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Using Eye-Tracking to Create Impactful Interpretation Signage for Botanic Gardens and Other Visitor Attractions

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Abstract: Despite their prevalence in almost all publicly orientated conservation settings, sign design receives limited attention in the research literature. We used a remote eye-tracking device to test how visitors read educational signs, maps, and species signage. Three designs, plus a plain-text control sign, were tested for each sign type. Sign content was based on Brackenhurst Botanic Garden, Kenya, and included four different information texts (156–256 words long) and a species information text (64 words long). Four presentations of extinction threat status were also tested as were depictions of trail routes on maps. Data were collected from 51 participants at six cultural venues across Nottingham, U.K. Signs positioned centre-left of an exhibit were read first. Information on the left-hand side of signs was read first and dwelled upon the longest. Signs with a single large image and a single block of text were generally preferred, and images were most frequently recalled. Extinction threat status was most frequently viewed and best recalled from green–red thermometer diagrams and least from the IUCN red list diagram. Map routes were clearest when presented as coloured solid lines. This study indicates the potential benefit of eye-tracking research for measuring sign use and assisting in sign design.

Keywords: museum labels; zoo signage; visitor information; map design; sign design; threat status; botanic gardens

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1. Introduction

Information signs are a common feature of botanic gardens, zoos, and other cultural and conservation venues. They provide valuable information to direct visitors and educate them about the work of an organisation or about a particular species, environment, or exhibit. Information boards are relatively cheap to produce, require little maintenance and provide a constantly available source of information [1,2]. Consequently, they remain the main way of presenting information to visitors. Within zoos, animal information signs are estimated to be read by 10–30% of all visitors [3–6]. When extrapolated to the 700+ million visits to zoos globally each year [7], this equates to a potential 70–210 million sign readers in zoos alone. Therefore, the seemingly humble sign has a potentially enormous reach.

Environmental education is crucial for tackling climate change. Whilst the presence of a docent may increase an individual's learning [8], most visits are self-led. As such, understanding what information visitors engage with is vital to ensure that the best possible communication is provided. Despite their important role, there is still a lack of information about how to produce impactful signs for conservation and environmental education.

For example, in the U.K., government guidelines for licensed zoos and aquariums require them to provide accurate information and include at minimum 'the species name (both scientific and common), its natural habitat, some of its biological characteristics and details of its conservation status' [9]. However, there is no information on how this information should be presented, leaving organisations to design their signage themselves. For botanical gardens, there is even less support. Whilst guidance on sign content may be useful, Fraser et al. [10] found that visitors may prefer different aspects of sign content to what is recommended.

A few studies have provided some insight into sign use. Museum studies suggest shorter texts are read for longer and have increased recall than longer texts [11,12]. Recommendations for sign length are between 30 and 100 words [13], made up of short sentences [13–16]. Bitgood et al. [17] found that whilst 12% of respondents read texts of 100 words (n = 43), only 4.5% read those exceeding 200 words. Yet, even where signs are short, they are often not read in full [18]. They refer to this as the General Value Principle, where readers minimise the mental energy cost of reading for maximum information gain [19]. As museums may attract more learning-motivated individuals than other venues [20], it is possible that visitors to zoos and botanic gardens may read even less. This is supported by preliminary studies in zoos, which suggest that visitors read and recall mainly information from the top line of the sign or when information is presented as separate chunks [21]. Also based on the General Value Principle is the idea that signs should follow a consistent layout throughout a venue to make information easier to find and should be positioned on the main path at a height suitable for easy viewing [13,14].

Signs can draw attention to exhibit content and significantly increase holding power [22]. However, estimates of sign dwell times vary. Visitor observations at a zoo exhibit suggest individuals look at interactive interpretation signage for 12 s on average and non-interactive interpretation for just one second [22]. Other estimates of average sign holding power are around 5 s [23,24] and an average of 71 s for total sign viewing within an exhibit area [24]. Factors such as visit motivations and the presence of children were reported to affect viewing times [20,23,24]. Additionally, the sign's content (its attraction and holding power) can affect dwell time and number of views [6].

Most sign research is based on observing a visitor's movements and assuming sign reading based on whether a visitor stops in front of a sign for a given period. Until recently, this has been the best measure of interaction, despite longstanding criticism that it does not provide an accurate measure of reading [18]. However, using eye-tracking technologies, it is now possible to measure an individual's specific reading behaviours.

1.1. Eye-Tracking Research

The use of eye-tracking research is still relatively novel. The high costs of technology and processing software have previously been prohibitive for many research projects. Whilst devices for measuring eye movements are becoming more affordable, there are still issues relating to the interpretation of data and privacy issues when recording conversations and visual recordings in a public place. Gradually, eye-tracking research is appearing in the educational research literature [25] and is being used to test visitor use of exhibits [26,27].

Eye-tracking devices work by measuring gaze co-ordinates. They measure fixations (when an individual focuses on a point for between 100 and 600 ms) and saccades (quick eye shifts among points lasting fewer than 100 ms) [26]. Measuring these two aspects provides an indication of how long and in what order an individual reads information. Remote eye tracking can also identify how often a particular object or aspect of a text (an area of interest (AOI)) is viewed [28].

Mason et al. [25] used eye tracking to examine 49 children's use of textbooks (text and pictures) and measured reading, comprehension, and recall. They showed a correlation between the duration of eye fixations and the depth of learning, thus demonstrating that fixation and dwell times are reasonable indicators of learning.

Krogh-Jespersen et al. [27] used eye-tracking glasses within the context of a science museum. Their study provides the first detailed analysis of how visitors engage with an exhibit space including how interpretation signage is used. They found that visitors fixed their gaze on posters for between 0.22 s and 5.16 s. Across 11 information signs in an exhibit, the average total fixation time was 1 min 37 s, and for individual signs, average fixation ranged between 1.44 and 14.12 s. This reiterates that information provided by signs must be presented as quickly and clearly as possible.

A 2022 study of biology undergraduates visiting a zoo exhibit used eye tracking to test sign use and found a high rate of sign observation (91.0 s), much longer than the time spent viewing the animals in the exhibit (10.5 s) [29]. Whilst that study adds to the understanding of exhibit and sign use and does use eye-tracking software, the motivations of the participants (students on a university visit) potentially reflect a different use pattern than the typical zoo visitor.

We are unaware of any study to date that focuses on the topic of eye tracking in botanic gardens.

1.2. Study Location and Purpose

This study aimed to investigate sign reading preferences and reading patterns amongst visitors to cultural venues. Sign content was based on Brackenhurst Botanic Garden and eco-resort in Limuru, Kenya (https://www.brackenhurst.com/, accessed on 1 June 2021). This site has undergone major ecological restoration over the past 24 years to remove invasive species such as Eucalyptus (*Eucalyptus* spp.) and replant native species. As well as attracting locals, the site is aimed at an international audience with a strong connection to the U.K. (it was recently partnered with a Nottingham Trent University campus, which shares the same name and has an ancestral connection; however, at the time of data collection, this connection was not widely reported). The site has several public trails through the newly restored forest, and the interpretation boards were designed to inform visitors about the history and ecology of the site, maps of walking trails, and specific tree species information.

Whilst the text content was site-specific, the signs were designed to test features common to information signs found more broadly across visitor attractions.

We examined the following:

- The order in which a sign was read (which sections were read first).
- Duration of reading.
- Information recall.
- Visitor sign design preferences.
- The most effective way of delivering species threat-status information.
- The most effective way of presenting map layouts.

Because of coronavirus restrictions at the time of data collection, we were unable to use eye-tracking glasses to test sