of the study, i.e., reading/observation of text and test of memorability. Participants then walked along the path, and an experimenter followed behind at a distance (approx. 3 m). At the endpoint, the experimenter stopped the recording, asked if the participant had any questions, and, after a short break, proceeded with recording the participant as they walked in the opposite direction. The side of the pavement and direction of the eye-tracking path (from A to B, then B to A) remained the same across all participants. When the participants returned to the original starting point, the eye-tracking session was concluded.

Participants were then seated facing away from the recorded section of the street and a post-viewing questionnaire was administered *via* a QR code. Here participants provided responses to open recall questions regarding what they noticed, remembered most clearly, liked and disliked. They also reported on 5-point scales (1 = not at all, 5 = very much) how much they liked, how familiar they were with and how often they visited the section of the street. Finally, they were asked if they would visit the section again in their free time and how comfortable they found the mobile eye-tracking glasses. Participants were then reminded they would be sent a further questionnaire to complete online *via* email within a 1–2 weeks timeframe.

Follow-up session procedure

All participants were sent a further questionnaire to complete online 1–2 weeks after the initial in-person eye-tracking session. Firstly, participants performed a recall task, where they provided open-ended responses for any shop signs, architecture, street signs, people, advertisements, nature and text elements they remembered seeing from the eye-tracking walk; i.e., ‘Do you remember any shop signs that you saw during the walk?’ (translated from German). We note that participants’ open responses to the memory recall questions are not analysed in this paper as this was included exploratively to inform further study. For more detail regarding open recall refer to OSF (<https://osf.io/ajr48/>).

Secondly, participants performed recognition and rating tasks for the 40 photographs provided. Twenty photographs were taken of text sign elements from the eye-tracking path, and additional twenty photographs containing text from other areas within the city streets, which were used as distractors in the memory task.¹ All photos were taken in landscape format with a ratio of 19.5:9 on a mobile phone camera (Huawei Mate40 Pro). Photos portrayed text from shop fasciae/signs and were selected at random from a larger corpus of images photographed from both directions of one side of the street. Though restricted to the text elements were present within the testing environment, we chose to focus on text signs due to the high prevalence and variation of shop signage within the street environment. We also reported such variations in terms of physical features (e.g., size, height, position, number of characters) (see [Supplementary Table S2](#)). For the recognition task, participants were asked to indicate whether the



photographs of text elements from street scenes presented were from the eye-tracking path (yes/no dichotomous response). Participants also rated all 40 photographs for subjective aesthetic judgement on 7-Point scales, which are commonly used in empirical aesthetic research (beauty, interest, meaningfulness, likeability, attractiveness, emotionality, familiarity). The commonly used scales in empirical aesthetic research were adapted in the current study, as those scales, measuring aesthetic experiences, were not used in the past related studies of reading, and hence, there are no specific established findings in this regard. As such, all common scales are adopted not to overlook any possible effects of aesthetics in texts on viewing behaviour/memorability.

Afterward, participants completed a language history questionnaire (LHQ v3.0; [Li et al., 2020](#)), to see if participants have similar levels of reading ability and more exploratively, provide insight about their language use. In the LHQ, they reported demographics about their native language(s) and languages they had learned, as well as ratings of their proficiency in terms of reading, writing, speaking and listening (i.e., 7-point scale; 1 = very poor, 7 = native-like). Upon completion, participants were debriefed, thanked for their participation. We note the LHQ was asked to the participants for more explorative purpose, i.e., to develop further study ideas for future studies, and to analyse this data in relation to viewing behaviour and aesthetic was beyond the scope of the present study. Hence, the results are not reported here.

Data preparation

The data for participants with complete eye-tracking video material was included for this analysis. With this criterion, the final sample of 25 (16 female) were included in the eye-tracking results below, reduced from an initial collection of 39 participants. Given the technical challenges faced with automatic labelling the eye movement data for the field camera footage, like [Reitstätter et al. \(2020\)](#), a manual approach was adopted using the software Eye Movement Coder (version 2.4). In this manner, frame length was used as a proxy of viewing time. This required looking at each video, on a frame-by-frame basis (33 ms per frame), and marking the start and end times for viewing specific objects of interest, in accordance with predefined labels for broad categories, similar to [Mitschke et al. \(2017\)](#) (see [Table 1](#)), and the 20 specific sign labels from the eye-tracking path³. Although a more laborious task, this allows objects of interest to be coded when partially occluded (i.e., when a text sign overlaps with another). These annotations were labelled by two researchers individually. Two videos were doubly checked to ensure consistency in the labelling and a unanimous decision was made for any annotations points where uncertain. On this basis, we were able to determine viewing time for object categories and sign labels (measured *via* frame length) as well as the frequency of fixations (i.e., multiple looks). Following from the manual annotations and data extraction, the eye-tracking data was then analysed with R environment (Version 1.1.423. R Development Core Team) using dplyr package ([Wickham et al., 2023](#)). Note that all analyses reported below were performed in the same R environment.

³ These materials are available upon request from the corresponding author.



Table 1. Predefined object categories of interest for eye-tracking coding.

Category	Subcategories
Advertisements	Billboards, Posters, Sale Signs, Special Offers
Animals	Dogs, Pigeons
Architecture	Balconies, Facades, Ornate details, Windows
Graphic elements	ATM sign, Logo, Symbols
Nature	Bushes, Grass, Potted Plants, Trees
Other text	Graffiti, Plaques, Stickers
People	Adults, Children
Shop signs	All shop signs (Fascia/Hanging Signs)
Street signs	Bus signs, Road signs, Traffic signs, Tram signs
Traffic	Bicycles, E-Scooters, Scooters, Trams, Vehicles

For Study 2, 'Animals' was included, and 'People' were sub-divided by body/face.

Importantly, across the two studies in this paper, we only used fixation data points that were longer than 200 ms (i.e., where one frame is 33 ms, we removed fixations with a frame length of less than 6). Although minimum fixation duration is often set much lower at 100 ms as threshold that distinguishes between saccades and fixations, we adopted this more stringent fixation criteria ([Salvucci and Goldberg, 2000](#); [Deane et al., 2023](#); see also [Supplementary Table S3](#); [Supplementary Figures S1, S2](#)) given there appears to be no clear consensus in past literature (for more extensive overview, see [Holmqvist et al., 2011](#); [Bojko, 2013](#)). Overall, 8,530 fixations were made in entire recording. The number of fixations made by individual participants ranged from 123 to 609. The total time of the annotated videos was 1 h 57 min 20 s. Moreover, the guidelines for fixation criteria are often set from stationary eye-tracking data, and there is much less in regard to mobile eye-tracking, especially in field environments ([Kiefer et al., 2014](#)). This results in, out of 8,530 fixations, 1,381 fixations, which were included in the main analysis below.

Results

All of the data reported in Study 1 and 2 is available on OSF (see footnote 3). Prior to any further analyses, we calculated the average scores for information regarding the street location (5-point scales; 1 = not at all, 5 = very much) for the 37 participants in the final sample. Note that data from two participants were removed due to recording issues. This included participants' liking ($M = 3.81$, $SD = 0.81$), familiarity ($M = 3.84$, $SD = 1.14$) and frequency ($M = 3.19$, $SD = 1.05$) of visiting this section of the street. Further, we asked if participants would visit this part of the street again; No = 7, Yes = 30. Additionally, the scores for comfort of the glasses were assessed on a 5-point scale (1 = not at all, 5 = very comfortable) to evaluate how natural wearing the mobile eye-tracking glasses felt to the participants. The average score for this question was 4.24 ($SD = 0.80$), and thereby, for the interpretation of the results, it was assumed the participants' viewing behaviour was not constrained by wearing eye-tracking glasses and could be included in the analysis.

The number of fixations per object category.

Firstly, to test our first research question: 'What is the prevalence of reading?', we analysed which objects captured attention proportional to overall viewing time, and how many of these fixations fall toward specific signs and text more generally. To this aim, the total amount of fixations toward each category across all participants (%) were calculated (see [Figure 2A](#)). We note, since the results of the number



fixations per object category should be compared visually between Study 1 and 2 to see the generalizability of our findings in different street environments, the results of Study 2 in this section are presented together with those of Study 1. As shown in [Figure 2A](#), 70% of the total fixations fell into Shop Signs (26%), Nature (23%), and People (21%). The remaining 30% of total fixations fell toward Advertisements (11%), Other Text (5.9%), Architecture (5.4%), Traffic (4.5%), Graphic Elements (3%) and Street Signs (0.22%). Thus, our results show Shop signs are the most viewed component which people are paying attention to while walking street.

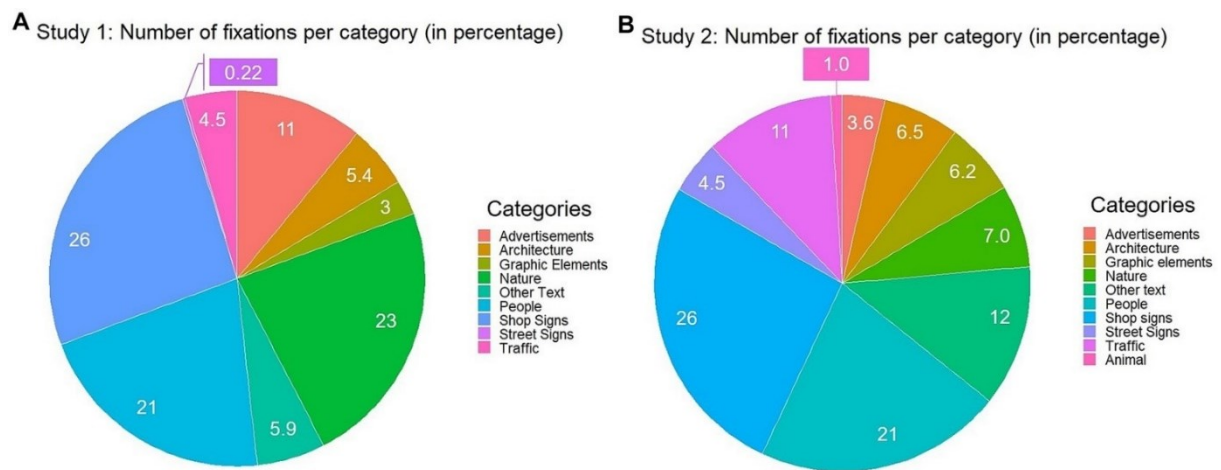


Figure 2. (A) Pie chart using all fixations made by all participants from the results of Study 1. (B) Pie chart using all fixations made by all participants from the results of Study 2. The number shown in the chart represents the percentage of fixations that fell into the given category.

Further, to see inter-individual differences, the percentage of the fixations on each category per participant was calculated ([Figure 3A](#)). The descriptive statistics for the percentage of the fixations are presented in the upper part of [Table 2](#). The descriptive statistics were calculated as follows. First, the percentage of the fixation per category was calculated for each participant. These values per participant were then used to calculate the mean percentage of the fixation per category. In case one did not make any fixation on one object category, we used 0. Seeing [Figure 3A](#); [Table 2](#), not surprisingly, people divide their attention quite differently. For example, there were only three participants who made fixations on Street signs, while the other participants did not make any fixations at all. Similarly, almost only half of the participants made no fixations on Architecture and Graphic elements. This inter-individual difference can be also seen in large standard deviations (*SD*) for the mean percentage of those categories ([Table 2](#)). However, our results also show Nature, People, and Shop signs are the object categories to which the majority of the participants made fixations. Accordingly, despite huge inter-individual differences, there seems to also be general patterns in how people divide their attention in a street environment.

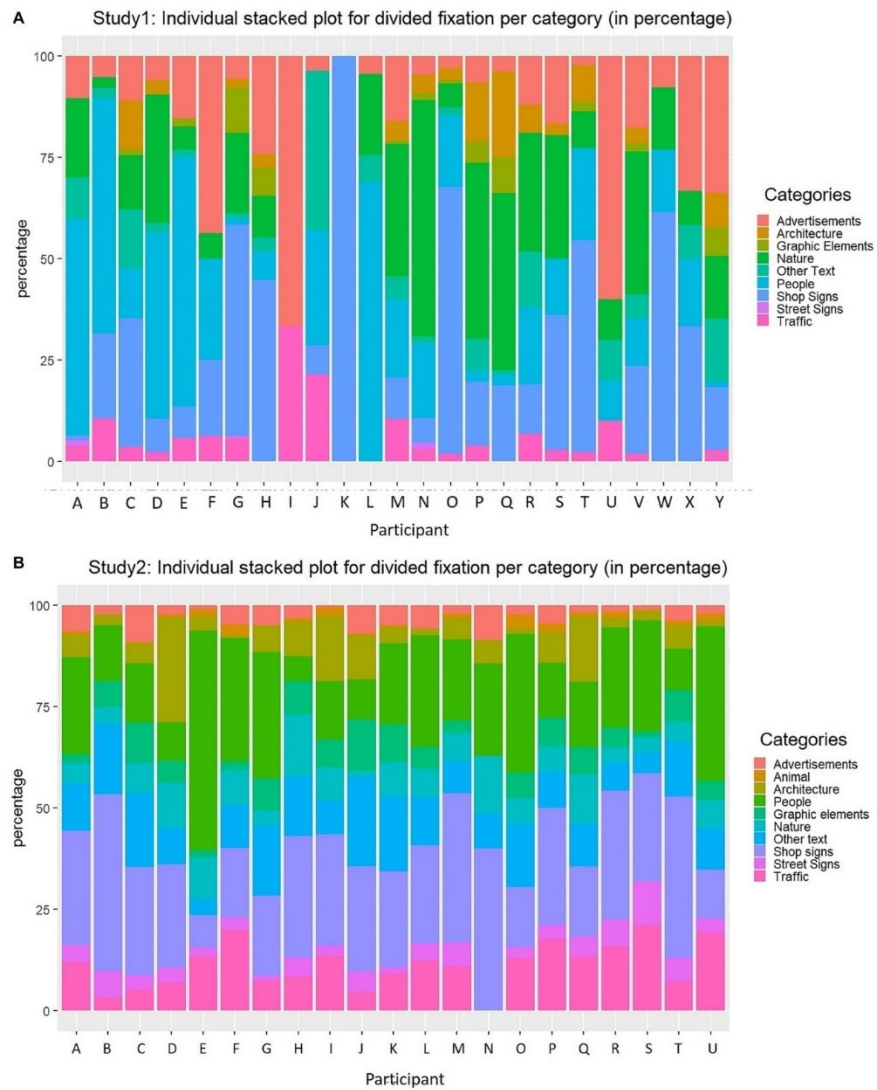


Figure 3. (A) Stacked barplot using fixations made by each individual on each category from the results of Study 1. (B) Stacked barplot using fixations made by each individual on each category from the results of Study 2.



Table 2. Descriptive statistics for the number of fixations per category.

Category	Mean percentage	SD	N1	N2	95% lower CI	95% upper CI
Results from Study 1						
Shop signs	24.30	20.60	21	25	15.60	33.00
People	21.60	20.30	23	25	13.10	30.20
Nature	19.50	15.50	22	25	12.90	26.00
Advertisements	17.20	18.00	24	25	9.56	24.80
Other text	5.66	5.87	19	25	3.19	8.14
Traffic	5.37	6.93	19	25	2.44	8.30
Architecture	4.19	5.50	14	25	1.87	6.51
Graphic elements	2.08	3.25	12	25	0.71	3.45
Street signs	0.15	0.42	3	25	0.00	0.32
Result from Study 2						
Shop signs	26.10	9.29	21	21	21.90	30.30
People	22.10	11.50	21	21	16.80	27.30
Other text	12.00	4.86	21	21	9.77	14.20
Traffic	11.20	5.69	20	21	8.57	13.80
Nature	7.39	3.60	21	21	5.76	9.03
Architecture	6.59	6.21	21	21	3.77	9.42
Graphic elements	5.71	3.15	20	21	4.28	7.14
Street Signs	4.11	2.32	20	21	3.05	5.16
Advertisements	3.79	2.49	21	21	2.66	4.93
Animal	1.07	0.89	17	21	0.64	1.50

The Category is sorted by the number of the Mean percentage. N_1 represents the actual number of participants who viewed the given object category. N_2 represents the number of participants who were used to calculate the descriptive statistics. If one participant did not make any fixations on one object category, 0 was included in the calculation of the average percentage and SDs.

Viewing behaviour and aesthetic evaluations toward the target signs

Viewing behaviour toward the target signs. Secondly, to test our second research question: ‘How does viewing behaviour correlate with the aesthetic qualities of text?’, we analysed the relationships between the viewing behaviour (i.e., the number of fixations fall into our target signs, viewing time for them) and their aesthetic value, measured in the follow-up test.

Before assessing the relationship between the viewing behaviour toward target signs and its aesthetic evaluation, we analysed how much attention our 20 target signs actually received in the testing street capture in general, as well as how long each sign was viewed. Overall, 161 fixations fell into the 20 target signs (11.66% out of the total 1,381 fixations), and the average viewing time, measured *via* the frame length, across the 20 target signs was 11.53 (c.a. 380 ms, $SD = 6.53$). The total amount of fixations toward each sign across all participants (%) were calculated (see [Figure 4](#)). 47% of the total fixations fell into three signs; *Der Mann* (12%), *Interio* (16%), and *Phoever* (19%), and there were three signs which did not received fixations at all from the participants; *Misttelefon*, *Pizza*, and *To go*.

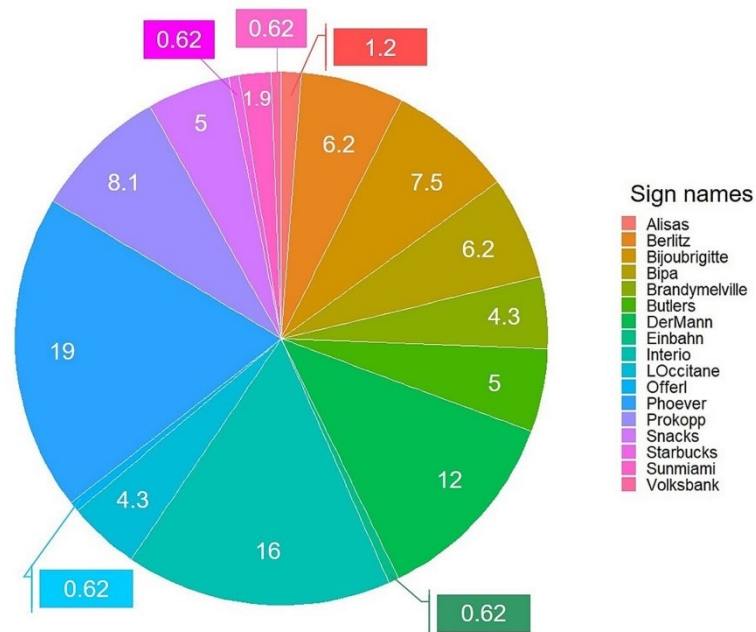


Figure 4. Pie chart using all fixations made by all participants for the 20 target signs from the results of Study 1. The number shown in the chart represents the percentage of fixations that fell into the given sign.

Further, we computed the average percentage of the fixations as well as viewing time, using individual participants' data (see [Table 3](#)). The average values for percentage of fixations were calculated in the same manner as in the previous section. For the viewing time, first, the average viewing time was computed, using the total duration of viewing times for each sign per participant. For example, when one participant gave a single fixation on one sign, the duration of this fixation was used to calculate the average viewing time across the participants. However, when one participant gave multiple fixations on one sign, the sum of each fixation duration of this participant was used for the calculation. We adapted this method, as our interest was not to assess how long on average the sign was viewed in each fixation. Rather, our main focus was to assess how much one's attention is held to each sign in total. Note that, as with the computation for the amount of the fixations, when a participant did not give any fixations on one sign, 0 was used for the computation.



Table 3. Descriptive statistics for the number of fixations and viewing time per target sign in Study 1.

Sign names	N	Percentage of the fixations				Total viewing time (frame length)			
		Mean	SD	Lower CI	Upper CI	Mean	SD	Lower CI	Upper CI
Alisas	2	0.90	3.49	−0.54	2.34	0.84	3.08	−0.43	2.11
Berlitz	8	8.58	21.37	−0.24	17.40	4.64	8.73	1.04	8.24
Bijoubrigitte	4	2.29	5.98	−0.18	4.76	4.56	14.05	−1.24	10.36
Bipa	5	2.44	5.14	0.32	4.56	4.68	12.31	−0.40	9.76
Brandymelville	6	3.36	6.97	0.48	6.24	4.56	13.16	−0.87	9.99
Butlers	7	3.74	7.00	0.84	6.63	3.68	7.53	0.57	6.79
DerMann	12	10.48	15.82	3.95	17.01	8.24	10.96	3.71	12.77
Einbahn	1	0.24	1.18	−0.25	0.72	1.00	5.00	−1.06	3.06
Interio	11	13.91	22.98	4.43	23.40	9.60	16.99	2.59	16.61
LOccitane	5	2.62	5.97	0.16	5.08	3.48	8.06	0.15	6.81
Misttelefon	0	–	–	–	–	–	–	–	–
Offerl	1	0.40	2.00	−0.43	1.23	0.40	2.00	−0.43	1.23
Phoever	14	16.24	19.43	8.22	24.26	14.32	18.49	6.69	21.95
Pizze	0	–	–	–	–	–	–	–	–
Prokopp	9	7.15	11.83	2.26	12.03	5.88	11.07	1.31	10.45
Snacks	5	6.73	21.43	−2.12	15.57	4.92	10.65	0.53	9.31
Starbucks	1	0.24	1.18	−0.25	0.72	0.44	2.20	−0.47	1.35
Sunmiami	2	0.46	1.58	−0.20	1.11	2.36	8.20	−1.02	5.74
Togo	0	–	–	–	–	–	–	–	–
Volksbank	1	0.24	1.18	−0.25	0.72	0.68	3.40	−0.72	2.08

N represents the actual number of participants who viewed the given target sign. Lower/Upper CIs represent the lower/upper 95% confidence intervals. For the viewing time, when only one participant gave a single look on the given target sign, NAs were produced for SDs and confidence intervals.

Seeing the actual number of participants who viewed the target sign (see [Table 3](#)), no signs were viewed by all of the participants. The most viewed sign on average was *Phoever* (16.24%) by 14 participants, followed by *Interio* (13.91%) and *Der Mann* (10.48%). *Phoever* received the longest viewing time (14.32 frames, c.a. 470 ms), followed by *Interio* (9.60 frames, c.a. 310 ms) and *Der Mann* (8.24 frames, c.a. 270 ms). However, seeing that those signs were viewed by relatively few participants, these results seem to reflect a strong influence of individuals.

Aesthetic evaluations X viewing behaviour. To assess the relationship between aesthetic ratings for the signs and viewing behaviour, correlation scores were computed between each of the aesthetic ratings for each target sign, sign character length, divided attention toward the target sign in percentage as well the total duration of viewing time, measured *via* frame length. As all rating scores were not normally distributed (as was visually assessed before the analysis), Kendall's Tau scores were computed. [Figure 5](#) shows the correlation plot for all variables listed above. Note that, for the computation of the correlation scores, the data points from the participants who are missing parts of rating scores, due to recording issues, were not used. For the evaluation of the results from 36 correlation tests, we used adjusted alpha level $p = 0.0011$ (0.05/45). The correlation scores as well as the correlation matrix shown in [Figure 5](#) are made with `cor_pmat()` and `ggcorrplot()` functions in *rstatix* ([Kassambara, 2022](#)) and *ggplot2* ([Wickham, 2016](#)) packages, respectively.

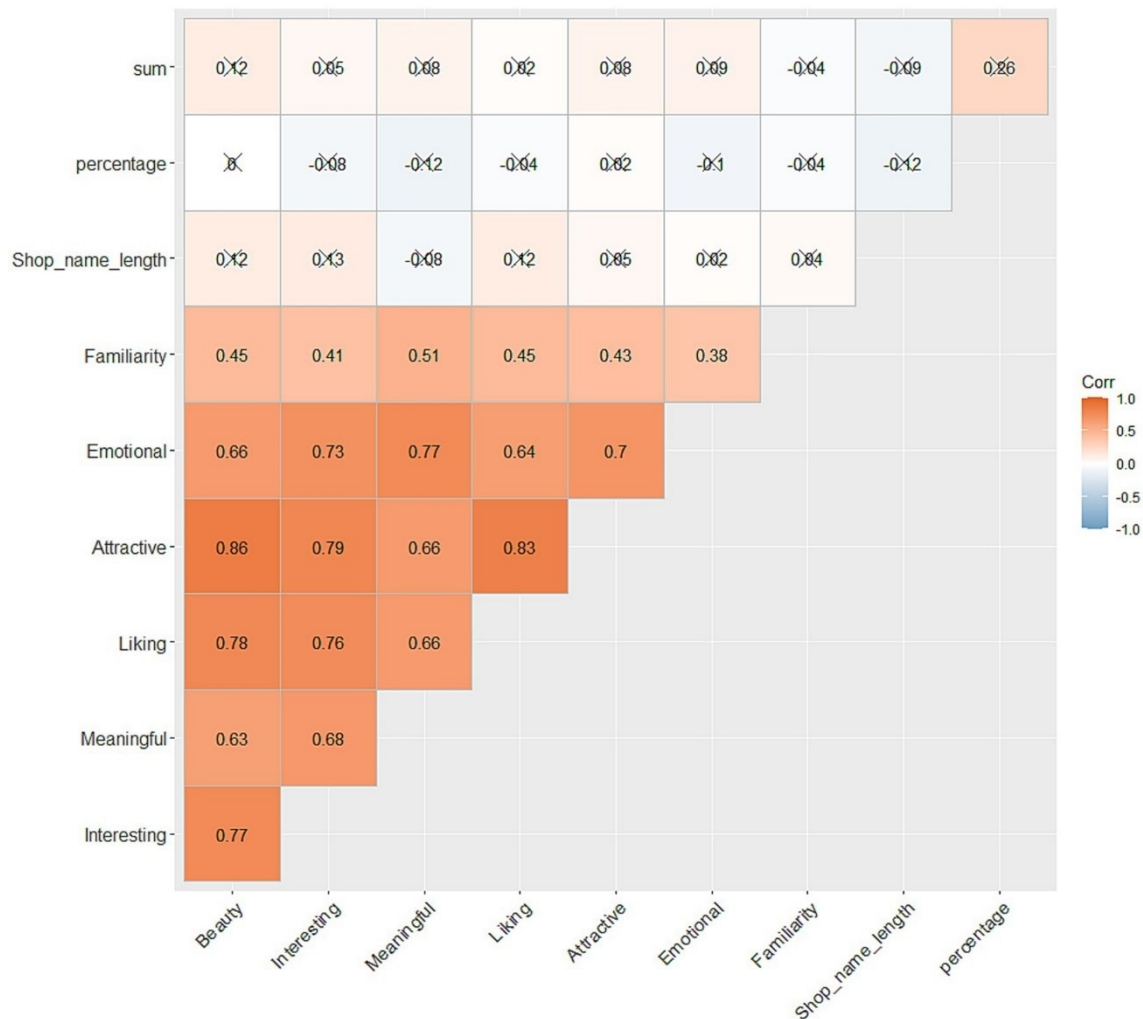


Figure 5. Correlation plot between the divided attention (%), total amount of viewing time, character length and aesthetic ratings toward signs. The numbers in the figures show the actual scores of Kendall's Tau. Xs in the figure represent where the results of the correlation tests were not significant.

As can be seen in [Figure 5](#), no systematic relationships were found between viewing behaviour, aesthetic ratings for target signs, and the number of characters in target signs. However, all of the aesthetic ratings toward the signs were positively correlated. This point will be further discussed in the discussion. Hence, our second hypothesis: more aesthetically valued texts also yield longer fixation times, was not supported.

Aesthetic evaluations X memorability (recognition task performance)

The third research question we aimed to address is whether memorability is driven aesthetic evaluations (e.g., do people recognize target signs better if they are beautiful?). The data revealed that, overall, participants correctly responded 'yes' and recognized the target signs 48.47% of the time. Participants correctly responded 'no' and rejected the distractors 96.52% of the time. Participants' overall performance was better for detecting the distractor signs than for the target signs, but performance was not greater than chance for detecting the signs from the eye-tracking path. However, it is noted this also does not follow the assumption that all participants included in the analysis viewed the target signs during the eye-tracking walk, since many signs received little or no fixations (see [Table 3](#)).



To predict the probability of memory performance as a function of the individual rating scales, we performed a series of multinomial logistic regression models, using each rating scores as independent variables, and four response types in the memory recognition task (i.e., False Alarm, Correct rejection, Hit, Miss) as the dependent variable. Note that, amongst the four categorical responses in the recognition task, False Alarm was set as a baseline for the prediction of odds ratios. The results of all models are shown in [Table 4](#). For building and running multinomial logistic regression models, we used `multinom()` function in `nnet` package ([Venables and Ripley, 2002](#)).

Table 4. Multinomial logistic regression models using aesthetic rating scores as predictors for the odds ratio of memory recognition responses.

Characteristic	CR			Hit			Miss		
	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>
Beauty	0.95	0.82, 1.12	0.60	1.29	1.09, 1.51	0.0020	0.85	0.73, 1.01	0.06
Interesting	1.04	0.90, 1.21	0.60	1.45	1.24, 1.70	<0.001	0.98	0.84, 1.15	0.80
Meaningful	0.86	0.74, 1.00	0.04	1.52	1.30, 1.76	<0.001	0.94	0.81, 1.09	0.40
Liking	0.96	0.83, 1.12	0.60	1.33	1.14, 1.56	<0.001	0.90	0.77, 1.05	0.20
Attractiveness	0.93	0.81, 1.08	0.40	1.26	1.08, 1.46	0.0030	0.85	0.73, 0.99	0.04
Emotional	0.97	0.83, 1.13	0.70	1.43	1.22, 1.67	<0.001	0.97	0.83, 1.14	0.70
Familiarity	0.64	0.57, 0.72	<0.001	1.52	1.30, 1.76	<0.001	0.68	0.60, 0.77	<0.001

OR, Odds Ratio; CI, Confidence Interval. For the evaluation of the results from seven models, we used adjusted alpha level $p = 0.007$ (0.05/7).

The results indicate that across all ratings, the probability of a hit response increased significantly as the rating scores increased. In other words, when signs were more beautiful, interesting, meaningful, etc., participants answered ‘yes’ to recognising the target stimuli in the memory task. However, except for familiarity ratings, this trend was not found for correct rejection and miss responses. For familiarity, the rating scores influenced all response types. Specifically, when participants were more familiar with the sign, the probability of a hit response increased, and the probability of a correct rejection and miss response significantly decreased. This can be interpreted as a tendency to answer ‘yes’ to the presence of a sign in the testing environment regardless of stimulus type (target/distractor), when the signs are more familiar to the participants.

Viewing behaviour X memorability (recognition task performance)

As viewing behaviour during the walk might also impact on memory performance (e.g., when the participants looked longer at a sign, they might remember this sign better, regardless of its aesthetic quality), we perform a follow-up analysis, predicting the probability of memory performance as a function of total amount of viewing time. Note that, in the present experiment (Study 1), total frame length was used as a proxy of the viewing time as with other analyses. As the viewing time can only be obtained for the target signs, the possible response in the memory test was either Hit or Miss. Since we have binary output, we used logistic regression model, using the frame length as the independent variable, and two response type (Hit, Miss) as the dependent variable. Note that, in the actual code, Hit was coded as 1, and Miss as 0. The results of this regression model suggested that, the actual viewing times toward the signs did not predict the recognition task performance (OR = -0.002, 95%CI [-0.0002, 0.02], $p = 0.853$).

Discussion

The first aim of Study 1 was to address the prevalence of reading experiences within the visual exploration of a street setting. Indeed, it was found that relative to other viewing categories, text and specifically shop



signs were looked at the most. However, our results also suggest that, amongst text elements, participants divide their attention differently. Specifically, some categories with texts received far less attention compared to the Shop signs (e.g., 11% for Advertisements and 0.22% for Street signs), suggesting it was not that participants pay attention to texts in a natural environment in general but rather selectively paid more attention to the Shop signs. As aforementioned in the introduction, though paying attention to the traffic situation for better locomotion is one of the major tasks in urban street environments, interestingly, the participants paid little attention to the street signs.

Whilst this is a novel and compelling finding, it appears somewhat plausible that substantial viewing behaviour would be dedicated toward shop signs, nature and people due to the attributes of the street. The testing street, Mariahilferstraße, is a main shopping street in the city of Vienna, and, as such, there is, as one may expect for a street of this kind, a huge density of signs. Consequently, it is not just that signs capture attention, but there is a certain expectation that they ought to, given there are a lot of signs available and the main purpose of the street involves shopping. Thus, further investigation on an alternative urban street, with perhaps a more ‘normal’ balance of signage, would be important to form a solid conclusion of reading prevalence in such settings.

Our second aim was to assess how viewing behaviour correlates with the aesthetic qualities of text. It was hypothesised that the more aesthetically valued texts also yield longer fixation times, however no systematic relationships were found. This somewhat unexpected result may allude to the fact that multiple types of stimulation may draw visual attention and this led to visual engagement. That is, while aesthetically pleasing stimuli (i.e., attractive, beautiful, liked, etc.) can incite engagement, this can also arise through other types of stimulation (e.g., aversion, confusing, threatening, etc.). However, this point should be, in part, further addressed with improved study design. Specifically, as shown in [Supplementary Table S4](#), the aesthetic rating scores for each sign did not scatter, especially toward the higher values; i.e., many participants did not choose the values ‘6’ or ‘7.’ This trend was also visually obvious when the normality was evaluated in the aesthetic rating data before the computation of the correlation scores. In other words, in this study, we lacked signs that the participants evaluated highly across any scales, meaning the relationship between the viewing behaviour and aesthetic ratings was not fully captured. We would like to note that such difficulties in selecting stimuli/manipulating some specific values can happen especially in the field environment, where we cannot fully control the contents of the environment. Such limitations found in field environment should/could be covered by follow-up testing, perhaps in well-controlled laboratory studies. This point will be further addressed in the General Discussion together with the results of Study 2. It should be noted, though there was no systematic relationship between the viewing behaviour and aesthetic ratings, the aesthetic ratings themselves measured in the follow-up session were positively correlated. This can be interpreted that many scales included in the present study acted quite similarly. Based on this finding, for Study 2, we tried to reduce the number of scales. To this aim, we performed PCA (principle component analysis) for the purpose of reduction of dimensions. The results showed that three principle components explained around the 90% of the proportions of variance in the aesthetic rating data. Those three components could be divided into an appraisal dimension (e.g., beauty, liking, attractiveness), a meaningfulness dimension (i.e., meaningfulness), and a familiarity dimension (i.e., familiarity). The detailed results as well as the code for this part of result can be found in [Supplementary material](#) (OSF). Based on this result, we decided to use only three scales in the follow-up session for the aesthetic evaluation, namely, beauty, meaningfulness, and familiarity. Beauty was explicitly chosen amongst the other scales, as it tends to relate highly to other hedonic assessments such as liking or interest, serving as a general measure of aesthetic appreciation especially amongst lay people ([Jacobsen et al., 2004](#)).

Lastly, we investigated whether aesthetic texts are more memorable. Looking at the recognition data alone, we found participants’ overall memory performance was not better than chance. Nevertheless, when compared with aesthetic evaluations of the texts, participants’ memory for target signs increased as



ratings increased. Though, this may be due to a response bias, saying yes in the recognition task, irrespective of the text sign's actual presence. It is, however noted that for the familiarity ratings, memory performance improved significantly across all possible responses to the task, so that participants were not only better at correctly identifying the target signs that were more familiar, but also better at correctly rejecting the distractor signs too. These results suggest the aesthetic quality of texts does indeed drive memory in some way, with familiarity having the strongest influence on memorability.

Overall, especially our first and third hypotheses seem to be supported from the results of Study 1. However, as discussed, such results can stem from specific characteristics of the street environment or expectations from participants. To test the generalizability of our findings further, we conducted another field study in a quite different street environment in Study 2.

Study 2

Materials and methods

Participants

A sample of 26 participants (19 female, 6 male, 1 other; $M_{\text{age}} = 25.96$, $SD_{\text{age}} = 7.72$, range: 18–46 years) were recruited with a circular email sent out University of Vienna. All participants included in the analysis had normal vision and spoke German. The average height of the participants was 169.92 cm ($SD = 10.79$, range: 150–192 cm). Anonymity was guaranteed with the use of personal identifiers and participants received monetary compensation (10 €). The study corresponds with the ethical standards of the Declaration of Helsinki and the ethical regulations at University of Vienna.

Apparatus

The Tobii Pro Glasses 3 wearable eye-tracking headset was utilised for the purpose of the study. We note there was a change in eye-tracking glasses from Study 1 due to equipment availability, and also given that this device and compatible software would facilitate the speed of the time-consuming manual coding process. The Tobii portable glasses (76.5 grams) are embedded with eight infrared illuminators and two eye cameras per eye, as well as a scene camera to recorded the outer environment with 106° view in 16:9 format (H: 95°, V: 63°; 1920 × 1,080 at 25 fps, 50 Hz). The eye-tracking data was collected on a connected recording unit (312 grams) fitted with an SD card, but controlled on an Android smartphone, running the Glasses 3 Controller app.

Calibration was administered with a target marker on a calibration card. This requires participants to focus on the centre of the calibration card, with the card placed approximately 1 m distance away at eye-level (area where we require most accuracy).

Setting

A 180 m section of Siebensterngasse in the 7th district of Vienna was chosen for the eye-tracking path. The start point was set at Siebensterngasse 42 (48.20255, 16.35150; 6,922 + WJ Vienna) and the end point was set at Siebensterngasse 60 (48.20239; 16.34927; 682X + VP Vienna) ([Figure 6](#)). This street sits behind the back of the MuseumQuartier and this particular section joins from the popular shopping street Neubaugasse. There are a range of retail stores, restaurants and other services along this street. Whilst this is not a pedestrianised street, with a road and 49 tram line in use, only one small side street (Stuckgasse) with little vehicle use fell within this path. This meant there would be minimal traffic interfering with the eye-tracking path. Participants walked west to east and back again. All recordings



took place between 7:30 am – 11:30 am when the street was less busy and the majority of stores were still closed or less frequented.



Figure 6. OpenStreetMap image, depicting the eye-tracking route along Siebensterngasse 42 to 60 in Vienna's seventh district. The four images denote the start (A) and finish (B) positions along the eye-tracking path.

Eye-tracking procedure

The eye-tracking testing procedure was the same as Study 1. To keep the conditions across participants as similar as possible and avoid too many changes to the street, data was collected in a short time span of 1 week. Testing occurred across all days within this time (Monday to Sunday) to cover slight differences in the environment across the span of a week. For the most part, the general street setting was the same, with minor changes to traffic (i.e., number of trams, passers-by, waste collection) and one occasion where maintenance work was carried out to a drain at the starting point of eye-tracking path (see [Supplementary Table S1](#)).

Follow-up session procedure

The follow-up session procedure was the same as Study 1. Again, 20 photographs were taken of text elements from the eye-tracking path and 20 distractor photographs containing text from other areas within the city streets (see footnote 4). All photos were taken on a mobile phone camera (Huawei Mate40 Pro) and cropped to a 16:9 aspect ratio with landscape orientation. Photos portrayed text from shop fasciae/signs and were selected at random from a larger corpus of images photographed from both directions and both sides of the street. Though restricted to the text elements present within the testing environment, we chose to focus on text signs due to the high prevalence and variation of shop signage within the street environment. We also reported such variations in terms of physical features (e.g., size, height, position, number of characters) (see [Supplementary Table S2](#)).



Participants completed a further questionnaire 1 week after the initial in-person eye-tracking session. Firstly, participants performed an open recall task, followed by a recognition and rating task for the 40 photographs provided (20 from the eye-pathing path, 20 distractors). For the recognition task, participants indicated whether the photographs were of text signs that were present on the eye-tracking path (yes/no dichotomous response). Participants also rated the 40 photographs for subjective aesthetic judgement on 7-point scales (beauty, meaningfulness, familiarity). Finally, participants completed the LHQ v3.0 ([Li et al., 2020](#)), in which they reported demographics and subjective ratings about their language background. Again, the open responses to the memory recall as well as the measurements of LHQ v3.0 questionnaire were performed for exploratory purpose for planning our future studies, and they are beyond the scope of the present study. Hence, analyses for those measures will not be presented in the present study.

Data preparation

First, we checked the general quality of the eye-tracking data obtained by the 26 participants. For the eye movement data, five participants were excluded due to insufficient data quality, as calculated by a marked reduction in the percentage of fixation data collected compared to the amount of expected data. We note a possible explanation for this reduction in data quality could partly be due to the lighting conditions in the field environment, where, during the mornings, there was sometimes strong sunlight (see [Holmqvist et al., 2023](#)). The data for the remaining participants with complete eye-tracking video material was included for this analysis; $N = 21$ (13 female).

Overall, 14,361 fixations were made in entire recording. The number of fixations made by individual participants ranged from 87 to 952. The total time of the annotated videos was 1 h 57 min 20 s. Regarding the number of the fixations longer than 200 ms, overall, there were 6,621 fixations. We again note only the fixations longer than 200 ms were included in the main analysis below. The annotations (see [Table 1](#)) and data extraction were performed with iMotions software (version 9.3), and the eye-tracking data was then analysed with the same R environment as in Study 1.

Results

We again calculated the average scores for information regarding the eye-tracking street location for the 26 participants prior to the main part of the analysis, including participants' liking ($M = 4.46$, $SD = 0.65$), familiarity ($M = 3.00$, $SD = 1.65$) and frequency ($M = 2.23$, $SD = 1.18$) of visiting this section of the street. Further, we asked if participants would visit this part of the street again (No = 11, Yes = 15). The scores for comfort of the glasses were also assessed on a 5-point scale (1 = not at all, 5 = very comfortable). The average score for this question was 4.15 ($SD = 0.88$). Thus, it was again assumed that the participants' viewing behaviour was not constrained by wearing eye-tracking glasses and could be included in the analysis.

The number of fixations per object category

Firstly, to see which objects captured attention overall, again, the total amount of fixations toward each category across all participants (%) were calculated (see [Figure 2B](#)). 59% of the total fixations fell into Shop Signs (26%), People (21%), and Other Text (12%). The remaining 30% of total fixations fell toward Other Text (12%), Traffic (11%) Nature (7%), Architecture (6.5%), Graphic Elements (6.2%). Hence, this result shows, even with less amount of shops, Shop signs are by far a dominant component that people pay attention to amongst other (text) categories while walking regardless of the testing environments. Though Nature was one of the dominant categories to be viewed in Study 1, only 7% of total fixations fell



into this category in Study 2. Such difference seems to reflect the different characteristics of the two streets, as in Siebensterngasse, there are fewer green components compared to the Mariahilferstraße.

Further, the percentage of the fixations on each category per participant is shown in [Figure 3B](#), and the descriptive statistics for this measure is presented in the bottom part of [Table 2](#), showing the variance in participants' gaze distribution. Descriptive statistics were calculated in the same manner as in Study 1. As with the results from Study 1, People and Shop signs were the object categories to which the participants made the most fixations. Hence, our second study, in a quite different street environment, showed similar results as Study 1.

Viewing behaviour and aesthetic evaluations toward the target signs

Viewing behaviour toward the target signs. Next, the relationships between the viewing behaviour (i.e., the number of fixations that fall into our target signs, viewing time for them) and their aesthetic value, measured in the follow-up test, were analysed.

Overall, 420 fixations fell into the 20 target signs (6.34% out of the total 6,621 fixations), and the average viewing time across all 20 target signs was 240.77 ms ($SD = 311.10$). To assess which signs were viewed the most and least, the total amount of fixations toward each shop sign (%) were calculated (see [Figure 7](#)). The most viewed sign was *Ina Kent* (16%), followed by *Café Voodoo* (9.3%) and *Café Nil* (8.8%). There were four signs (*adlerhof*, *chicohangematten*, *r_s*, *tabaktrafik*) that received no fixations.

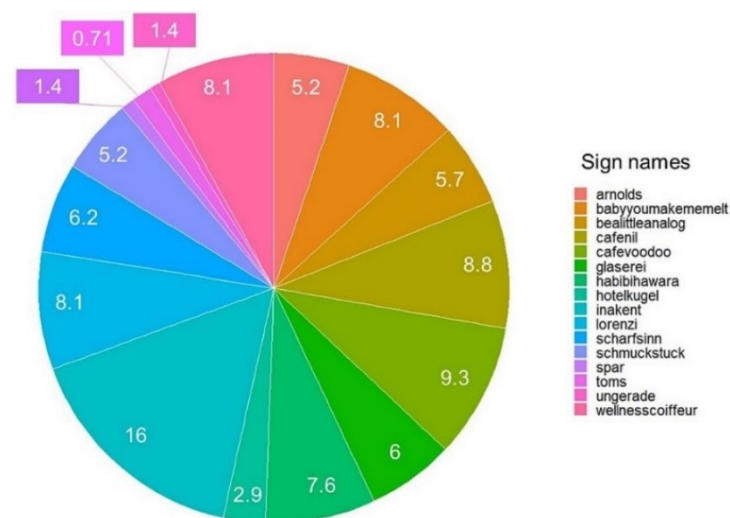


Figure 7. Pie chart using all fixations made by all participants for the 20 target signs from the results of Study 1. The number shown in the chart represents the percentage of fixations that fell into the given sign.

We also computed the average percentage of the fixations as well as viewing time, using individual participants' data (see [Table 5](#)). The average values for percentage of fixations as well as the average viewing time were computed as in the same manner in Study 1.



Table 5. Descriptive statistics for the number of fixations and viewing time per target sign in Study 2.

Sign names	N	Percentage of the fixations				Viewing time (frame length)			
		Mean	SD	Lower CI	Upper CI	Mean	SD	Lower CI	Upper CI
adlerhof	0	–	–	–	–	–	–	–	–
arnolds	17	5.32	5.18	3.18	7.46	615.92	374.96	377.68	854.15
babyyoumakememelt	11	3.89	5.95	1.44	6.35	1580.90	821.06	993.55	2168.25
bealittleanalog	17	3.55	3.75	2.00	5.10	1477.67	1400.42	587.89	2367.45
cafenil	17	11.83	11.17	7.22	16.44	944.85	683.79	531.64	1358.05
cafevoodoo	16	5.41	5.70	3.06	7.77	1389.29	850.13	898.43	1880.14
chicohangematten	0	–	–	–	–	–	–	–	–
glaserei	14	3.42	3.64	1.91	4.92	651.85	370.86	427.74	875.95
habibihawara	16	4.43	4.56	2.55	6.31	1571.17	1518.45	606.39	2535.94
hotelkugel	12	1.60	2.24	0.67	2.52	619.50	353.69	323.81	915.19
inakent	19	16.49	12.81	11.20	21.78	1590.83	1265.07	961.73	2219.94
lorenzi	16	4.58	5.36	2.37	6.79	1157.20	1168.96	509.85	1804.55
r_s	0	–	–	–	–	–	–	–	–
scharfsinn	16	3.58	3.80	2.01	5.15	1308.86	836.60	825.82	1791.89
schmuckstuck	13	3.10	3.44	1.68	4.52	989.82	1209.42	177.32	1802.32
spar	8	0.86	1.54	0.23	1.50	371.67	181.88	–80.16	823.49
tabaktrafik	0	–	–	–	–	–	–	–	–
toms	10	1.49	2.67	0.39	2.60	330.00	60.00	255.49	404.51
ungerade	8	1.13	2.05	0.28	1.97	468.33	140.43	119.49	817.18
wellnesscoiffeur	18	5.32	4.86	3.31	7.33	948.00	681.15	536.39	1359.61

N represents the actual number of participants who viewed the given target sign. Lower/Upper CIs represent the lower/upper 95% confidence intervals.

Compared to Study 1, more participants gave fixations to the target signs in Study 2 (see [Table 2](#)). This difference might be caused by the number of available shop signs in the testing environment; whilst there are numerous shop signs available in the Mariahilferstraße, there are less shops in the Siebensterngasse. Hence, when the participants viewed any signs, the chance that our target sign received looks should be generally higher. However, again, no signs were viewed from all of the participants. The most viewed sign on average was *Inakent* (16.49%) by 19 participants, followed by *Café nil* (11.83%) and *Arnolds* and *Wellness coiffeur* (both 5.32%). *Inakent* received the longest average total viewing time (1590.83 ms), followed by *Baby youmakememelt* (1580.90 ms) and *Habibihawara* (1571.17 ms).

Aesthetic evaluations X viewing behaviour. To assess whether aesthetic value modulates viewing behaviour, a series of correlations were performed between viewing behaviour [i.e., divided attention toward target sign in percentage as well as total viewing time (ms) for each sign per participant], each of the aesthetic ratings and sign character length. Again, as all rating scores were not normally distributed (as was visually assessed before the analysis), Kendall's Tau was computed. [Figure 8](#) shows correlation plot for all variables listed above. Note that, for the evaluation of the results from 10 correlation tests, we used adjusted alpha level $p = 0.005$ (0.05/15). As in Study 1, no systematic relationships were found between viewing behaviour and aesthetic ratings for target signs. Again, all of the aesthetic ratings toward the signs were positively correlated. One result which is different from Study 1 was the correlation between the divided attention toward the signs and total viewing time toward them. In Study 2, there is a positive correlation between the two variables, meaning when the participants took more looks at the sign, the total viewing time toward the sign increased. This result is quite intuitive, and raises a question why we did not find such relationship in Study 1. Further, Study 2 did find a negative correlation between beauty and sign character length, meaning when texts included more characters, they were evaluated as more beautiful. These points will be further discussed in the General Discussion.

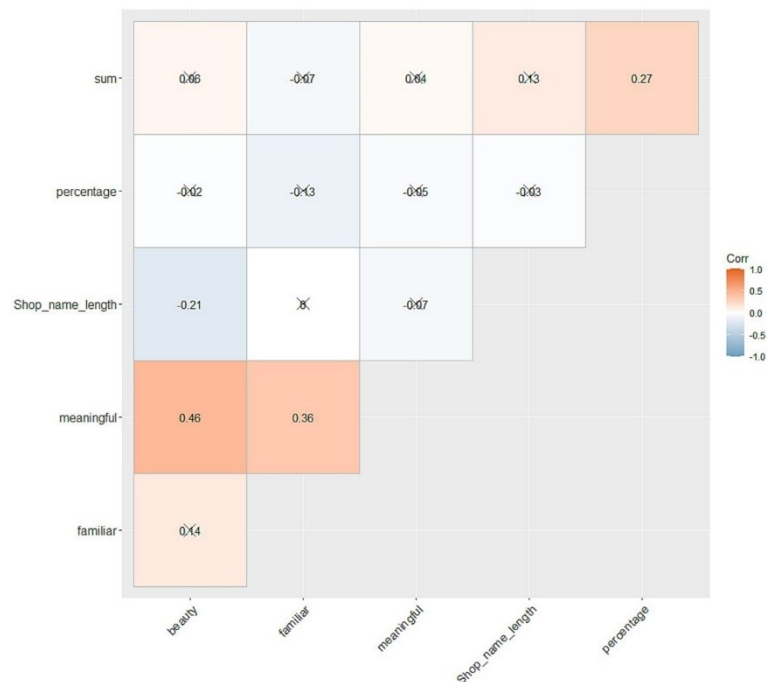


Figure 8. Correlation plot between the divided attention (%), total amount of viewing time, character length and aesthetic ratings toward signs. The numbers in the figures show the actual scores of Kendall's Tau. Xs in the figure represent where the results of the correlation tests were not significant.

Aesthetic evaluations X memorability (recognition task performance)

The data revealed that, overall, participants correctly responded 'yes' and recognized the target signs 18.46% of the time. Participants correctly responded 'no' and rejected the distractors 80.96% of the time. Participants' overall performance was not greater than the chance for detecting the signs from the eye-tracking path. Further, it is noted that there appears to be a general tendency to indicate a 'no' response across signs, resulting in a high proportion of correct rejections of distractors and misses of target signs.

Again, to predict the probability of memory performance as a function of the individual rating scales, a series of multinomial logistic regression models were performed. The model structures were the same as in Study 1. The results of all models are shown in [Table 6](#). The results indicate that across all ratings, the probability of a correct rejection and miss decreased significantly as rating scores increased. In other words, when signs were more beautiful, meaningful or familiar, participants tended to answer 'yes' for distractor stimuli in the memory task.



Table 6. Multinomial logistic regression models for aesthetic rating scores (characteristic) and memory recognition responses

Characteristic	CR				Hit				Miss		
	OR ₁	95% CI ₁	p		OR	95% CI	p		OR	95% CI	p
Beauty	0.75	0.66, 0.86	<0.001		0.87	0.73, 1.03	0.11		0.69	0.60, 0.79	< 0.001
Meaningful	0.60	0.52, 0.68	<0.001		1.01	0.87, 1.18	0.90		0.58	0.67	< 0.001
Familiarity	0.48	0.43, 0.55	<0.001		0.96	0.84, 1.09	0.50		0.48	0.42, 0.54	<0.001

1 OR, odds ratio; CI, confidence interval. For the evaluation of the results from three models, we used adjusted alpha level $p=0.016$ (0.05/3).

Viewing behaviour X memorability (recognition task performance)

As with Study 1, we assessed the impact of viewing times toward the signs on recognition task performance. To this aim, we performed the same structured regression model, using the viewing time (ms) as the independent variable, and two response types (Hit, Miss) as the dependent variable. We note that, while we used the total frame lengths as the proxy of the viewing time, in Study 2, we directly used the viewing time (ms) as the independent variable. Again, the results of this regression model suggested that the actual viewing times toward the signs did not predict the recognition task performance ($OR = -0.00$, 95%CI $[-0.02, 0.0004]$, $p = 0.499$).

Discussion

The aim of Study 2 was to further investigate attention toward signs in a second location, to see whether the suggested prevalence of text viewing withstands. It was indeed found that even on a relatively 'normal' inner-city street, not as inundated with large shop signs, text elements, and specifically shop signs, attracted attention more than other object categories. Our results also suggest in this street environment participants again divide their attention differently to text elements. Some categories with text received far less attention compared to Shop signs (e.g., 12% for Other Text and 4.2% for Street signs), which again suggests it was not that participants pay attention to texts in a natural environment in general, but rather selectively paid more attention to the Shop signs. Thus, with text signs capturing attention on this alternative urban street, this alludes to a high reading prevalence in such settings overall.

Our second aim was to assess how viewing behaviour correlates with the aesthetic qualities of text. It was hypothesised that the more aesthetically valued texts also yield longer fixation times; however, again, no systematic relationships were found. Yet again, this point should be further addressed with improved study design. Specifically, as shown in [Supplementary Table S5](#), the aesthetic rating scores did not scatter largely, especially toward the high values, i.e., many participants did not choose values '6' or '7.' This trend was also visually obvious, when we evaluated the normality in the aesthetic rating data before the computation of the correlation scores. In other words, in this study, we lacked the signs that participants evaluated highly across any scales, meaning the relationship between the viewing behaviour and aesthetic ratings were not fully captured. Moreover, this again could reflect in that types of stimulation other than aesthetic appeal, such as aversion, can incite engagement.

Lastly, we investigated whether aesthetic texts are more memorable. Looking at recognition data alone, we found participants' overall memory performance was not greater than chance. However, this may be due to a response bias, with a high propensity to answer 'no' in the recognition task, therefore, we can question how well this indicates their memory for the signs. Nevertheless, when compared with aesthetic evaluations of the texts, participants' memory for target signs increased as ratings increased. These results suggest the aesthetic quality of texts does indeed drive memory in some way, with familiarity having the most influence on memorability.



Overall, our first and third hypotheses appear to be supported by the results of Study 2. This suggests our findings stem from different characteristics of the street environment or expectations from participants. In this light, the findings are further discussed in the General Discussion.

General discussion

The aim of this research was to investigate the way in which people engage with and explore text in an urban setting. In an everyday street context, there is an abundance of text that could capture attention amongst a broader selection of objects present in such a busy, outdoor environment. Thus, an exploratory approach was taken to examine/provide insight into interactions with text in public spaces. Particularly, focus was placed upon which objects are looked at often, what text captures most attention and how viewing behaviour then relates to aesthetic evaluations, and also to memorability.

Viewing behaviour: which objects are looked at most?

The initial query this paper addresses is which objects capture attention. It was hypothesised that signs and texts would receive more attention than other visual objects within the testing street. The fixations recorded from eye-tracking data were assigned to object categories to reveal how much something was looked at. By comparing the distribution of fixations across these categories, both Studies 1 and 2 found shop signs are the components in urban streets that capture most attention across people. This corroborates with previous findings based in laboratory settings that there is an inclination to look at text in real world scenes ([Cerf et al., 2009](#); [Wang and Pomplun, 2012](#)). We see this finding despite the noticeable differences between the two study locations here. For example, the greater number of fixations toward traffic and street signs for Study 2, and to nature and advertisements in Study 1, greatly reflects on the street composition. Therefore, this outcome is particularly compelling given that this insinuates similarity in how people divide their attention and read text during such walks, even with such complex settings and despite individual differences.

Further, aside from shop signs, both studies found a high proportion of viewing behaviour toward people, and in Study 1 also to nature. These findings appear plausible given that past research demonstrated a preference (to attend) toward people/faces (e.g., [Rousselet et al., 2003](#); [Bindemann et al., 2005](#); [Fei-Fei et al., 2007](#); [Ro et al., 2007](#); [Fletcher-Watson et al., 2008](#); [Langton et al., 2008](#); [Leder et al., 2010](#)) and to nature (e.g., [Biederman and Vessel, 2006](#); [Fei-Fei et al., 2007](#); [Tinio and Leder, 2009](#)). In Study 2, we further separated the eye-tracking data for people, finding that whilst participants were inclined to look closely at faces, a large proportion of gaze was directed toward other parts of the body (i.e., legs, feet) (see [Supplementary Table S6](#)). This reflects on previous research more specifically on eye guidance and locomotion in natural scenes, in terms of spatial location and saliency with regard to walking safely. This may be due in part to the social ‘costs’ associated with direct eye contact ([Goffman, 2008](#); [Cristino and Baddeley, 2009](#)), but also to avoiding colliding into other people ([Jovancevic et al., 2006](#); [Foulsham et al., 2011](#)). [Cristino and Baddeley \(2009\)](#) observed greater fixations to the kerb, a low contrast feature, whilst none toward a flock of birds, a highly salient image feature. This suggests attentional guidance toward the task at hand, since the kerb indicates the separation of the road and pavement, which is imperative for a pedestrian to detect when walking safely along the street (see also [Patla and Vickers, 2003](#); [Patla, 2004](#); [Marigold and Patla, 2008](#)). This could possibly also explain the inclination to look at the path and to tree trunks/lampposts as potential landmarks (see [Foulsham et al., 2011](#)). Thus, it appears the tendency to look toward people and nature within an urban setting could be a result from preference/social cues or obstacles/hazards that occur while walking along a street. This separation was not initially included in our object category list, which followed [Mitschke et al. \(2017\)](#), but we noticed this tendency during the annotation process. As such, any future studies in this line of research might also be interested in this regard.



Viewing behaviour: inter-individual difference in viewing behaviour in target shop signs

Seeing the viewing time for each target shop sign, there was considerable variance in the average viewing times for the individual shop signs of interest. Additionally, it was apparent that some of these signs were looked at by all participants, while others were seldom looked at or not at all. Such a trend might be challenging when it comes to analysing the results. For example, when we want to investigate the relationship between the viewing behaviour and aesthetic quality in the shop signs, it would be impossible to assess such relationship, if the participants do not take a look at the target signs at all in the testing environment.

One can make possible inferences as to why this is the case, and how this could possibly reflect more on the specifics of the particular streets in question. It is established that the position of the text is imperative for it to capture attention ([Wang and Pomplun, 2012](#)). Many of the signs used in the follow up depicted the text on a fascia, however it is not known whether text printed on the fasciae were looked at much less than the projecting/hanging signs protruding from the shop fronts. Furthermore, [Kim and Park \(2021\)](#) found signs placed in a higher position elicited more and longer fixations than signs in a lower position. As such, perhaps knowledge of these streets alludes to the fact that Mariahilferstraße has a larger abundance of retail stores, consequently in this location there is a greater disposition to look at the protruding signs. Siebensterngasse, on the other hand, is a much quieter street with less of an incline, hence gaze is directed more at eye level, as opposed to upward, as was often the case with Mariahilferstraße. The nature of the current studies meant there was not a balanced number of signs differing in terms of fascia/protruding (or even high vs. low), to assess whether there was a significant difference between sign position and viewing times.

For these reasons, a suggestion for future studies is to consider the positions of the target signs, and perhaps also the incorporation of images of the protruding signs, which would have been seen at a similar angle during the eye-tracking walk, instead of images taken of the shop front, which would not have been seen face on (as in our follow-up). Such selection criteria would provide better quality of results and analysis in the field environment.

Aesthetic quality of text signs

Given that aesthetic quality has been associated with longer looks, the current studies explored whether the viewing behaviour toward signs was correlated with participants' evaluations of them. Specifically, we hypothesised that the more aesthetically valued text signs would yield longer viewing times. However, no systematic relationship was found between the ratings and eye movement patterns in both studies. The lack of association may have arisen because the signs that were present were generally rated quite low (see [Supplementary Tables S4, S5](#)), as such it is possible they were not high enough in aesthetic value to elicit longer looks. We note this is a major difficulty in the field study design, since there is a certain lack of control in the selected variables, and therefore stresses the importance of follow-up laboratory studies where signs with more variation (i.e., covering the entire scale) in aesthetic value can be implemented.

Alternatively, it may be the case that something other than the aesthetic qualities measured in these studies drives viewing behaviour in this instance (e.g., saliency, aversion, confusion, threat, etc.). For instance, [Bojko \(2013\)](#) notes that elements in the environment may capture attention due to the “visual prominence of the area,” contrasting to the rest of the environment, perhaps in regard to the colour, shape, size, or other physical characteristics (see also [Chatterjee, 2003](#); [Estrada-Gonzalez et al., 2020](#)). Further, more specific linguistic characteristics related to text (e.g., word length, word frequency) could influence viewing time, given that longer, infrequent words may require more cognitive processing



(see [Rayner et al., 2011](#)). It is also plausible that the location of the stimulus in relation to the wider environment also plays a role in attention to text. It is perhaps not even that these areas stand out *per se*, but that prior knowledge leads to expectations that such areas will contain information of importance ([Wang and Pomplun, 2012](#)). The extent to which the visual features or word content influence participants ratings is not clear. For this reason, this study cannot ascertain whether this attention to text is driven more by top-down or bottom-up factors (see also [Wu et al., 2014](#)).

In addition, the use of a free-viewing paradigm leaves the question as to what determines viewing behaviour rather open, given that there was no specific purpose/task aside from locomotion to drive attention in a particular direction. To address this, a retrospective thinking out loud task could be administered to gain further insight into participants' thoughts and therefore possibly why longer fixations were made toward certain signs (see [Mitschke et al., 2017](#)). Moreover, a more specific instruction could be implemented during the eye-tracking procedure. Previous research suggests this would mean a change from explorative to active looking ([Janiszewski, 1998](#)). In this light, viewing behaviour could be linked more specifically to visual search, and therefore scanning/reading signs for relevancy/meaning, or even implementing other behavioural metrics – if an individual is more inclined to visit a store when attracted to the signs, and therefore if signs are correlated to consumer behaviour.

Memorability of text signs

The current study also provides insights into how the environment is perceived, by considering the memorability of text that features within this space. Text is an element featured in real world scene studies but in the broader context of the natural environment, where it is present amongst so many other 'distractions', it still attracts our attention. Therefore, we can question whether such text signs are memorable, and what may drive this memorability. We hypothesised that aesthetic quality of text would be a contending factor, and found that indeed text signs rated higher were better recognised.

Whilst this finding indicates aesthetically values texts have an effect on memorability, this only partially supports the notion that high aesthetic value leads to longer looks and better memory, given that neither of the two studies found a relationship between viewing behaviour and aesthetic quality. Specifically, whilst we see improved memorability (through recognition performance) of signs with higher aesthetic value, we do not find that these aesthetically valued signs are looked at longer. In this light, whilst in previous studies the aesthetic appeal draws visual attention, perhaps confusing or even unappealing elements are equally salient to the visual system (see [Wu et al., 2014](#)). Thus, signs eliciting aversion could also be retained in memory, given that arousal -irrespective of valence- could predict memorability. Further, we also find that not all participants looked at all of the target signs in the testing streets, therefore one can question how much the memory performance for signs reflects on participants' actual engagements with text during the eye-tracking walk. It is possible that we highlight upon a tendency to report recognising a sign when in fact the participant did not look at it. We can infer that this is due to prior knowledge of the street and familiarity with the text signs that are present. [Brockmole \(2008\)](#) notes the memory advantage for objects which are linked to the setting in which they were shown. This insinuates that there is a stronger memory trace for aesthetically valued signs, but this memory trace may be built over time and not from a single walk of around 5 min where it was possible to read such signs. To see if this is the case, and that attending to aesthetically valued signs during a natural walk lead to better memory, this would require selecting participants who are completely new to the surroundings and with no prior knowledge about the street in question.

Further, from these studies it is not clear the extent to which visual features of text drive memory, and it is possible something else might be driving both the aesthetic value ratings and the memorability ratings. As aforementioned, image saliency models for scene viewing suggest there are both image-driven and informational-driven features. In this light, both need to be addressed to assess the interaction between



the two. Perhaps the sign that is more memorable is so because of a participants' likelihood to visit the shop, or the purpose of their walks (to shop, to find food, to commute), and these in turn also lead them to regard such signs with high aesthetic value. Addressing this would require the isolation of such features, also since it is not clear what specifically about the signs leads to this aesthetic/memory relation (e.g., fonts, colors, size, word frequency, word length, etc.).

Limitations

A smaller sample size allowed us to explore viewing behaviour more meticulously across the span of each individuals' walk, however is a limitation of the current studies, especially since we are dealing with behaviour in such a complex, multifaceted environment with supposedly large individual differences. Despite this, we still see a high proportion of attention toward shop signs/text. Moreover, whilst carrying out the same walk (A to B, B to A) allowed the midpoint environment during the calibration check to remain the same across participants, we also reflect that counterbalancing the start direction of the walk would be prudent to establish a contrasting priming effect. Therefore, it would be interesting to see how similar viewing behaviour is under more controlled settings, such as within a laboratory context or using virtual reality simulations, as this would mean all participants experience the same street conditions and subsequently have the same likelihood of viewing text elements. Further, this would combat another limitation of this study in that, given the laboriousness of manually annotating mobile eye-tracking data, it was not feasible to quantify the number of potential opportunities for the individual participants to have seen the signs and proportion this to the actual incidents where they looked at the signs.

Whilst both Study 1 and 2 uncover compelling findings regarding text perception and the prevalence to look at signs, a direct comparison cannot be made for the viewing behaviour patterns across these two locations. The different hardware and software used in both studies, whilst allowed for more robust measure of eye-tracking performance for the latter study, means that it is not possible to determine if differences in results arise due to the methods of data collection (e.g., differences in viewing behaviour and fixation durations across both studies due to the devices' sampling rates, temporal resolution, spatial accuracy, etc.) or if this reflects the nature of viewing behaviour in the two testing environments. For example, the attention of participants in the first study was short and scattered, in contrast to the second street where there were generally longer fixations. This may be due to the first street having much more signage and other distractors competing for attention, as compared to the second with less available stimuli and a quieter atmosphere. Yet it is also possible that this reflects not on the viewing behaviour of the testing environment, but that performance of fixation detection differed between the two eye-tracking devices. However, this remains speculative and cannot be confirmed with direct statistical comparisons given that the possible differences in data quality cannot be excluded. We would suggest that future studies comparing locations use the same devices and software so that differences in fixations can be further elucidated.

To sum, these studies reveal how attention is divided during a natural walk, finding that indeed shop signs and text elements do attract people's attention in an urban street environment. We also address caveats that arose and propose improvements to consider in future studies, with the hope that this aids future research on natural reading behaviours and aesthetic viewing in urban environments.



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2.3. Lab-based investigations Lab-based investigation: Text and image in unified everyday reading experiences



Chana, K., Mikuni, J., Vezzani, G., Rebora, S., Meyer, A., Salgaro, M., & Leder, H. (accepted).

Judging books by their covers: the impact of text and image features in the aesthetic evaluation and memorability of Italian novels. *Literature*.

My Contribution:

CRedit author statement: **Kirren Chana:** Conceptualisation, Methodology, Software, Validation, Formal Analysis, Investigation, Data Curation, Writing – Original Draft, Writing – Review and editing, Visualisation;

Jan Mikuni: Formal Analysis, Data Curation, Writing – Original Draft, Writing – Review and editing;

Gabriele Vezzani: Conceptualisation, Formal Analysis, Investigation, Writing – Review and editing; **Simone**

Rebora: Conceptualisation, Investigation, Resources, Writing – Review and editing; **Anja Meyer:**

Conceptualisation, Project Administration; **Massimo Salgaro:** Conceptualisation, Supervision, Funding acquisition; **Helmut Leder:** Conceptualisation, Writing – Review and editing, Supervision, Funding acquisition.

2.3.1.1. Key findings

- We investigated the effects of verbal (text) and visual (image) features on the memorability and aesthetic evaluations of Italian book covers.
- In a recognition task (N=50) we explored how text and image informational cues influence memory performance when the same book cover information was encoded during a learning phase, finding that image features significantly improved memory recognition.
- While more aesthetically rated images did not lead to better recognition, memory performance varied depending on familiarity and, non-linearly, on how well the book's content could be inferred from the image.
- Reading behaviour did not significantly affect memory performance, suggesting that memory was more influenced by the informational content of visual cues rather than how the text was processed.

2.3.1.2. Original Manuscript

(see next page)



Judging books by their covers: the impact of text and image features in the aesthetic evaluation and memorability of Italian novels.

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Abstract

Book covers are often the first item seen before a reader engages with its contents, therefore careful consideration is placed into the text and image features that constitute its design. This study investigates the effects of the presentation of verbal (text) and visual (image) features on memorability and aesthetic evaluations in the context of book covers. To this aim, 50 participants took part in a memory recognition task where the same book cover information was encoded in a learning phase, but either text or image features from the book covers acted as an informational cue for memory recognition and aesthetic evaluations. Our results revealed image features significantly aided memory performance more than text features. Image features that were rated more beautiful were not better recognized as a result. However, differences in memory performance were found in relation to familiarity and, in a non-linear fashion, the extent to which the book's contents could be inferred from the image informational content. Additionally, reading behaviour was not found to influence memory performance. These results are discussed with regard to the interplay of text and image informational cues on book cover perception and provides implications for future studies.

Keywords: Book covers, Fiction, Memory, Cognitive studies, Aesthetic evaluation, Reading behavior



Judging books by their covers: the impact of text and image features in the aesthetic evaluation and memorability of Italian novels.

Empirical studies of literature often concern the cognitive effects of literary texts. Literary texts, also referred to narrative texts, form a large body of research, especially pertaining to the reading experience. However, a broader, often overlooked concern, is the extent to which a literary text can ever independently impact, or influence a reader's cognition, without being linked to other attenuating factors. One such factor is paratextual information, which no doubt has a bearing on the reading experience (Altmann et al., 2014). Whilst it is not the purpose of this paper to dispute/explore all possible attenuating factors, with efforts to explore the everyday reading experience from a cognitive science perspective, the focus here is strictly on paratextual information. This is explored in the form of book covers and brief interactions with paratext (see Appel et al., 2021), that can be characterized as 'micro-reading' and perhaps lexical processing even more akin to image viewing (Bauer & Mayer, 2008).

Despite its overuse, the idiom 'Don't judge a book by its cover' alludes to the moral decision regarding how assumptions are made by an 'outward appearance'. While the phrase refers to objects and people more generally, in a literal sense, book covers themselves are indeed often judged - and form our first impression of the book's contents. Hence, as opposed to the literary text itself, we focus on the informational content of the book cover. Being the first thing that we see, the book cover and its design set the expectations a reader has of its contents. This design comprises of several features that can be categorised as either text or image based, and are processed in distinct ways that influence cognitive and psychological processes differently (Reed, 2022). Despite their combined use in design, the role text and image features have in shaping book cover perception has received little attention. At the same time, recent studies suggest potential of the interplay of text and image and their collective impact specifically on memorability and aesthetic judgement, which again remains understudied. As such, this study seeks to address this research gap by investigating how visual and textual factors of book covers contribute to the perception, memory and evaluations of books.

The function of a book cover

A book cover can have many functions, including acting as a teaser, highlight, or even an attention grab. In some cases, the cover offers seemingly random glimpses of the mood of the book or simply suggests a mode of reading (as in the case of book covers without pictures). In other cases, the cover offers a spectrum of interpretation. For example, in the different covers of Dumas' *The Count of Monte Cristo* which depict a couple suggesting a sad love story, a chained young man suggesting a tragic hero, or even a masked, uncanny man with wild eyes suggesting the story of a madman. These book cover variations each imply different interpretations regarding the type of story the reader is about to embark on, and may very well even trigger genre expectations. In some sense, these depictions could insinuate that a book cover acts as a 'visual summary' (Sonzogni, 2011) with regard to the brief précis these pictorial aspects allow for, in the interpretation and evaluation of the book as a whole.

As Sonzogni (2011) highlights, the book's cover may provide three functions: (1) present visual content that allows potential readers to decide whether to read a book or not (within a brief span of a few seconds); (2) impart information to the reader by displaying the title and author as well as summarising the text through images and words; (3) prompt the reader's memory regarding their existing knowledge of



the text. Conveying visual information about the book, the cover can be considered as aesthetic stimuli with regard to the way the illustrations, author's name, the title and any other information (e.g., awards/prizes, endorsements/testimonials, taglines) are integrated into a pleasing design (Sonzogni, 2011). By taking the function of the cover into account, we can then explore how words and images are integrated within a design, and *how* this affects the subsequent evaluations that are formed.

Text and image information in book cover perception/evaluation

Classically aesthetic objects¹ often pair imagery with text, such as a painting being displayed with a caption or title (Darda & Chatterjee, 2023; Leder et al., 2006; Mastandrea & Umiltà, 2016; Millis, 2001; Mullennix & Robinet, 2018) or street art incorporating text within the depicted images (Chamberlin, 2018). Additionally, in album covers, which are arguably a closer parallel to that of books, we also see the pairing of the album title and music artist with the album cover's graphics (Le, 2020; Venkatesan et al., 2022)². As Sonzogni (2011) points out with book covers, the pairing of captions or titles alongside art goes beyond identification and facilitates the meaning making process (Franklin, 1988; Leder et al., 2004; 2006; Russell, 2003; Russell & Milne, 1997). In doing so, the additional elaboration that such text provides, in turn increases the aesthetic response (Millis, 2001; Venkatesan et al., 2022), with this being more apparent for shorter viewing times (Leder et al., 2006).

Similar to art and music, the way that literature is consumed has also changed with increased use of digital platforms, streaming and online interfaces (Murray, 2018; Pianzola, 2021; Spjeldnæs & Karlsen, 2024). Given that album artwork no longer actively encourages music purchases (Le, 2020), in the same light, the way book covers are presented/perceived may have varying effects on consumer purchase. Research has leant itself towards how consumers select books, especially given the shorter time-span of viewing linked with the presentation of thumbnail previews or image tiles on digital online interfaces (Gudinavičius & Šuminas, 2018; McKay et al., 2012; Osinka & Osinki, 2020; Rollins, 2014). Pictorial and text elements featured on the book cover therefore evidently determine choice (Ross, 2013; see also Wang & Song, 2020). For example, Childers et al. (1985; 2002) point toward typeface as one factor to consider in influencing consumer perceptions. Specifically, this alludes to a preference for visual information over verbal information³, and consequently the more image-related properties of typeface (see Melmer et al., 2013) being more influential than textual (semantic) information.

It is noted that these studies focus on the verbal/visual features of text, i.e., the effects of semantic information compared to image-related properties of the text such as typeface. The current paper, however, does not place its focus on the processing of visual and verbal properties of *text*, but rather on the effects of verbal (titles/words) and nonverbal (pictorial/illustrative) information. The subsequent sections will elaborate on the interplay of this verbal/visual information (i.e., text and image information), and in the context of book covers.

Text and image information on book cover memorability

When considering book covers and similar stimuli, one could explore how verbal and nonverbal information is processed, especially given that the main underlying intention of text is to preserve

¹ In this paper we do not restrict aesthetic objects to paintings, but here we specifically refer to artworks given the origins of empirical aesthetics in studying art. It is important to note that, despite art being the predominant subject for aesthetic inquiry, other objects aside from art can also be aesthetically relevant (see Leder et al., 2004; 2014; Pelowski et al., 2017; Skov & Nadal, 2020; Zimmerman, 1966), and the notion of aesthetics can be applied to objects from our everyday urban environments, i.e., those that are not traditionally categorised as art (Knoll et al., 2024; Specker, et al., 2024), such as books and book covers.

² In Le (2020) specific colours were more noticeable in specific genres, yet colour was not a significant predictor of album genre. In Venkatesan et al. (2022) manipulating album covers influenced expectations and perception of music, with increased pleasantness according to whether this corresponded with a rounded or angular typeface. This further demonstrates how text and image features of such stimuli influence perceptions and subsequent evaluations.

³ Research often mentions visual vs. verbal information. Visual commonly refers to the image-related properties of textual information (e.g., typeface, font, colour), whilst verbal information refers to the semantic content in written form.



information (Jean, 1992; Sonzogni, 2011). Investigating the types of information that are remembered from a book cover and the strength of the memory trace therefore provides insights into which of this information is important. Whilst text (i.e., words in the written form) is the preferred method of communication (Dewan, 2015), images are easier to recognise, process and remember (Kulhavy et al., 1993; Levie & Lentz, 1982; Robinson et al., 2003; Verdi et al., 2014), with images and words being processed by different neural networks (Feng et al., 2021). This is known as the Picture Superiority Effect (Paivio & Csapo, 1973; see also Mintzer & Snodgrass, 1999). A possible reason for this increased memorability of pictures/images is that, in our mental representations, images are coded both visually and verbally (i.e., dually encoded), which means that both visual and verbal mental codes can be used for memory retrieval (Paivo, 1990; Sadoski & Paivo, 2013).

Language is fundamentally built on visual thinking (Reed, 2022), with metaphoric language especially intertwined with visual imagery. Building a clear mental model is essential for understanding a text, such as a book (Kintsch, 2004). As aforementioned, using verbal and visual information can contribute to this. However, there is evidence to suggest that visual information is more robustly encoded, and therefore when the recognition task involves images, the stimuli is recognised more easily and quickly than with its word counterparts (Nelson et al., 1976).

Book covers, as stimuli, contain both image and word information which, according to the aforementioned theories, is processed and encoded differently, making use of both verbal and visual codes. This dual-coding thus strengthens the memory trace and likelihood of recall (Harp & Mayer, 1997; Sadoski & Paivo, 2013), since multiple retrieval codes are created for the visual (image) and linguistic (word) information. This suggests to effectively remember something such as a book, a combination of words and images should be used during encoding. With regards to the memorability, given that visual and verbal information uses separate memory stores, recall is improved when either one can be accessed (Kosslyn, 2007). This notion of cross-modal recognition taps into the levels of processing theory (Lockhart & Craik, 1990), which asserts that deeper encoding leads to better memory retention. The combined text-image stimuli during encoding encourages a more elaborate processing of the words and image, thus strengthening the associations with visual and verbal memory traces, and subsequently improving the retrieval of information from memory.

There is research to suggest the readers' capabilities also affect the construction of a mental model. Stronger readers⁴, for example, tend to have better memory recall (e.g., author recognition: Moore & Gordan, 2015; Stanovich & West, 1989), largely due to their ability to build robust mental models while reading. Enhanced vocabulary, comprehension skills, and memory capacity help these readers make more meaningful connections between new information and what they already know, supporting a deeper understanding and retention of text (Kintsch, 2004; Calvo et al., 2003). In contrast, weaker readers may benefit more from illustrations in written texts than stronger readers, as illustrations can help compensate for difficulties in processing and integrating textual information (Cooney & Swanson, 1987; Levie & Lentz, 1982; Mastropieri & Scruggs, 1989; Schnotz, 2014; Mendhakar et al., 2024).

In the context of book covers, combining text and imagery can activate this memory process, providing visual and verbal cues that engage readers more deeply. For skilled readers, the interaction between these elements may facilitate stronger connections with the content and enhance memory retention, as the interplay of words and images reinforces memory pathways (De Leeuw et al, 2016). Conversely, Schnotz (2014) highlights that the cognitive effort invested in processing text may decrease when images are added, potentially resulting in less thorough textual processing and lower memory retention for the text itself (Mayer & Gallini, 1990; Schnotz & Bannert, 1999). These findings raise the question of whether

⁴ Whilst reading strength may refer to those who read frequently or avidly (Merga, 2017), here we refer to stronger readers in terms of reading skill and proficiency (Golland, 2019), with the number of books read being a possible determinant of reading skill (Allington, 2014; Li et al., 2023; Stephenson et al., 2008).



reading ability influences how effectively readers integrate text and imagery to form memorable impressions of book covers. This study aims to address this question by exploring whether stronger readers are better able to process and more importantly retain information from book covers.

Influence of aesthetic evaluations on memorability

The memorability of a book cover could also be enhanced by its aesthetic evaluation, by engaging both cognitive and emotional processes through text and image elements (Chana et al., 2023). Text on a book cover, such as the title, can trigger mental representations and emotional responses by evoking background knowledge and generating inferences, which in turn strengthen memory encoding (Jacobs, 2015; 2016). This aligns with Jacobs' findings on the role of language in evoking emotional reactions and mental imagery, suggesting that the more evocative or emotionally charged the text, the stronger the memorability. On the other hand, image elements of the cover—such as illustrations, colours, and design—can immediately activate visual-spatial processing, creating vivid mental images and emotional associations. According to his research on mental imagery, visual elements are processed differently from text, leading to an immediate emotional response that reinforces memory retention through sensory experiences (Jacobs, 2016). The combination of these text and image elements taps into dual-processing systems, which suggests that verbal and visual stimuli are processed through separate mental systems, strengthening recall by engaging both verbal and visual mental codes (Kosslyn, 2007). While text engages deeper cognitive processing through language, images perhaps evoke more immediate emotional reactions and mental representations (Alpium & Ehrenberg, 2023; Bradley et al., 2014; Jacobs, 2015; Leder et al., 2022). When effectively integrated, these elements work together to activate both memory systems, leading to more durable and accessible recall. In a similar vein, Leder et al. (2006) found that text influences how viewers interpret and emotionally engage with visual art, enhancing their appreciation and overall memorability. Therefore, one can posit that a well-designed book cover that blends evocative text with compelling imagery can create a stronger, more lasting impression on the reader, improving the likelihood of the book being remembered.

Research indicates that a well-aligned combination of textual and visual elements on a book cover enhances comprehension and emotional engagement, leading to a more cohesive and memorable impression (Yonelinas, 1994). Recognition memory theories, such as the dual-process model, highlight the interplay between recollection, a slower process of retrieving contextual details, and familiarity, a faster mechanism that relies on memory strength without specific details (Yonelinas, 1994). Additionally, signal detection theory posits that recognition is influenced by the strength of the memory trace and decision criteria. While reading, verbal and semantic attributes of text are typically prioritized, with visual/physical properties assumed to be transient. However, studies have shown that these physical attributes persist in memory for 10–25 seconds, far exceeding the time required for word identification (Kroll et al., 1970; Warrington & Shallice, 1969). Visual properties, or rather typographic features, such as typeface and letter case, influence verbal processing at early stages, potentially activating independent semantic representations (Posner, 1970; Tinker, 1963; Webster & Tinker, 1935).

Building on this foundation, the present study isolates text and image features of book covers to test their respective contributions to aesthetic evaluations and recognition memory. This approach allows us to disentangle the cognitive and emotional impacts of these elements, providing insight into how design features influence memorability and appeal.

Aims and Objectives

Previous research has explored the effects of visual and verbal information on memory and perception. This study focuses on the text vs. image content present in Italian book covers, and which can be used a



better cue for remembering the book. Furthermore, the role of aesthetic quality, particularly how it influences memorability and perception, has been investigated in art, advertising and other areas but remains unclear with regard to book cover design. By picking apart these elements and accounting for individual differences in reading behaviour, this study aims to provide a comprehensive understanding of how book covers are perceived, remembered and evaluated.

Importantly, we note here that the purpose of this study is not to alter the text/image information since we use pre-existing stimuli which should already have been designed professionally with this intent. Instead, the primary focus is to gain a better understanding of the interplay between visual and verbal factors. With this aim, we intend to investigate how much memorability and aesthetic value is driven by visual (image) vs. verbal (text) information. We answered this with the following research questions:

- 4) Do we have better memory recognition of a book based on the presentation of the book cover image or its text information?
- 5) What are the effects of book cover information differing in aesthetic quality on memory performance?
- 6) Does reading behaviour influence the memorability of book covers?

We aimed to assess our research questions by performing a memory recognition task, in which the same book cover information is encoded during a learning phase. During the testing phase, either text or image content from the book covers acted as an informational cue for memory recognition. This allows one to see the different contributions of verbal and visual information in the memory retrieval, and which can be used as a better informational cue for remembering a book. The details of the experimental procedure and conditions are outlined in further detail in the Methods section.

The following hypotheses correspond to the research questions outlined above:

- 1) Memory recognition will be greater when presented with the book cover image (visual information) than the book title (verbal information);
- 2) Memory recognition will be greater for information with higher aesthetic value;
- 3) Stronger readers will demonstrate better memory performance.

Materials and Methods

Study Design

The book cover information type (text/image condition) was set as the between-subjects factor of the experiment. Hence, whilst all participants saw the same book cover stimuli during the learning phase, in the testing phase half of the participants saw the book covers only with text, and the other half only with the image for memory retrieval (see Procedure). Following this, their recognition and aesthetics evaluations were assessed and results were compared between the two conditions.

Measurement

Memorability measurements

The memorability was measured through a recognition task. Recognition memory is often assessed with forced choice or yes-no test formats (Khoe et al., 2000; Stanislaw & Todorov, 1999). The present study adopts the latter, whereby target and distractor stimuli are displayed in single trials following from a study/learning phase, and individuals are asked to say whether or not they had seen the stimuli (see Procedure for further detail). This allows us to analyse the data with the framework of Signal Detection Theory (Green & Swets, 1966).



Aesthetic evaluation measurements

We are interested in assessing whether participants' aesthetic evaluation of a book cover influences the way they process the information it conveys, thus affecting their memory performance. Importantly, this evaluation can operate on multiple levels: readers may assess the cover purely as a visual artifact or consider how effectively it communicates the essence of the book. We assumed that these levels can contribute differently to readers' aesthetic evaluation, and therefore decided to target them separately.

With regards to the aesthetic value of the book cover itself, we asked participants to rate, on a scale from 1 to 7, both how beautiful and how interesting they found it. Beauty was selected over other rating scales because it has been previously connected to other hedonic assessments, such as liking and interests (see Chana et al., 2023; Jacobsen et al., 2004), and thus serves as a broad indicator of aesthetic appreciation. Interest was included given the debate of how closely related beauty and interest are in this line of research (Mastandrea & Umiltà, 2006; Millis, 2001). Concerning the level of the literary work, we first asked participants to quantify the degree to which they believed they were able to infer the content on the book based on its cover. Following from Salgaro and colleagues (2018; see also Heydebrand and Winko, 1996), we also assessed literary value, through both the social prestige and economic value of the work, asking participants to rate how well they thought the book was received by critics and to try and guess its price (on a range from 5 to 35 euros).

Finally, we included a question (Yes/No) to check whether participants were familiar with the book in question. Although the stimuli had been pre-selected for unfamiliarity, this item was included to control for possible effects of familiarity, given its strong influence on recognition tasks (McKenzie & Tiberghien, 2000).

Participants

The study includes a final opportunistic sample of 50 participants (39 female, 10 male, 1 undisclosed gender; $M_{age} = 22.32$, $SD_{age} = 2.34$, range: 19 - 33 years). Twenty-five participants were in either one of the experimental conditions. All participants included in the analysis were proficient in Italian language. Participants were all university students at the University of Verona and took part in the study as per course requirement. Anonymity was guaranteed with the use of personal identifiers. The study adhered to the ethical guidelines set by the University of Verona.

Stimuli

As familiarity and recollection has been reported to affect recognition performance (Bastin & Van der Linden, 2003; Chana et al., 2023), we aimed to collect book covers which are generally unfamiliar to avoid familiarity effects on memorability and so that recognition performance can be considered an effect of the recognition test format. To select the stimuli, the most sold Italian books per month were ranked and scored from a series of bestseller lists (<https://www.giornaledellalibreria.it/categorie/narrativa-italiana-22.html>). Books that scored the lowest were used as a proxy for unfamiliarity ($n=474$). Similar to Gudinavičius and Šuminas (2017), we excluded books deemed as bestsellers and those by widely recognised authors. Any classics were also excluded from the sample. The selected books were all fictional novels that were written in Italian language by Italian authors. From this corpus, only the lowest scoring books ($n=160$) were selected for a pre-test of familiarity.

One hundred and sixty books selected from a larger corpus were used in a pre-test to assess the familiarity of the novels. Fifty-seven students at the University of Verona were asked to indicate their familiarity with the book titles and authors of a series of Italian novels by marking one of three boxes (read, know the book, know the author). At the same time, participants provided an approximation of



how many books they had read in their spare time over the past year as an indicator of their reading habits (see Supplementary Figure S1; OSF <https://osf.io/zy9ut/>).

For each book, if a participant knew the author, the book was given a score of 0.25, if they knew the book title a score of 0.5, and if they read the book a score of 1. This means that for each participant the total score per book was a maximum of 1. There were 27 books which had a score of 0, meaning that none of the participants asked were familiar with the title or author, nor had they read the book.

The final sample included 80 books that had the lowest familiarity scores (see Supplementary Table S1).

Procedure

Data collection took place across two days in December 2023 (04.12.23; 06.12.23). On average, participation time was 41.56 minutes ($SD_{\text{time}} = 8.55$; range: 22 - 64 minutes). Participants were provided with a link to the study through the Labvanced online platform (Finger et al., 2017) and randomly assigned to one of the two between-subjects conditions. Once they had given informed consent, participants provided demographic information and completed the learning phase.

The experiment consisted of three phases: a learning phase, an interference phase, and a testing phase. The learning phase required participants to view 40 book cover tiles that were presented on the screen for three seconds each at a time in a randomised order (a total of two minutes).

Following the learning phase, participants completed an interference phase, in which they answered questions about their reading habits, use of media and the Interest section of the Vienna Art Interest and Art Knowledge (VAIAK; Specker et al., 2020) (see Supplementary Table S2). They also indicated which Italian publishing houses (out of a list of 43) they were familiar with (see Supplementary Table S3).

Following the interference tasks, participants performed memory and rating tasks in the testing phase. This involved the 40 book covers presented in the learning phase (target) and 40 additional book covers that were not presented in the learning phase (distractor) (see Supplementary Table S1 for the target and distractor stimuli). According to the between-subjects condition that participants were assigned to, the book cover stimuli were either presented based on the image content (with text removed) or text content (with image removed and in a neutral typeface) (see Figure 1). Based upon the stimuli presented on the screen and participants had to respond whether they had seen the book cover in the learning phase (yes/no). At the same time, participants reported if they were familiar with the book and rated the stimuli on a series of 7-Point scales (beauty, interest, contents, importance to critics, cost estimate).

At the end of the experiment, participants were debriefed and thanked for their participation.

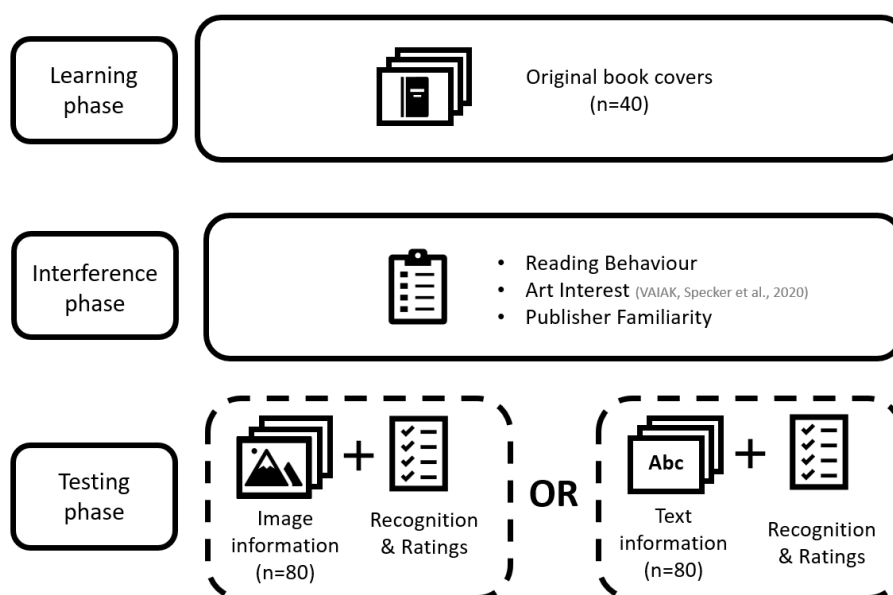


Figure 1. Graphical representation of procedural design.

Data Preparation

The data was analysed with R (Version 1.1.423. R Development Core Team) using dplyr package (Wickham et al., 2023). All the analyses reported in the Results section were performed in the same R environment.

Signal detection theory (SDT) is an established mathematical model that can be used in memory recognition (Green & Swets, 1996). In the memory recognition task, a person must decide on a response based on the evidence they are presented with, i.e., whether the target vs. distractor stimuli was shown in the learning phase, by indicating yes (same; 1) or no (different; 0) as a response. After completion, the responses were marked using signal detection analysis (see Table 1) and the number of 'Hits', 'False Alarms', 'Misses', and 'Correct Rejections' for each participant were computed.

SDT then accounts for the assumption that there is not random variation and that responses are bias – in other words, this controls for the tendency to respond yes in the task. The recognition task responses were converted into d' prime (d') scores. The statistic d' is a measure of sensitivity, reflecting on participants' ability to distinguish between target stimuli (signal) and distractor stimuli (noise), controlling for the inclination to say that the stimuli was present when it was not (response bias, β) (for more extensive explanation, see Green & Swets, 1996 or Stanislaw & Todorov, 1999).

The SDT analyses were performed using the psycho package in R (Makowski, 2018).

Table 1. Signal detection theory paradigm.

	Your response Different (0)	Your response Same (1)	Total number per condition
Stimuli different (0)	Hit	Miss	40
Stimuli Same (1)	False Alarm (FA)	Correct Rejection (CR)	40



Results

Before the main analyses, we first conducted a series of manipulation checks to ensure there were no pre-existing differences between the groups. All of the reported data and codes used for analysis is available on the Open Scientific Framework (OSF): <https://osf.io/zy9ut/>.

First, as well as choosing the least familiar books in the stimuli selection with a pre-study (see Methods section), the familiarity of the book cover stimuli was also assessed by participants in both the text and image conditions. For the text condition, participants reported that the book covers were familiar 2.95% of the time. For the image condition, participants reported that the book covers were familiar 4.55% of the time. This suggests that the book cover stimuli were not familiar to the participants and therefore the results henceforth are not driven by familiarity.

Second, we compared general reading behaviour and art interest across the Text and Image conditions, as these aspects can be confounding factors for both recognition and evaluation performance. The number of books read per year, as a proxy of the participants' general reading behaviour, was compared across the two conditions. In the Image condition, an average of 10.6 books were read per year ($SD = 17.0$, 95% CI [3.62, 17.7]), while in the Text condition an average of 11.4 books were read per year ($SD = 13.4$, 95% CI [5.86, 16.9]). Seeing the range of the 95% confidence intervals, there was no significant differences in reading behaviour across the two conditions. Participants' art interest, as measured with the Art Interest section of the VAIK (Specker et al., 2020), also showed no significant differences between the two conditions (Text condition: $M = 45.7$, $SD = 12.4$, 95% CI [40.6, 50.8]; Image condition: $M = 41.0$, $SD = 11.9$, 95% CI [36.1, 46.0]).

Overall, the two condition groups exhibited low familiarity to the presented book cover stimuli and also showed similar reading behaviour and art interest, with moderate variability in both measures. Hence, any observed differences can be more confidently attributed to the experimental manipulation (i.e., the text vs. image conditions), rather than pre-existing differences between the groups.

Further, we also computed the descriptive statistics for the evaluations for stimuli per condition. Table 2 shows the means, standard deviations (SD) and 95% confidence intervals (CI) for each scale per condition. Seeing the range of the 95% confidence intervals, there were significant differences between the ratings in the two conditions.

Table 2. Descriptive statistics for book cover evaluations for Text/Image conditions.

	Condition					
	Text			Image		
	M	SD	95% CI ¹	M	SD	95% CI ¹
Beauty	2.35	1.40	[2.29, 2.41]	3.75	1.79	[3.67, 3.83]
Interest	2.53	1.50	[2.46, 2.59]	3.62	1.80	[3.54, 3.70]
Contents	2.77	1.61	[2.70, 2.84]	2.94	1.51	[2.88, 3.01]
Cost	3.12	0.92	[3.08, 3.16]	3.10	0.944	[3.06, 3.14]
Critic Importance	2.68	1.22	[2.62, 2.73]	2.81	1.26	[2.75, 2.87]

¹ 95% CI = 95% confidence interval.



Memory Performance

Our primary research question addressed whether memory performance differed according to condition (text/image) in the recognition task, with better memory recognition for image content than text content. First, participants' responses to the recognition task were categorised as hits, correct rejections (CR), false alarms (FA) and misses. Overall, hits accounted for the highest percentage of responses (44.64%), followed by CRs (26.29%), FAs (23.39%), and misses (5.68%) (see Table 3). This distribution indicates that participants were generally accurate, with a substantial proportion of correct responses (hits and CRs combined = 70.93%).

When considering performance by group, shown in Table 3, the Text condition had a similar proportion of hits (20.5%) compared to the Image condition (23.85%). Similarly, CRs were marginally lower in the Text condition (12.62%) than the Image condition (13.55%). False alarms were marginally higher in the Text condition (12.38%) compared to the Image condition (11.45%), while misses were more frequent in the Text condition (4.50%) than the Image condition (1.15%). These findings suggest differences in memory accuracy and response patterns between text and image conditions, with participants generally exhibiting higher memory accuracy for image-based stimuli. Figure 2 shows the distribution of these responses across the two conditions for each response type, with individual data points, boxplots and violin plots.

Table 3. Descriptive statistics for average frequency of each response type in recognition task.

Response Type	Group ¹	<i>M</i>	<i>SD</i>	95% CI
CR	(Overall)	20.9	7.55	[18.8, 23.1]
	Text	20.2	8.19	[16.8, 23.6]
	Image	21.7	6.94	[18.8, 24.5]
FA	(Overall)	19.1	7.55	[16.9, 21.2]
	Text	19.8	8.19	[16.4, 23.2]
	Image	18.3	6.94	[15.5, 21.2]
Hit	(Overall)	35.5	7.19	[33.4, 37.5]
	Text	32.8	9.34	[28.9, 36.7]
	Image	38.2	1.89	[37.4, 38.9]
Miss	(Overall)	4.52	7.19	[2.48, 6.56]
	Text	7.2	9.34	[3.35, 11.1]
	Image	1.84	1.89	[1.06, 2.62]

¹ *N* = 50; *n* = 25 (Text condition), *n* = 25 (Image condition).

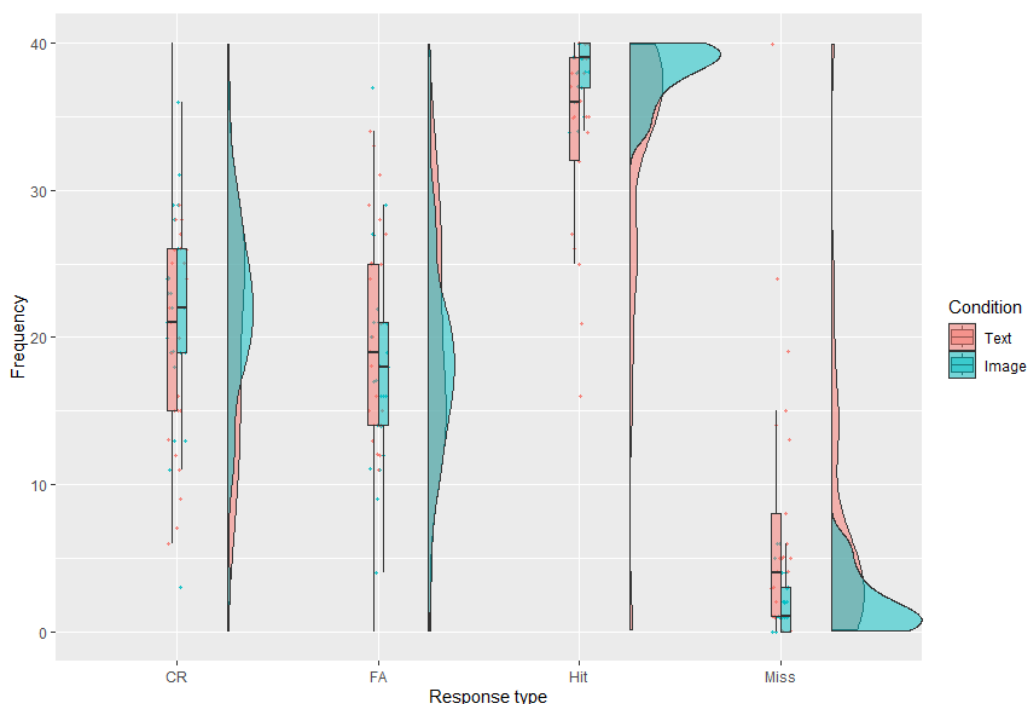


Figure 1. Frequency of recognition task responses by condition and response type.

To statistically assess the impact of the two conditions on the memory performance, we compared the two memory performance measures retrieved from signal detection theory (SDT), d' and β . d' measures the sensitivity or the ability to discriminate between the target (i.e., hits) and distractors (i.e., false alarms) in the recognition task. It is computed by subtracting the z value of false alarm from that of the hit. Higher d' values indicate better sensitivity and more accurate recognition. β measures the response bias or the tendency to say yes or no regardless of the types of the stimuli (target or distractor). A neutral unbiased response would reflect in a β value of 1.0, meaning there is an equal likelihood to respond yes or no to both targets and distractors. A β value less than 1.0 indicates a tendency to respond 'yes' (i.e., leading to more hits and false alarms), while a β value above 1.0 indicates a bias to say 'no' (i.e., leading to more correct rejections and misses). First, we computed the d' and β per participant for the two conditions, and then performed Welch two sample t tests, using each measure as the dependent variables across the two conditions.

A Welch two sample t test using d' scores revealed a significant difference between the Text and Image conditions ($t(45.89) = -3.66, p = .0006, 95\% \text{ CI } [-1.04, -0.30]$). Seeing the descriptive statistics, participants in the Image condition showed higher memory sensitivity ($M = 1.82, SD = 0.71, 95\% \text{ CI } [1.52, 2.11]$) compared to participants in the Text condition ($M = 1.15, SD = 0.57, 95\% \text{ CI } [0.91, 1.38]$). The Cohen's d for this difference was 1.04 ($95\% \text{ CI } [0.44, 1.62]$), indicating a large effect.

A Welch two sample t test using β scores revealed a significant difference between Text and Image conditions ($t(46.64) = 2.45, p = 0.018$). Participants in the Text condition ($M = 0.54, SD = 0.33, 95\% \text{ CI } [0.41, 0.68]$) had higher β values compared to the Image group ($M = 0.33, SD = 0.28, 95\% \text{ CI } [0.22, 0.45]$). The Cohen's d for this difference was 0.69 ($95\% \text{ CI } [0.12, 1.26]$), indicating a moderate effect. In both conditions, β was less than 1.0, meaning that participants were more liberal in their responses, tending to respond 'yes' to both the target and distractor. The lower β values in the Image condition indicate an increased response bias. In spite of this, it remains unclear from these results whether the response can be attributed to the condition not a response bias in one of the conditions. Further elaboration on this point can be found in the discussion section.



Memory performance X Aesthetic evaluation

In this section, the relationship between the memory performance and hedonic evaluations (i.e., beauty rating) for the presented cue in the recognition task will be assessed. The question addressed here assesses whether the memorability of a book cover is influenced by its perceived beauty. Given our experimental design, SDT measures, such as d' and β , are not the most appropriate metrics to tackle this question. First, such measures are obtained by aggregating responses over the entire set of stimuli, while beauty ratings are attributed to individual stimuli. Secondly, they are computed using the participants' responses for both targets and distractors. As we, in this section, aim to assess whether participants remember the target stimuli better when evaluating the stimuli as more beautiful, the responses for the distractors are not our interest.

For these reasons, the responses for the distractors were excluded from the following analysis. By doing so, we ensured that responses could be taken as a proxy of the book cover's memorability: since all the stimuli were presented during the learning phase, we can assume that the higher the memorability is, the higher the chances of a positive response.

Furthermore, even though participants were asked to rate all stimuli in the same way in both image and text conditions (to ensure consistency in the design), when it comes to the analysis, it would not make much sense to compare the ratings attributed to book cover images to those attributed to plain text. For this reason, the present analysis was limited to the target stimuli in the image condition.

To assess the effect of beauty rating for the book covers on memorability, we included the beauty ratings as the independent variables in a logistic regression model, with recognition response (0 or 1) as the dependent variable. To control for its effect on memorability, other ratings such as familiarity (whether the participant knew the book), contents (whether they can guess the contents of the book from the book cover), cost (how much do they think the book costs), and importance for the critic (whether they think that literary critics deemed the book important) were also included as predictors in the model. Before running the model, we checked Spearman's correlation coefficients between the variables with 7-point Likert scales (i.e., beauty, contents, cost, importance for the critic, and interest). Beauty and interest scores were strongly correlated ($r = .82$), hence, the interest score was not included as the controlling variable to avoid issues, such as multicollinearity. The predictors and the model outputs are shown in Table 4.

Table 4. Descriptive statistics for average frequency of each response type in recognition task.

Fixed Factors	Estimate	95% CI		z value	Pr(> t)
		Lower	Upper		
(Intercept)	-0.43	-0.93	0.060	-1.71	.086
Beauty	-0.021	-0.10	0.058	-0.52	.60
Contents	0.16	0.075	0.25	3.67	< .001
Cost	0.13	-0.029	0.29	1.59	.11
Critic	-0.09	-0.21	0.035	-1.40	.16
Familiarity	1.20	0.49	2.01	3.13	.0017

¹ 95% CI = 95% confidence interval.

As shown in Table 4, familiarity significantly influenced the model's performance. The only other significant effect was due to the item measuring how much participants could infer the book's contents based on the cover itself (*Rating_Content*). However, a point biserial correlation test between this item and the model's target returned a coefficient that, albeit significant ($p < 0.001$), was negligible ($r = 0.01$).



This suggests that the effect of the variable *Rating_Content* on recognition might be non-linear. Indeed, looking at Figure 3, we note that the ratio of recognised and non-recognised stimuli does not increase consistently with the rating. Specifically, book covers rated 4 or higher tend to be remembered considerably better than those rated 3 or lower, suggesting a threshold effect. In other words, it appears that a certain level of perceived contents informativeness is necessary to significantly enhance recognition performance, which is not influenced by variations below this threshold.

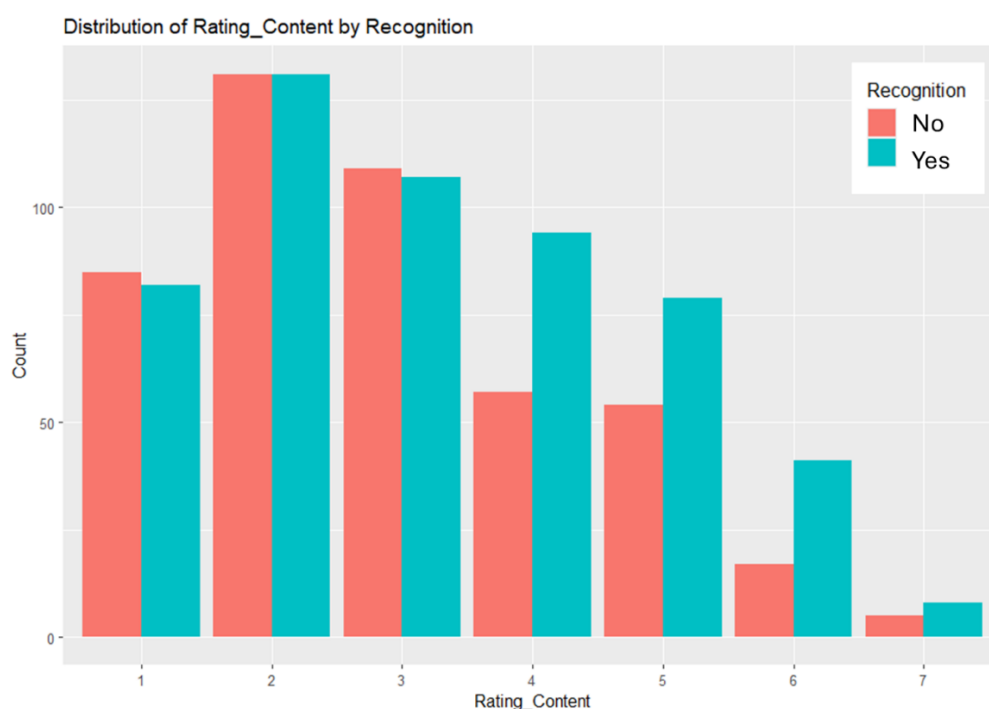


Figure 3. Bar plot showing the content rating responses (whether they can guess the contents of the book from the book cover) separately for recognition response type (yes/no).

Memory performance X Reading behaviour

The third aim was to examine whether reading behaviour influence the memorability of book covers. To this aim, we assessed whether participants' reading habits impact the memory task performances, specifically the d' and β scores. Number of the book participants read in a year, their reading frequency, and speed were used as a proxy of their general reading habits and used as the variables to predict the memory task performance in multiple linear regression models. As there are multiple predictors, we applied the model selection process using MuMIn package in R to select the best fit models.

Two global models, separately for d' and β , included the main effects of number of the book they read in a year, their reading frequency, and speed scores, all coded as continuous. Model selection was performed using dredge function in MuMIn package. Here, all possible subsets of the global model structure are assessed. Akaike's Information Criterion (AICs) was used to evaluate the model performance. The results of all model performance for both d' and β are reported in the Supplementary material (see Table S4). Below, we only report the result of best fitting models.

Regarding d' , the best model is the one only including intercept ($\beta_{\text{Intercept}} = 1.47, t = 14.49, p < .001, 95\% \text{ CI } [1.28, 1.69], \text{AIC} = 112.7$). Hence, the addition of any reading habits did not improve the model performance and they did not significantly impact the d' score. Regarding β , the best model includes the intercept and Reading frequency score (Intercept: $\beta = 0.82, t = 5.76, p < .001, 95\% \text{ CI } [0.54, 1.11]$, Reading frequency: $\beta = -0.08, t = -2.82, p = .006, 95\% \text{ CI } [-0.13, -0.02]$). Seeing the model coefficient, the result



suggests that the more often they read, the smaller the β . Hence, people who read more often tend to say yes more often in the recognition task.

Discussion

This study considered the differences in sensitivity of memory recognition and aesthetic evaluations according to the presentation of different book cover information. The primary aim was to see whether memory recognition performance was better with image or text informational cues from book covers. Memory performance was analysed using signal detection theory, which posits that recognition is dependent on the strength of the memory trace related to a decision criterion. In line with our hypothesis, differences were found in d' in accordance with information type, with greater recognition for the image than text features, alluding that manipulating which book cover information acted as a cue influenced memory sensitivity. From this, image features appear to strongly aid recognition of book covers, which supports previous findings that visual information strengthens memorability (Kulhavy et al., 1993; Levie & Lentz, 1982; Robinson et al., 2003; Verdi et al., 2014).

Furthermore, we also assessed β to reflect on response bias to prior presentation independent of memory performance. As with the d' sensitivity measure, β scores were also significantly different in accordance with information type. As a whole, participants responded liberally, being more likely to answer 'yes' irrespective of prior presentation (i.e., despite whether the book cover was a target or distractor stimuli). This response bias was significantly greater for the image features than text features as indicated with lower β scores; however, from this study it is not possible to determine if this result is attributable to the Image condition itself or not. This is because the information type (text/image) was a between-subjects factor and the same individuals are not partaking in both the text and image conditions. To ascertain whether there is a stronger response bias towards image features of book covers, it is suggested that future studies include information type as a within-subjects factor to account for individual participants' response tendencies.

The second aim was to address the effects of aesthetic quality on memory performance. To this aim, we looked at the relationship between hedonic responses (i.e., pertaining to beauty) for image content in target stimuli. The results did not verify the hypothesis that more aesthetically valued book covers would be more recognisable, with no significant effect on memorability in accordance with beauty ratings. The recognition of book covers in the image condition did not improve as a result of increased beauty, however a significant effect was found for familiarity and book contents. This indicates that the ability to correctly identify target stimuli is not impacted by how beautiful it is perceived. Instead, differences were found in memory performance according to the presentation of image features in relation to familiarity and the extent to which the book's contents could be inferred from the book cover image. Although we controlled for familiarity in our stimuli selection, in line with past research, it is still plausible that familiarity influenced recognition performance (Bastin & Van der Linden, 2003; Chana et al., 2023). Most interestingly, the effect of the book's contents was non-linear, suggesting a certain threshold of inferred information needs to be reached in order to improve memory. This finding is elaborated further in the subsequent sections of the discussion.

The lack of a hedonic effect might have been because the ratings were insufficient to create a stronger memory trace. Whilst it was supposed that beauty would drive memorability, book cover information that was rated less beautiful (i.e., ugly) was also well recognised. Accordingly, book cover information that evoked aversion could also be remembered, as arousal – regardless of positive or negative valence – may influence memorability (Chana et al., 2023). Moreover, these assessments were made based on the image features (text features were assessed in the same way for consistency in study design but only the image condition was used for this analysis) as opposed to the ratings of the book cover as a whole, therefore it is



unclear to what extent the visual features or word content affect participants' ratings and memory. This study highlights that the way aesthetic evaluations are made towards text and image information does indeed differ. Whilst this means that the aesthetic evaluations in the two conditions are not directly comparable, this draws attention to how book covers are assessed when both information types are presented together. Thus, if the entire book cover was evaluated (i.e., with both text and image information present), one can question how and what features are driving these evaluations of a book cover, given that the quality assessment of verbal and visual information is fundamentally different.

The third aim was to address the effects of reading behaviour on memory performance. The results did not verify the hypothesis that stronger readers would have better recognition. No statistical differences were found in d' in accordance with reading behaviours. The recognition of book covers did not improve as a result of reading behaviour. This indicates that the ability to correctly identify target stimuli is not impacted by individual reading habits, and the differences in memory performance according to the presentation of text or image features of the book cover is consistent regardless of reading behaviour.

Again, we also assessed β to reflect on response bias to reading behaviour. β scores were significantly impacted in accordance with reading frequency score. As a whole, participants responded liberally, being more likely to answer 'yes' in relation to reading frequency, with this response bias significantly greater for people who read more.

The interplay of text and image features

While this research has explored the effects of visual and verbal information/text and image elements on memory and perception independently, the combined impact of these modalities in book covers remains unclear. Therefore, in addition to analysing the effects of text and image in book cover design separately, a more cohesive understanding could be gained by further examining the effects of text and image in combination. Exploring how text and images work together to influence cognitive processing would address the notion of *congruence* between the features of a book cover (i.e., the extent to which these features impart the same information or meaning) and how this congruency impacts memory and perception.

The ITPC (Integrated Text-Picture Comprehension) model suggests that the effectiveness of combining text and images in creating a shared mental model depends on the semantic relationship between the two elements (Scholtz, 2014). For both text and image to effectively contribute to the mental model, they must share related meaning, facilitating a seamless integration. This extent of this alignment could influence how the elements of a book cover interact, with a more complementary relationship between text and image enhancing overall cognitive processing.

Alternatively, and contrary to dual-coding theory, which asserts that adding pictures to text always leads to better learning by providing two distinct memory codes, the ITPC model therefore also offers a different perspective. It suggests that combining text and images can sometimes have negative effects, particularly when the viewer has high prior knowledge. In such cases, the multimedia effect may be reduced or even suspended, as the added visual input may not offer new or useful information. Moreover, the ITPC model highlights that presenting both text and images simultaneously can divide the viewer's attention. The eye must switch between the two sources of information, resulting in split attention, which can disrupt cognitive processing and affect memory retention.

Processing fluency theory, on the other hand, suggests that stimuli that are easier to process are evaluated more positively, due to a preference for simplicity and clarity (Reber, Schwarz & Winkielman, 2004). When applied to book cover design, this theory could explain how the visual and textual components of the cover influence perception and memory. If the text and image are semantically related



and presented in a way that allows for efficient processing in working memory, this can enhance processing fluency. However, as outlined by the ITPC model, this requires both the text and image to be simultaneously available in working memory, which is necessary for effective integration (Scholtz, 2014). The interaction between text and image features of a cover could either enhance or hinder overall processing fluency and memory.

Therefore, as a development of this current study, future research should examine the integrations of text and image information together on memory retrieval. This may in turn lead to stark differences in accordance with reading behaviour, or even a more pronounced effect of aesthetic value, especially in response to the entire stimuli (i.e., visual/verbal information collectively). Understanding how their combination impacts cognitive ease and memory retention could provide further valuable insights into how the design of book covers—through its textual and visual elements—affects both immediate perception and long-term memory, ultimately shaping aesthetic judgements.

Evaluations of text and image informational content

One of the aims of this study was to consider how aesthetic evaluations influence the memorability of book covers. In doing so, we highlight that responses differ to text and image features of books. Indeed, as addressed in the analysis conducted, images and text are not evaluated in the same way – the way the beauty of an image is assessed cannot be likened to the beauty of plain text. For this reason, it does not make sense to compare both conditions in this way – and highlights how assessments of aesthetics for literary material differs when the focus is placed on verbal or visual information (see also Chamberlain et al., 2020; Chana et al., 2023). As such, this could also reflect further on what makes a text and image beautiful, given that thinking verbally or visually appear to be different processes. Therefore, a next step is then to explore how much of the way we perceive and respond to book covers is driven by visual beauty or semantic beauty. This could involve further investigations into the content depicted within the book covers, both in terms of images or text. For example, whether the image content is in the form of an artwork, illustration or photograph, or depicts everyday objects, scenes or people, could be seen as more or less beautiful. Furthermore, many studies have looked at verbal and visual information in text (e.g., semantics vs. typeface, see Childers et al., 1985; 2002; Melmer et al., 2013; Schnotz, 2014), which was not the focus of this paper.

Moreover, in everyday evaluations of books and with the phrase ‘judging a book by its cover’, it is not just the front-cover of the book but also the evaluations of the book content that also form a judgement of the book as a whole. This was not the focus of this study since the book covers were regarded as aesthetic objects rather than the books as literary devices, and we considered how evaluations would be made solely using this information. This choice was made to reflect the way in which books are often presented as consumer products, with the book cover tile on display. However, this does not reflect further interactions that people have with physical copies of books and other expectations, such as genre. For instance, flicking through the pages of a book in a bookstore in the decision-making process, gaging the book’s thickness as an indicator of how the number of words, reading the back-cover content including the blurb and price. Perhaps further investigations should take this into consideration, seeing as our study shows that the contents influence memorability in a non-linear fashion. This suggests the need to pick apart the semantic information inferred from text and image features and how they work together in our aesthetic responses to book stimuli.

Conclusions

This study reveals how responses are impacted by text and image informational cues, resulting in differences in memorability in terms of both sensitivity and response biases. Whilst we do see that image



and text features are recognised differently, with better memory performance for image/visual information, it is important to note that the role of text and image in the book cover design was looked at separately during the testing phase in this memory task. This provides insight into the differences in how features of book cover design are perceived and also how they aid memory retrieval; however, we are unable to draw conclusions as to how the *interplay* of text and image influences subsequent memorability and evaluations.

On a broader perspective, this research provides insights into how literature is initially perceived when presented in the form of a book and prior to reading the literary text itself. Perceiving a literary book as a visual object in this way shapes the subsequent evaluations. The different features that go into its design, namely visual and verbal information, are presented harmoniously in for aesthetic appeal whilst also acting as informational cues towards the book's content and quality. This study is one step towards understanding how this combination of text and image information in the design of a book cover influences how it is perceived, evaluated and remembered.

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2.3.2. Lab-based investigation: The naturalness of the everyday reading experience



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My Contribution:

CRediT author statement: **Akshay Mendhakar**: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Katarzyna Sierak**: Conceptualization, Data curation, Methodology, Writing – review & editing. **Kirren Chana**: Writing – review & editing. **Helmut Leder**: Supervision, Writing – review & editing.

2.3.2.1. Key findings

- In this research, we report the eye-tracking evidence of 80 participants during digital reading versus paper-based reading.
- Reading behaviour when using three popular reading mediums (PC screen, hand-held e-reader and iPad) were compared to a control condition (book reading) in 80 participants.
- Mean fixation duration was only statistically different for the PC reading condition.
- Reading time and total number of fixations were comparable for the e-reader, iPad and printed book reading conditions.
- The findings shed light on the adaptability of modern digital reading technology in mimicking text on the screen.

2.3.2.2. Original Manuscript

(see next page)



Does the reading platform matter? An eye-tracking study.

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Abstract

Most of the reading technology claims to provide similar reading experiences to that of a print paper. This study compared reading across different digital platforms and overall reading behaviour. Digital reading mediums used in this study were reading on a PC screen, a hand-held e-reader and an iPad. A total of 80 participants enrolled in various courses at the University took part in this experiment. Each participant was randomly assigned to one of the reading conditions, and subsequent eye-tracking measurements were compared. Results indicated that the mean fixation duration was statistically different only for the reading from the PC condition, whereas it was similar across all three conditions. The reading time and the total number of fixations were comparable for the dedicated e-reader, iPad and printed book. The present study adds to the empirical proof of eye-tracking evidence on the capability of e-reading tools to mimic an actual book reading condition closely.

Keywords: reading, medium, eye-tracking, digital, screen, technology



Does the reading platform matter? An eye-tracking study.

A recent report by Perrin (2022) indicates that at least three in ten people prefer digital books. Digital books only capture a market share of 10-20% of book sales (Milliot, 2014; Rainie & Duggan, 2012), despite a gradual fall in printed book sales in the past decade (Desilver, 2014; Tanner, 2014). These statistics have not changed drastically since the earlier report by Rainie and Duggan (2012). Initial user experience reports (Tenopir et al., 2012) showed that users' reading time on digital screens is similar to that of printed books. Other reports point towards a higher user engagement with digital books and a consequent acceptance of digital books into the mainstream (Dobler, 2015; Paczkowski, 2013). This has been possible due to the development of better digital tools coupled with a change in reading behaviour in readers (Labrecque et al., 2013; Tyner, 2014; Warschauer & Matuchniak, 2010). Reading behaviour refers to how readers interact with the text and approach the act of reading. It encompasses a wide range of cognitive, emotional, and physical processes measured at skill level, motivation, personal preferences, purpose of reading, medium of reading, etc. (McLaughlin, 2012).

Recent research (Liao et al., 2024) highlights the potential disadvantages of digital reading platforms, particularly in relation to metacognitive regulation and comprehension. Liao et al. (2024) emphasise that digital reading environments promote more shallow processing and reduced metacognitive regulation, especially with complex, time-sensitive texts. This phenomenon, referred to as the "screen inferiority effect", suggests that readers engage less deeply with digital texts, leading to potentially inferior comprehension outcomes.

Digital or electronic books¹ (e-books) are digital versions of physical books. E-books were introduced in the early 1970s. However, the concept of digital books and electronic text dates back even further (Mendieta, 2021). Depending on the device being used to read, it can be said that there are two categories of digital books. The first category is digital books intended to be used with dedicated e-readers such as Kindle Reader, Cybook Opus, Nook, etc. The second category of digital books is non-dedicated e-books, which can be read on any device, such as a tablet, personal computer, smartphone, etc. The evolution of these devices has continuously influenced reading behaviours (Leu et al., 2013), making it necessary to reassess their effects on cognitive and visual processing (Liao et al., 2024).

Modern-day digital reading tools and e-books augment the reading process more than traditional paper-based books by providing numerous additional features. These features include searching, correcting errors, annotation, hyperlinking, multimedia integration, and more. That being said, there are a few disadvantages of these digital books that have not been fully addressed, such as making notes, highlighting, turning pages back and forth. Additionally, key sensory elements such as tactility or haptic feedback (Mangen & Kuiken, 2014) and bibliosmia—the smell of books (Driscoll & Squires, 2018)—are lost in digital formats, which may affect overall reading engagement (Spence, 2020; Cuiñas & Augusto, 2022).

Researchers have systematically conducted experiments which try to compare the reading behaviour across digital tools and paper-based reading (Baron et al., 2017; de Jong & Bus, 2002; Gallant et al., 2008; Kerr & Symons, 2006; Kong et al., 2018; Liao et al., 2008), with inconsistent findings. Whilst no significant differences have been reported across the reading mediums in some studies (Grimshaw et al., 2007; Murray & Pérez, 2011; O'Toole & Kannass, 2018), others point to the advantage of paper over digital reading (Ackerman & Lauterman, 2012; Guimbretière, 2003; Korat & Shamir, 2007; Kurata et al., 2016; Liu, 2005; Macedo-Rouet et al., 2003; Mangen et al., 2013). Contrariwise, a growing number of reports point to

¹ We refer to e-books and digital books synonymously in this manuscript.



the superiority of digital reading in comparison to paper (Abanomey, 2013; Arsham, 2002; Aydemir et al., 2013; Ebrahimi, 2016; Korat & Shamir, 2007; Moody et al., 2010). The superiority of digital reading devices has been made possible due to improved affordance in portability, connectivity, adaptability and storage of digital text (Ballatore & Natale, 2016). Though there are numerous benefits of digital reading devices, studies point to the inconsistency in reading behaviours and can be accredited to two significant factors; i.e., the rapid change in digital technology and the complex nature of reading behaviour.

Technical variabilities in digital reading devices are speculated to significantly impact reading behaviour (Benedetto et al., 2013). Early digital tools, for example, were associated with poor display resolution, variable refresh rate, and contrast levels (Dillon & Emurian, 1995). Additionally, such tools have been shown to induce visual fatigue in readers, which is unsuitable for sustained reading (Garland & Noyes, 2004; Lee et al., 2011; Mangen et al., 2013; Sellen & Harper, 2003).

With technological advancements, however, digital reading tools have employed faster microchips and machine learning algorithms to render the text as close to printed text as possible. Modern digital readers make use of electronic paper display or E-Ink display technology. These advancements, particularly E-Ink displays, have addressed some previous concerns by offering low-glare, energy-efficient alternatives to LCD and OLED screens (Liao et al., 2024). E-Ink displays are reflective and do not emit light directly, which reduces eye strain and glare. They are energy-efficient and can hold text without power, making them ideal for e-readers. E-Ink technology works with wide viewing angles similar to paper, with minimal to no glare, reflections, and flickers. Current e-readers can mimic the text on the screen and also augment textual features with interactive elements (Burstyn & Herriotts, 2010; Lahey et al., 2011; Prensky, 2013; Watanabe et al., 2008). Major publishing houses have embraced this digital reader trend and have invested heavily in developing digital reading solutions. Coupled with the undeniable convenience of accessibility and portability of digital books (Waycott & Kukulska-Hulme, 2003), the current digital reading tools claim to provide the closest digital rendering of text.

Although the technology has evolved, challenges such as screen-induced cognitive overload and fatigue persist, especially when reading complex texts (Liao et al., 2024). Digital readers not only encompass e-readers but also multiple other platforms, such as computer screens, iPads, smartphones and tablets. Not all of them employ the E-Ink technology and instead use a range of technologies such as Liquid Crystal Display (LCD), Light-Emitting Diode (LED) display, Organic Light-Emitting Diode (OLED) display, Active Matrix Organic Light-Emitting Diode (AMOLED). These technologies differ in technical specifications and form the basis for variable reading behaviour shown in the previous studies (Lin et al., 2013; Köpper et al., 2016; Siegenthaler et al., 2012). Therefore, it is essential to acknowledge the technical specifications of digital reading platforms while comparing the mediums used in reading experiments.

Additionally, variability in the reports on reading behaviour across screen and print can be accredited to the complex nature of reading behaviour and its measurement. Previous studies have reported reading behaviour using measures such as reading speed, reading comprehension, experiences, and preference (Delgado et al., 2018; Dillon, 1992; Schwabe et al., 2021; Singer & Alexander, 2017). Reading behaviour is viewed as a multifaceted interaction of factors grouped according to the reader, the reading situation and the text. Reading starts with the visual perception of symbols and is further processed by higher cognitive processes to derive meaning. With the studies focusing on measuring reading behaviour, the first step would be to systematically compare readers' eye movements to understand the influence of reading medium on reading behaviour (Rayner, 1978).

Eye-tracking studies have increasingly shed light on how different reading mediums affect visual processing. The earliest report by Dillon et al. (1988) highlighted broad differences in processing across screen and paper reading. Screen-based reading was associated with being slower, less accurate, more fatigued, decreased comprehension, and rated inferior by readers. They argued that screen display



quality was crucial in these findings, suggesting inferior screen reading. Similarly, multiple review reports comparing the reading behaviour on screen versus book reading suggest mixed findings (Clinton, 2019; Delgado et al., 2018; Dillon et al., 1988; Singer & Alexander, 2017; Walsh, 2016).

As screens have improved, more recent studies highlight how newer technologies mitigate some of the earlier limitations of digital reading, although the fundamental cognitive differences still remain (Liao et al., 2024). There has been a change in the technical features of screens, which might impact text rendering capabilities (Castellano, 1992); therefore, many empirical studies evaluate the different reading mediums based on such features. An early study by Osborne and Holton (1988) compared reading on screens with dark and bright background displays to that of paper-based reading. Their results did not find any significant differences in reading speed and comprehension. Following this landmark study, multiple other empirical experiments have shown mixed findings when comparing screen versus paper reading (Nielsen, 2010; Siegenthaler et al., 2011; Zambarbieri & Carniglia, 2012). Nielsen (2010) compared reading across an iPad, Kindle and a printed book, reporting a slow reading pace on Kindle (10.7%) and iPad (6.2%) over traditional print books. Similarly, Siegenthaler et al. (2011) compared the reading processes on e-ink displays and print, reporting that the reading behaviour of e-readers produced similar proportions of regressive saccades to that of print. These results were not replicated in a successive study by the same researchers (Siegenthaler et al., 2012). Zambarbieri and Carniglia (2012) compared reading behaviour across a PC, iPad, and Kindle DX reader based on comparable eye-tracking features for digital and print reading. They found that PC-based reading produced significantly different mean fixation durations, whereas the other conditions showed no significant differences. Similarly, Miranda et al. (2018) reported that fixation duration during computer reading was longer than during print, tablet, and smartphone reading. A recent study by Jeong and Gweon (2021) examined the effects of the reading medium (print vs. digital) on readers' visual patterns, reading performance, and reading attitudes. Their two within-subject experiments compared the visual reading on three reading media: print, computer, and tablets. Their results demonstrated a shorter fixation duration and a higher fixation count during print reading than during screen reading. They also concluded that there are lower perceived fatigue levels when reading printed text than when reading from a device screen. The study concluded that the performance gap between print and screen reading is narrowing.

Given the mixed results on visual processing across mediums, additional studies are required to draw more definitive conclusions. Despite extensive research on visual processing in reading, only two recent studies have systematically compared different reading mediums. The comprehensive study by Zambarbieri and Carniglia (2012) is now a decade old, and rapid technological advancements may have produced enhanced visual processing results. Moreover, the recent study by Jeong and Gweon (2021) did not include Kindle readers, a significant omission given their popularity (Garland & Noyes, 2004).

The present study seeks to address these gaps by using eye-tracking methods to compare the visual processing patterns between paper-based and digital reading platforms, including PC, iPad, and Kindle. Since the early reports of Dillon et al. (1988), reading speed and accuracy have been considered the variables under investigation. Earlier studies using eye-tracking methods consistently utilised outcome measures such as the number of fixations, fixation duration and reading time (Jeong & Gweon, 2021; Miranda et al., 2018; Schwabe et al., 2021; Siegenthaler et al., 2011; Zambarbieri & Carniglia, 2012). Therefore, the current study tried to build upon the previous experiment by Zambarbieri and Carniglia (2012) and compare the screen and print conditions by considering the same experimental variables. The visual processing while reading three different digital reading mediums (PC reading, iPad, Kindle) and traditional book reading is reported in this paper. In the current study, the reading behaviour is evaluated by the visual processing of text, and henceforth, in this paper, when we say reading behaviour, we refer to the visual processing of text while reading. In addition, meta-analysis reports (Kong et al., 2018; Schwabe et al., 2021) on reading across screens and papers have suggested that a between-subject design is more commonly used. While we report the within-group variability, the design followed by the current



experiment will be a between-group experiment. This research design would help us compare the results with previous reports and get a better insight into the evolution of digital mediums. Even though the measurement of reading comprehension and reading experience will provide a complete picture of reading, we chose to exclude both these measures as the plan was to comment upon the visual processing/reading differences across mediums. We were interested in determining which digital platform produces eye-tracking parameters (i.e., reading time and fixation measures) closer to reading on paper and if there are any differences across reading on a PC, iPad and Kindle reader.

Methods

This study was conducted in association with the Laboratory of Experimental Oculographic Linguistics at the University of Warsaw and the Empirical Visual Aesthetics lab at the University of Vienna. To empirically test the aim of this study, three different digital reading tools (experimental conditions) and reading a physical book (control condition) were compared. The technical specifications of reading conditions, i.e., a Dell PC, an Apple iPad, an Amazon Kindle reader, and a printed book, are summarised in Table 1.

Table 1. Technical specifications of reading conditions of the study

Device	Size	Weight	Font size	Display type	Display size	Screen pixel density	Screen resolution	Luminance/ Contrast ratio
PC (Dell 22)	19.9 inches x 15.1 inches x 7 inches	2671 grams	2.4 mm	LED-backlit LCD monitor / TFT active matrix	21.5 inches	103 ppi	1920 x 1080	300 cd/m ² , 1000:1
iPad (10 th gen)	9.79 inches x 7.07 inches x 0.28 inch	481 grams	2.3 mm	LED-backlit Multi-Touch display with IPS technology	10.9 inches	264 ppi	2360 x 1640	500 cd/m ² , 1500:1
Kindle (11 th gen)	6.2 inches x 4.3 inches x 0.32 inch	158 grams	2.2 mm	E Ink display	6 inches	300 ppi	N/A	80 cd/m ² , 15:1
Book	10 inches x 8 inches x 0.44 inch	394 grams	2.2 mm	N/A	N/A	N/A	N/A	200 cd/m ² , 10:1

Participants

Eighty participants (26 male, 54 female; $M_{age} = 25.2 \pm 4.6$ years; age range = 18 to 34 years), enrolled in various university-level programs, were included in this study. Participants were recruited via online advertisements disseminated across multiple social media platforms. Interested candidates were then screened based on specific inclusion and exclusion criteria.

The exclusion criteria for the experiment included defective eyesight; participants with spectacles or corrected vision were excluded from the study. Additionally, only participants with at least a B2 level of English proficiency were considered. Selected participants were further screened for any cognitive, memory, language, or reading difficulties using the Montreal Cognitive Assessment - MoCA (Nasreddine et al., 2005), the Language History Questionnaire - LHQ3 (Li et al., 2006), and an adaptation of the Reading Habits Questionnaire (Kuijpers et al., 2020). These assessments evaluated participants' reading skills, including their reading acquisition, preferences, and habits.



Participants who met the criteria were assigned to one of four groups (three experimental and one control) and completed the assigned reading tasks. This subgrouping ensured that age, gender, and reading acquisition levels were matched across the conditions.

Materials

Pride and Prejudice by Jane Austen was chosen as the experimental material for this study. This is a classic literary novel used by multiple researchers in the field of linguistic and literary experiments due to its story structure and language complexity. During the experiments, the first two chapters of the novel were read in the printed edition (Control condition- C4) and eBook format (Experimental condition 1-3) in English (L2). While the digital tools allowed manipulations of physical attributes of the text, such as text space on the screen, font size and font type, they were maintained as constants and matched across all the conditions.

Eye movements were recorded using Tobii Pro Glasses 3. No external head mount/chin rest was used for this study to closely represent natural reading conditions. Binocular eye tracking was carried out with a sampling rate of 100 Hz and a spatial accuracy of 0.6°. At the start of eye tracking, one-point calibration was carried out for each participant.

Procedure

Each participant was seated comfortably in a chair, and informed consent was obtained.

Experimental condition 1

The text was presented on a Dell 22-inch computer monitor with a screen resolution of 1920 x 1080 in an e-book format using Adobe Acrobat Reader (see Table 1). The participant was seated 60cm from the computer display, and a one-point calibration was performed before the test presentation (Benedetto et al., 2013). The participant was then instructed to read the text comfortably and silently.

Experimental condition 2

The text was presented on an iPad in an e-book format using Adobe Acrobat Reader. The distance between the reader and the screen was maintained at a distance of 60 cm distance with the help of an external stand. However, once the experiment started, the device could not be moved.

Experimental condition 3

The text was presented on a dedicated Amazon Kindle reader at a distance of 60 cm. Participants could choose whether to place the device on their lap, hold it in their hands, or position it on a desk using an external stand. However, once the experiment began, the device could not be moved.

Control condition

The text was presented in a traditional printed book. Participants could again choose whether to hold the book in their hands, place it on their lap, or set it on a desk. The distance between the text and the presenter was maintained at 60 cm across the experiment using an external stand.

All conditions were conducted under similar environmental conditions, with consistent ambient lighting. The total reading time varied for individual participants, and at the end of the reading, participants were debriefed and thanked for their participation.



Data analysis

The eye-tracking data collected in this study were analysed using Tobii Pro Lab. Holmqvist et al. (2011) recommend using a predetermined list of eye-tracking measures to avoid a ‘fishing trip’ approach, which involves searching for statistical significance across too many metrics. Therefore, this study focused on evaluating reading time and fixation measures (Jeong & Gweon, 2021; Miranda et al., 2018; Schwabe et al., 2021; Siegenthaler et al., 2011; Zambarbieri & Carniglia, 2012) from each participant, comparing these metrics between subjects and across different study conditions.

The definitions and standard protocols for analysing these eye-tracking measures were based on the Tobii Pro Lab user manual. Since participants’ head movements were not restricted to simulate a natural reading environment, we anticipated greater variability in the eye-tracking parameters. The numerical data extracted from each participant were systematically tabulated and subjected to statistical analysis.

Results

The tabulated data were checked for normality using the Shapiro-Wilk test, indicating a normal distribution for eye tracking parameters ($p > 0.05$). Therefore, a one-way ANOVA and pairwise post hoc analysis were used to find differences across the study conditions. The following sections report the results under parameters related to reading time, total number of fixations, and fixation duration.

Table 2. Eye tracking parameter comparison across different conditions in the study.

Condition	Reading duration (s)		Total Fixations		Fixation duration (ms)	
	Mean	SD	Mean	SD	Mean	SD
PC	478.1	143.4	519.3	122.7	226.2	98.2
iPad	523.7	156.9	627.5	174.5	212.3	101.1
Kindle	503.4	150.9	592.3	124.3	205.7	95.4
Book	509.7	152.7	570.5	136.5	207.8	82.1

Reading time

Multiple research studies have measured reading time as a window into the reading process (Rayner & Reichle, 2010). Therefore, total reading time was documented and compared within the group and across the conditions. Table 2 highlights the reading time across different conditions. It was noted that mean reading time across the reading conditions was smaller than the standard deviations across the groups; i.e., a 30% standard deviation was noted in each group. Following the main differences noted from ANOVA, a post hoc analysis using the Tukey test was conducted. The results showed that reading time was significantly faster on the PC (478.1 ± 143.4 sec, $p = 0.046$) and iPad (523.7 ± 156.9 sec, $p = .034$) compared to reading a book (509.7 ± 152.7 sec). However, there was no significant difference between the book and Kindle reading conditions ($p = .989$).

Fixation measures

Similar to reading duration, fixation-related measures give an insight into the reader’s cognitive ability while reading (Carpenter & Just, 1981). Data in Table 2 compares fixation duration on individual words in milliseconds across the conditions. It can be noted that similar to reading time, the group-wise differences were smaller than the within-group variation (Table 2). A statistically significant difference between the experiment conditions was noted using a one-way ANOVA test: $F(3, 56) = 3.48$, $p = 0.02$. Other group-wise exploration revealed a mean fixation duration was significantly different for PC (longer) versus all other conditions, whereas no statistical significance was noted across iPad, Kindle or printed books



(Table 3). These results support the versatility of handheld devices like iPad and Kindle in mimicking traditional paper-based reading.

Table 3. Comparisons of T-test significance value (p) of mean durations.

Fixation duration	PC	iPad	Kindle	Book
PC	–	0.005*	0.007*	0.04*
iPad	0.004*	–	0.43	0.45
Kindle	0.007*	0.43	–	0.07
Book	0.04*	0.45	0.07	–

* Asterisks indicate significantly different values ($p < 0.05$).

The total number of fixations significantly differed across the conditions: $F(3, 56) = 4.9$, $p = 0.004$. The post hoc analysis noted a similar finding from the fixation duration; i.e., fixations produced by iPad and Kindle readers are comparable to that of an actual book ($p > 0.05$) except for PC versus book reading with a statistically significant lower number of fixations ($p = 0.003$).

Discussion

Digital reading tools claim to provide reading experiences equivalent to paper-based reading, and this study set out to empirically test the current technology using eye movement measurements. In this study, we compared print versus digital, with three variations of digital reading. Four conditions were compared, and the following eye movement characteristics were analysed. The study mainly focused on the replicability of eye-tracking behaviour while reading on paper and how different digital mediums compare to it. In the result section, we highlighted the critical differences in reading across the different protocols of the study in terms of reading time and fixation-related measures. The word skipping rate of 0.47 ± 0.26 highlights the complex interplay between attentional processes and eye movement in readers (Morrison, 1984; Pollatsek & Rayner, 1990; Henderson & Ferreira, 1990) with similar reading habits and language expertise.

Reading time is significantly correlated with the processing of text (Rapp & van den Broek, 2005) and effort (Chen & Catrambone, 2015). We noted a shorter reading time of 478 seconds for PC reading, the fastest reading time across the conditions. Faster reading time for PC-based reading is supported by previous reports which suggest reading on a PC alters eye movement behaviours due to changes in screen characteristics like resolution, refresh rate, screen size, lighting and contrast level (Garland & Noyes, 2004). Similarly, the longest reading time (523 seconds) was noted for iPad-based reading. As iPads are multifunctional devices that can be used for communication, organisation, or leisure activities (Siegenthaler et al., 2012), they are not intended solely for reading and would not be the ideal platform for sustained reading. That being said, multiple reports (Siegenthaler et al., 2012; Benedetto et al., 2013) discuss that reading behaviours are influenced by the purpose of reading, and visual fatigue is one crucial factor that needs to be considered regardless of the platform of reading.

Reading time on a book and Kindle reader was similar (509 and 503 seconds, respectively). Statistical tests further explored this, but they did not reveal any differences. Kindle uses the Ink e-paper technology, mimicking the paper as much as possible. E-paper technology used in modern Kindle readers claims to provide a paper-like reading experience of up to one hour (Benedetto et al., 2013). The current findings add to the claim that tablet reading and e-ink-based devices do not differ significantly in reading (Lee et al., 2011; Siegenthaler et al., 2012). Nevertheless, in light of the current experimental findings, it has to be noted that the variability within the group was very high, which can be associated with the variable nature of the reading. Factors such as reading habits, reading preferences, level of attention and vigilance can influence reading (Kuijpers et al., 2020).



A previous study by Dillon (1992) on reading from screen versus paper showed a slower reading time on screen, which causes visual fatigue. However, meta-analysis reports reveal inconsistent findings in this avenue (Chen & Catrambone, 2015; Singer et al., 2019) and longer reading times for screens in others (Connell et al., 2012; Daniel & Woody, 2013). Earlier e-readers and their text rendering capabilities were primitive, requiring a reader's cognitive capacities to be split (Hillesund, 2010; Mason et al., 2013). In our experiment, we noted that reading on screens is similar to reading on paper. This aligns with previous studies on eye movements associated with reading on e-ink-readers and print (Siegenthaler et al., 2011). Reading time comparisons in our experiment did not reveal significant differences and were similar to reports of Siegenthaler et al. (2010). Our findings did not support the report by Nielsen (2010) that reading on a tablet was slower than reading a classic paper book.

Fixation duration is an established measure of cognitive processing during reading (Just & Carpenter, 1980; Menz & Groner, 1984). Previous reports have suggested a negative correlation between fixation duration and interrupted reading processes (Rayner et al., 2006; Reingold & Rayner, 2006). In our experiment, it was noted that the total number of fixations and fixation duration when reading over a PC were significantly different when compared to the reading in the other conditions. These findings are analogous to those from past research, which found stark differences in Kindle versus PC reading, and also go further to suggest that Kindle is better than PC reading, associated with impaired reading performance (Siegenthaler et al., 2011) and higher visual fatigue (Kang et al., 2009). Reading on a PC produced a longer fixation duration, suggesting that individuals who read text on a PC screen tend to blink less frequently to compensate for interruptions/ visual fatigue in reading processes, resulting in longer fixation duration. This can be associated with an adaptive mechanism that allows individuals to maintain continuous visual input and avoid disruptions in information intake.

However, it is important to note that our findings contrast with those of Jeong and Gweon (2021), who reported shorter fixation durations for screen-based reading, including on a PC, compared to print reading. Several factors could account for this discrepancy. First, differences in screen characteristics between the studies may have influenced fixation duration. In our study, the physical characteristics of the PC monitor used may have led to increased visual fatigue, leading to longer fixation durations.

Additionally, the cognitive load associated with reading on different devices might explain the divergent results. In our study, longer fixation durations on PC screens could indicate that readers experienced higher cognitive demands, as previous research has suggested that reading on screens may impose greater cognitive load compared to print due to factors like glare, text clarity, and screen refresh rates (Garland & Noyes, 2004). This aligns with findings from other studies that suggest readers adapt their eye movements when encountering visual fatigue or interruptions (Rayner et al., 2006; Siegenthaler et al., 2011).

It is also possible that the nature of the reading task and the participants' goals may have differed between our study and that of Jeong and Gweon (2021), influencing eye movement behaviour. For instance, participants in their study might have engaged in more efficient reading strategies, resulting in shorter fixation durations, whereas in our study, participants might have processed the text more deeply, particularly on the PC, which could have led to longer fixation durations as a compensatory mechanism.

Previous reports have evaluated factors like reading comprehension (Mangen et al., 2013) and speed of processing word identification (Kerr & Symons, 2006). As highlighted in our review, this study investigated reading differences at the fundamental level of eye movements. Therefore, no specific comprehension test or reading experience questionnaires were employed. When the eye-tracking results of the present study are considered alongside the findings of Rosenfield (2011), Siegenthaler et al. (2012), Zambardi & Carniglia (2012) and Benedetto et al. (2013), we refine our understanding of the unique functionalities of print, e-paper, and PC screens. It can be said that even though there is a significant difference noted for all



eye-tracking measures, PC and, to some extent, iPad screens are well suited for shorter reading sessions due to superior legibility and screen contrast (Findlay & Gilchrist, 2003; Dyson, 2004)—shorter texts like newspapers, magazines and articles. However, texts like novels and textbooks are better suited for e-paper/e-Ink technology. A significant replication of book-like reading on these screens would mimic the book-reading cognitive processes while reducing eye strain (Kang et al., 2009; Lee et al., 2011; Conlon & Sanders, 2011).

The present study expands earlier reports on modern-day digital reading platforms in multiple ways. First, it allowed for within-group comparisons of the eye-tracking parameters on the same reading task for the same text. As such, it provided a more detailed picture of the complexity of reading and how it depends entirely on the reader to make a reading situation successful. Secondly, the text length was one of the strong points of our experiment; in our experiment, the text length was longer, with more than 500 words, which was highlighted in previous studies as something that future research should adopt (Davis & Neitzel, 2012; Mangen et al., 2013). Using a longer text, we measured the reading behaviour of the participants to comment upon the long-term eye movement behaviour and how the reading medium influenced it. Previous reports have shown that reading across different mediums does not differ for shorter texts (Ali et al., 2013; Eden & Eshet-Alkalai, 2013; Margolin et al., 2013). Thirdly, the factor of reading pace was set by the participant. This eliminates the Shallowing Hypothesis proposed by Annisette and Lafreniere (2017), which turns the reading artificial when conducting experiments. Though we find a variability in reading of around 30 - 40%, the experimental design of reading at their own pace is better. High variability within the group highlights the variable nature of reading and the complex nature of reading and its measurement. This is closer to the real-life reading (Lauterman & Ackerman, 2014; Delgado et al., 2018).

The outcomes of the current experimental findings highlight the readers' abilities to adapt to reading changes across mediums to convert any reading situation into a successful one. Moreover, the current study revealed the superiority of digital mediums in representing text as close to paper as possible. The lack of any major differences in eye movement measures across the study conditions suggests that medium plays a minimal role, at least at the level of oculomotor movements.

The reading habits of participants and how they influence reading is a promising avenue for future research. It is speculated that avid readers generally prefer books over digital mediums (Kuijpers et al., 2020), and conducting a similar study that measures their eye-tracking behaviour would provide better insights into how the reading medium might facilitate or inhibit reading. A major drawback of the current experimental design is the exclusion of a measure of comprehension. Future studies could replicate this work with a larger, more homogeneous population (ensuring equal representation of males and females) and a detailed focus on additional reading elements such as comprehension tests, word recognition, recall, and narrative engagement. Additionally, the present study did not account for L1 or L2 English proficiency levels; instead, it considered a minimum B2 level of proficiency. Future research should investigate this variable in detail. Incorporating experimental protocols such as think-aloud procedures or other rating scales for reading experience may provide deeper insights into reading behaviour.

Despite the advancements in digital mediums representing text closely to printed text, it remains unclear whether the cognitive process of print reading differs fundamentally from screen reading. Successful reading experiences depend on multiple variables grouped under the reader, the reading situation, and the text (Jacobs, 2015). In comparison, a vast array of research compares reading speed, comprehension, and feedback on reading experiences (Rayner, 1978), and our experiment aimed to test differences at the objective level of eye tracking empirically. To fully understand successful reading experiences, future studies should include measures of reading comprehension and reading experience questionnaires. Given the highly individualistic nature of reading, the variability observed within groups needs to be addressed in future experiments.



The implications of the present study are significant for multiple professionals. Many researchers have documented the benefits of digital tools in enhancing student learning and reading. Educators planning to incorporate new technologies and policy designers must be aware of medium-specific differences in reading. Furthermore, these results are valuable for researchers working on human-computer interaction systems like Eyebook (Biedert et al., 2009) and WebGazeAnalyzer (Beymer & Russell, 2005).

Conclusion

As highlighted in our review, the way people read is evolving due to the development of digital tools. These changes are reflected in recent user engagement reports (Paczkowski, 2013; Perrin, 2022). The debate over print versus digital reading is an ongoing one with polarising claims in reports such as '*Print is dead*' (Gomez, 2008) to a responsive report by Carrière and Eco (2011) titled, "*This is not the end of the book*". Lauer (2020) suggests that this debate is a positive move in reading since more and more people are reading regardless of the reading medium.

Digital reading tools have brought a digital revolution with obvious advantages over traditional books. Changing multiple physical characteristics of the text and augmenting them with interactive multimedia elements opens up various possibilities for reading (Conlon & Sanders, 2011). Measuring eye movements provides insight into the cognitive state of the brain. In this study, eye movements were evaluated during reading on different mediums. The design of the experiment was set up close to an actual life reading situation, with participants free to read at their own speed. By comparing different digital reading tools in this experiment, it can be concluded that reading on a Kindle reader is the closest to the paper reading experiment. Even though reading on a PC produced statistically different eye-tracking parameters in this study, when considered alongside previous research findings (Rosenfield, 2011; Benedetto et al., 2013; Kretzschmar et al., 2013), it enhances our understanding of digital reading. Even though Kindle reading produced the closest eye-tracking measures in our experiment, some features, like the haptic dissonance of e-readers and bibliosis, still have to be addressed by further developing e-readers (Mangen & Kuiken, 2014). However, Kindle readers and iPads are evolving to include more extended reading and other highly cognitively challenging tasks. Since the reading time and fixation-related parameters were noted in this study, it can be concluded that digital reading does not significantly influence the reading medium.

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3. Discussion

In the discussion section, I reflect on the conclusions drawn from the manuscripts, corresponding with the preceding chapters, in relation to the overarching objective of this doctoral thesis. Through a combination of theoretical, field and lab-based methodologies, the dissertation is a first step in exploring the intersections between reading behaviour, visual stimuli, graphic design and urban design. This research contributes to develop a more comprehensive understanding of text aesthetics within urban environments and opens avenues for future interdisciplinary research on reading, everyday environments, and empirical aesthetics, further advancing the study of how we engage with and understand our surroundings.

3.1. Theoretical Perspectives

“When most of the world is characterized as urban, more than ever we must explore those characteristics of urbanism that offer us the chance to reinforce the essential qualities of a city.”

(Sudijc, 2016, p. 219)

Approaching reading from the perspective of environmental aesthetics allowed for the exploration of urban and everyday reading from an aesthetic point of view. From the standpoint of everyday aesthetics, this explored how the act of reading is reshaped and how a cognitive science approach to exploring reading can lead to future developments in the empirical study of literature that do not disregard text aesthetics. From the standpoint of urban aesthetics, this meant understanding how urban text and aesthetic reading experiences fit within the broader empirical research conducted on the aesthetics of the urban environment (Chana, Dehove et al., subm.).

3.1.1. Everyday aesthetics and the future of text reading

Within the framework of environmental aesthetics, everyday aesthetics constitutes a wide range of activities (see §1.3.). Reading, as one such everyday activity, could be argued to be one of the most pervasive and mundane undertakings in daily life. The shifts that we see in the perpetual flux of day-to-day existence are also evident in the shifts in everyday text reading that address our fluctuating needs and perspectives. The history of reading is also a history of aesthetic transformation; thus, we see through this evolution how texts have been shaped, encountered and valued as artful objects and interpretative experiences.

These shifts, however, continue to the present day. In our ever-changing world, the reading process, despite its historical roots dating back many millennia to ancient Mesopotamia, continues to

evolve. From the diverse text materials, to digitalisation, advances in typography, and shifting focuses to response, this is reflected in the measurements of text reading in empirical study. These developments and the historical time course lead us to consider the future of text reading, including how tools to enhance text aesthetics (Mendhakar et al., 2024, 2025)) and the approaches to reading.

Maintaining a forward-looking stance and anticipating shifts in the field, it becomes apparent that the future of text reading will be epitomised by increased focus on personalisation, multisensory engagement and aesthetic optimisation. As reading practices expand across digital and physical platforms, text environments will need to respond dynamically to the reader's content and preferences. Rather than adhering to a standard method of textual presentation, further developments ought to embrace a pluralistic approach that allows for a rich spectrum of functional and aesthetic configurations. By integrating insights from empirical aesthetics, computational linguistics and the like, the next generation of reading tools will not only facilitate information transfer but also foster deeper aesthetic experiences, and thus simultaneously reinforcing reading as an everyday aesthetic activity. Hence, the evolving landscape of text reading encourages a reimagining of the form and function of written material, ensuring they remain receptive, meaningful and aesthetically resonant to the complexities of everyday life.

3.1.2. Urban aesthetics and the future of text-based research

Urban aesthetics is shaped by design elements, such as buildings, streets, signage, which influence how people experience and engage with their environment. While attention has been given to the visual appeal of these components or to the urban environment as a whole, less focus has been placed on specific features like text, which plays a significant role in urban communication and design. In our scoping review, Chana, Dehove et al. (subm.), we highlight the underrepresentation of text as an aesthetic component in urban research and its potential to influence the way people perceive and interact with urban environments.

A key finding from the review is that certain categories of urban components warrant further investigation, both to reduce the gaps and to better understand which urban components have received limited attention in empirical research. While some urban components are frequently studied, such as architectural elements and green spaces, others receive far less attention. Some components within the 'Structural/Infrastructure' category, such as construction sites (Seresinhe et al., 2017), only appeared once in the reviewed research articles. As our cities are constantly evolving – being dismantled, rebuilt and improved – it is important to consider the impact of these transitional moments within the city landscape on the urban populations. Other components that are linked to the presentation and exchange of

information, such as art/cultural elements, building materials and textual elements like signage, were also found to be underexplored. Similar to art, signage, and other textual elements have been framed as ‘urban aesthetic’ objects and should also be researched more within this context (Chana et al., 2023; see Kim & Park, 2020 and Mitschke et al., 2017 from the reviewed articles).

Another key observation from Chana, Dehove et al. (subm.) is that much of the existing research examines multiple components together rather than focusing on the individual contribution of specific components. Few studies have specifically isolated text as a distinct aesthetic component, but it is often incorporated into a larger composition (Kim & Park, 2020; Mitschke et al., 2017). As a result, the distinctive visual and communicative roles of text, and its isolated aesthetic impact in the urban environment, remain underexamined. Yet, given its importance in communication and navigation, text warrants more dedicated investigation to assess its specific influence on urban aesthetic experiences.

Beyond text, several other areas in urban aesthetics remain underexplored. Certain sensory modalities—such as auditory and olfactory stimuli—are rarely studied, despite their potential influence on how we experience cities. For example, construction sites, which constantly reshape the cityscape in real time, offer a compelling example of an underrepresented component, having only been examined briefly in studies like Seresinhe et al. (2017). Likewise, the dominance of visual aesthetics leaves little room for considering how non-visual sensory inputs affect mood, comfort, or perception. Expanding urban aesthetic research to include these dimensions, alongside a deeper investigation of text, would provide a more comprehensive and multisensory understanding of how people interact with the constantly evolving urban landscape.

A common trend across the literature is the frequent use of classic ‘hedonic’ aesthetic dimensions (e.g., Attractiveness, Beauty, Complexity, Interest, Liking, Preference, Pleasure, etc.). While these dimensions are certainly important for capturing surface-level preference, they fail to fully represent the complex ways in which urban aesthetics is explored, also when capturing how urban design affects wellbeing. Another important insight is therefore the potential link between urban aesthetics influencing wellbeing, aligning with findings from natural environments (e.g., Yao et al., 2021). However, many studies lack systematic approaches or consistent methods of measurement, limiting the ability to draw definitive conclusions. Whilst there is certainly scope for further systematic reviews on the topic, the diversity of aesthetic dimensions reported, especially the use of highly specific adjectives, complicates comparisons across studies and limits the feasibility of conducting a meta-analysis.

The review also acknowledges several limitations. One challenge is the variability in terminology used to describe aesthetic experiences, which hinders cross-study comparison. The semantic differential scales employed by some studies contain very specific adjectives, making comparisons across studies

difficult. Additionally, the geographic scope of the studies included in the review is narrow, which means the findings may not be applicable to all urban contexts. Expanding the research to include a broader range of cities and regions would allow for a more nuanced understanding of how cultural and local factors shape perceptions of urban aesthetics.

Looking ahead, the review offers a roadmap for future research. A key next step is to explore text more systematically within urban aesthetics research. Isolating components like signage, public information, and street names, will allow for a better understanding of its impact on how people navigate and interpret urban spaces. This could involve studying how factors like font, colour, and placement of text influence perception and the overall aesthetic experience. Additionally, research should expand beyond the visual and investigate other sensory modalities. Auditory, tactile, and olfactory components can have significant effects on people's emotional responses to urban environments. Exploring how these elements, in conjunction with visual stimuli like text, shape the overall aesthetic experience of cities will offer a richer understanding of urban aesthetics.

3.1.3. Overall

Taken together, these two papers based on everyday and urban aesthetic suggest how to further develop research, rethinking reading as a cognitive act situated in urban aesthetic experience. Drawing on insights from empirical aesthetics, this encourages a multidisciplinary outlook combining cognitive science, psychological aesthetics, environmental psychology and the humanities. By bringing the aesthetic dimension of reading into conversation with broader environmental and urban contexts, this research highlights how text can function not only as a conduit of information, but also as an aesthetic object embedded in the rhythms of everyday life.

The dual perspective expands the conceptual boundaries of reading, moving beyond traditional literary models to account for how aesthetic engagements with text are shaped by contextual, sensory and environmental factors. From the shifting forms of everyday reading to the overlooked role of signage in shaping the urban landscape, the research calls for more systematic and nuanced approaches to studying text in real-world settings.

Importantly, these findings are not merely descriptive, they are cathartic¹³. By revealing the conceptual gaps surrounding text in aesthetic research, these inquiries create a moment of critical release through which new questions, frameworks and sensibilities might emerge. Overall, in doing so,

¹³Drawing on the Aristotelian notion of catharsis as a moment of emotional and intellectual release, the term is used here to suggest a disciplinary clearing, a purgation of inherited assumptions around reading, text, and aesthetics. In the context of the two papers included here, this 'cathartic' gesture marks a shift away from reductive frameworks and towards an integrated, situated understanding of reading as both a cognitive practice and aesthetic experience embedded in the everyday and the urban.

this lays the foundation for future avantgarde research that is empirically grounded, contextually attuned, and investigates how we read, interpret and aesthetically engage with text in the modern world.

3.2. Field Study Investigations

“We are bombarded by words. They pass through our urban landscape on the sides of buses and trains. They sit on billboards and posters as we drive to work or walk to a meeting. They are even more intrusive when they sneak up on us from the screens of our smart phones.”

(Chamberlin, 2018, p. v)

The field study investigations within this thesis explore how individuals engage with urban text within an everyday setting, utilising mobile eye-tracking to capture real-time interactions with urban signage and other textual elements. By examining how often and how long participants fixate on text compared to other objects in their environment, these studies enhance our understanding and the prevalence of reading experiences during naturalistic visual exploration. This approach also contributes to broader discussions of semantic guidance and the influence of meaningful context in shaping visual attention during real-world navigation.

In the context of urban aesthetics, field studies provide a valuable framework for understanding how people engage with urban texts in everyday settings. Urban signage, such as shop signs and street signs, serves as an essential function in how urban spaces are interpreted and navigated. However, Chana et al. (2023) highlights that these textual elements, functional at their core, can be considered as aesthetic objects, carrying significant aesthetic value and therefore influencing our perception of the environment. Urban texts often adopt a laconic style, relying on brevity to capture fleeting attention in fast-paced environments. As discussed in Chana et al. (2023), the design of such text (e.g., typography, placement and integration), its saliency and its familiarity/memorability could affect the emotional and sensory responses of city dwellers. For instance, the aesthetic quality of a shop sign could either enhance or detract from the overall aesthetic experience of an area. Much like how a literary text communicates themes and moods, urban texts can convey cultural, historical, or emotional cues to the observer (Clark et al., 2017; Cook, 2013; Gorter & Cenoz, 2008; Heurta, 2010; 2011; Metsker-Galarza, 2021; Rahman & Mehta, 2018; Snajdr & Trinch, 2018). This suggests that the city itself can be viewed as a kind of “text” that we continuously read. The physical and textual components of the city, from the design of buildings, the placement of signs, and other visual elements combining to create a visual narrative that shapes how we navigate and experience the urban environment. Therefore, in understanding urban aesthetics, it is

essential to consider how text-based elements of the environment interact with the broader urban design to produce a cohesive and meaningful aesthetic experience.

One key novel insight is that individuals fixate more on textual elements than other objects in their environment and highlights the intriguing role of text in the urban experience. Interestingly, while viewing behaviour was shown to vary across individuals (e.g., subjective viewing preference for nature or architectural facades) there was an overall trend of increased fixations on text elements. This suggests that, while fixations to natural elements is plausible from an evolutionary perspective, and attention to traffic-related items is rooted in functional needs (i.e., as a direct result of locomotion and ensuring safety), there is a compelling tendency to fixate on text. This high prevalence of viewing behaviour to text provides an intriguing opportunity to consider how written forms of communication are woven into our daily interactions with the built environment.

Moreover, these findings stem from a free viewing method which provides a useful framework for understanding how visual exploration works without explicit task direction. Free viewing or free exploration, where the participant is not given any task to perform but is merely encouraged to explore the visual scene, is typically used to highlight the influence of low-level or bottom-up influences on eye movements stemming from the visual scene itself. However, such effects are not stable over time (Tatler et al., 2005) suggesting the presence of some internally motivated, top-down tasks generated by the participant. It has been suggested that humans seek to create a stimulating and pleasing visual environment for themselves (Berlyne, 1971) and that such behaviour might be biologically conditioned as a result of the positive sensations that such stimuli provide (Biederman & Vessel, 2006). If that is indeed the case, then the pattern of eye movements made while performing an aesthetic evaluation task might allow preferences to be predicted under free viewing conditions, allowing aesthetic preferences to be explored experimentally bypassing some of the challenges associated with conscious reporting of subjective preferences (Nisbett & Wilson, 1977).

Field-based studies capture the complexities of navigation in the built environment that cannot be fully understood in a laboratory setting. However, the limitations of field studies, such as the lack of control over extraneous variables, raise important questions about the generalisability of the findings. While this type of investigation provides a high level of ecological validity, specific factors that influence eye movements and aesthetic preferences cannot be isolated. For example, laboratory studies are able to reproduce stimuli on a screen, ensuring that every participant is exposed to the same stimuli¹⁴ and thus making it easier to attribute changes in visual attention and memory to the factors under investigation.

¹⁴ In Chana et al. (2023), the participants has unequal exposure to the text signs under investigation, due to factors such as obstructions (e.g., a tram going past) or attention shifts, which leads to skewed results when comparing visual attention on individual vs group level. This highlights the importance of being mindful of exposure variability in field research, especially given that mere exposure could enhance liking or preference (Zajonc, 1968; Leder, 2001).

Furthermore, specifically towards reading, lab-based eye-tracking studies show that words in a narrative are fixated on consecutively, and participants can control the pace at which they read and view (Rayner, 1998). This allows a reader to pause, look back, reevaluate and repair any comprehension problems. These controlled settings are valuable in empirical aesthetics research, allowing more precise conclusions to be drawn about the impact of visual elements on perception and evaluation.

The findings from these urban field studies suggest that viewing behaviour may not always correlated with aesthetic evaluations. While beauty is often associated with longer viewing times in empirical aesthetics (Goller et al., 2019; Holmes & Zanker, 2012; Leder et al., 2010, 2016; Mitrovic et al., 2020; Shimojo et al., 2003), the lack of consistent relationship between gaze patterns and aesthetic judgement calls into question the assumption that eye movements reflect aesthetic preferences in free viewing/urban contexts. In fact, eye movements may be influenced by bottom-up, perceptual factors such as curiosity, novelty-seeking, or the saliency of the text, rather than intentional aesthetic evaluation.

This discrepancy with the notion of ‘BDLL’ (Beauty Demands Longer Looks; Leder, 2015) is particularly relevant for the study of reading in real-world settings, where the individuals encounter text not with the intent of making an aesthetic evaluation, but as an everyday task. In these natural contexts, gaze patterns may not reveal the subjective aesthetic experience individuals have with urban text but instead reflect task-driven attention, cognitive load, or environmental distractions, or simply object features, such as word lengths. This finding underscores the need for multi-method approaches in future research on urban text reading, to better understand the dynamic relationship between functional needs and aesthetic experiences determining what is read in everyday urban environments.

3.3. Lab-based Investigations

“One of the important talents of gifted writers is their ability to paint pictures with words.”

(Reed, 2022, p. 5)

While field studies examine real-world interactions with urban text, laboratory studies allow for more controlled examination of how individuals engage with specific textual and pictorial elements. This chapter focused on two investigations: first, how words (i.e., text) and images operate to shape perception and interpretation; and second, how digital and print reading formats influence the naturalness of reading behaviour. Both studies contribute to a broader understanding of aesthetic engagement with text in everyday contexts.

3.3.1. Text and image in the unified everyday reading experience

Reading, in our broader definition, is not limited to text alone but involved the concurrent processing of both text and image. The concept of text as image (i.e. the inability, or even that it is not recommended, to look at text and image independently) challenges traditional separations between visual and linguistic modes of communication (Hazlett et al., 2013; Reed, 2022). In graphic design, for example, text is often integrated into the image so much so that text and image are not separate parts but instead complement each other as a means of deciphering the message that the designed item is aiming to relay. This synergy is particularly evident in book cover design, where typographic and illustrative choices are inextricably linked and convey the book contents which perhaps cannot be fully deciphered through either mode alone.

This interplay is central to Chana, Mikuni et al. (acc.), which investigated how informational cues affect our responses to book covers. Book covers are an essential part of the reading experience in literature, influencing not only our initial impressions of a book but also the way we engage with its content. Thus, the design of a book cover (e.g., typography, imagery, colour) is more than just decorative; it can prime a reader's expectations, shape emotional responses, and even influence interpretation of the inner text itself. These findings, demonstrating that visual image features enhance memory, and that familiarity and ease of inference further influence recognition, highlight the book cover as a key part of the reading experience, acting as a threshold through which narrative is first accessed.

However, book covers are just one example, and a similar interplay can be observed in other urban and everyday environments or scenarios (see Harland 2015; Bauer & Mayer, 2008). In a broader urban context, *Urban Scrawl* exemplifies this union of text and image, revealing how graffiti and street art operate as hybrid aesthetic texts embedded in everyday space. Here, too, the viewer decodes meaning through the combined impact of textual content and visual form. Whether in a storybook or a graffiti-covered wall, the confluence of text and image invites a layered interpretation and aesthetic response.

3.3.2. The naturalness of the everyday reading experience

Parallel to this investigation into design is Mendhakar, Sierak et al. (in press), which focuses on how the shift to digital reading platforms influenced reading behaviours. These findings reveal that reading behaviour, as measured through eye movement patterns, do not change significantly when we move from print to digital formats. This challenges the common assumption that digital reading disrupts natural engagement with text.

This being said, the affordances of digital platforms do introduce new dynamics. Interactive features like hyperlinks, multimedia content, and adaptive layouts (Mendhakar et al., 2024; 2025) create a

more fluid, non-linear reading experience compared to traditional print media. Digital texts often encourage multitasking and non-linear reading, which can alter the way we experience narrative and engage with the aesthetic qualities of the text.

From an aesthetic perspective, this shift is not just technical but emotional and sensory. As an aesthetic researcher, one may be particularly attuned to the tactile pleasures of reading—a physical book offers a multi-sensory experience: the weight in one's hands, the rustle of turning pages, even the smell of paper. These elements contribute to a nostalgic, embodied sense of reading that digital platforms often struggle to replicate (Spence, 2020). Yet digital formats have clear practical advantages, especially in terms of storage and accessibility. Still, as Mendhakar et al. (2024; in press) suggest, this preference might be more about the *experience* of reading—its ritualistic and emotional dimensions—than any actual difference in cognitive or behavioural patterns.

Interestingly, Mendhakar, Sierak et al. (in press) shows that significant differences in reading behaviour only appear when reading on a PC or desktop. This may reflect issues of posture and physical comfort (Mc Laughlin, 2015)—reading for pleasure is more naturally mimicked by handheld devices like tablets or e-readers, whereas computer screens are often associated with work and information processing. The position and placement of the body, it seems, plays a role in how we engage with text and other objects aesthetically (Kühnapfel et al., 2023; 2024; Pelowski et al., 2018; Toro & Trasmundi, 2024).

3.3.3. Overall

These laboratory investigations contribute to the broader conceptualisation of reading as an aesthetic experience embedded in everyday life. While controlled settings might initially seem removed from the natural context of reading, these studies serve to isolate and illuminate the visual aspects that often go unnoticed. Drawing on everyday aesthetics, this work positions reading not only as a cognitive task, but as a mode of engagement shaped by affective responses to design, tactility and the environmental context. From the interplay of image and text on a book to the natural comfort associated with handheld reading devices, the studies suggest that aesthetic value lies as much in the experience of reading as in the content being read. In doing so, these lab-based investigations offer a nuanced lens to understand how people aesthetically inhabit and make meaning through texts in everyday life settings.

3.4. Conclusion

“... in addition to functionality the words in a city can and should be enjoyed as an aesthetic experience. If creation of beautiful letters and words is an art, then the city is a living art gallery with dozens if not hundreds of minor masterpieces scattered throughout its streets...”

(Simon, 2021, p. 14)

Reframing reading as a multimodal, cognitively and aesthetically rich activity allows for a more comprehensive understanding of how individuals interact with texts and environments. Far from being limited to linguistic decoding, reading involves visual perception, aesthetic judgment, emotional engagement, and socio-cultural interpretation. Drawing on environmental aesthetics (Berleant, 1992), eye-tracking studies (Rayner, 2009), cognitive-emotion models of aesthetic experience (Leder et al., 2004), and interdisciplinary literary research (Jacobs, 2015; Salgaro, 2023), we gain a richer framework for understanding reading in both traditional and contemporary contexts. Aesthetic reading is therefore a mode of literary engagement that goes beyond basic comprehension to include sensory/experiential, emotional and reflective dimensions of textual experience. This includes not only reading written words, but also reading images, environments, and digital interactions—reflecting the expanded aesthetic, cognitive, and symbolic dimensions of the act of reading.

Looking towards the future, the initial steps taken here in studying reading behaviour, in urban environments and through everyday scenarios, opens up exciting possibilities for further research. As environments become increasingly digitised and constantly evolving, with the rise of interactive signage, augmented reality, and digital billboards, the way we read the city and other everyday environments will continue to evolve. The integration of text into urban spaces presents new challenges and opportunities for aesthetic engagement, as text is no longer confined to the static, fixed locations of literary books but is part of a larger, dynamic system that changes in real time (Berleant, 1992).

Moreover, as the ways in which we read continues to develop, there is a growing need to understand how new formats and underexplored scenarios influence our perception of text and its surrounding environment. This shift raises important questions: How do digital texts (whether on e-readers, smartphones, billboards, or other interfaces) interact with the sensory experience of the reader? What role do elements like screen design, typography, and navigation play in shaping the aesthetic experience of reading? An initial foray into these underexplored queries offers foundational insights as to how reading behaviour affects how we interact with the world around us. Whether looking at a book cover (Chana, Mikuni et al., acc.), navigating a city street (Chana et al., 2023), or engaging with digital content (Mendhakar, Sierak et al., in press), our aesthetic reading experiences are shaped by the interplay

of text, image and environment. By studying these interactions in a holistic way (see also Chana, Dehove et al., subm.; Mendhakar, Chana et al., in prep), this work is a novel and exploratory line of inquiry through which we can begin to gain a deeper understanding of how reading and perception function within both the urban and everyday environments.

I place a strong emphasis on interdisciplinary research; thus, while my work originates from empirical aesthetics, it extends well beyond this domain through its focus on aesthetic reading experiences. Consequently, this thesis addresses broader definitions of urban aesthetics, and of everyday aesthetics, and of reading. To gauge this wider understanding of environmental aesthetics and natural reading experiences, a range of methods have been employed. These included theoretical approaches, examining historical and future perspectives, alongside a literature review to synthesise past and emerging research directions. Field study investigations are utilised with a more exploratory and ecologically valid approach, while laboratory investigations are conducted to examine more controlled measures of reading behaviours. Within these different studies, variables such as eye movements, memory recognition, recall and aesthetic evaluations are analysed to better understand the dynamics of reading as it occurs in everyday settings.

Overall, this holistic approach, framed through environmental aesthetics and supported by a multidisciplinary, multilingual, and multi-method strategy, breaks new ground in shifting the perspective of what constitutes reading and what defines the aesthetic reading experience. It highlights how such experiences are shaped by the environments in which reading occurs, whether urban, everyday, analogue or digital. Rather than seeking a panacea for understanding reading through any singular method or theoretical framework, this thesis advocates for an integrative, context-sensitive approach. In doing so, this thesis unfolds as a palimpsest: each theoretical lens, empirical study, and methodological approach layers new insights onto existing understandings of reading. Such a broadened conceptualisation of reading remains responsive to both changing environments and evolving research methods, and reflects the deeply embedded, situational and aesthetic nature of reading a lived, daily practice.

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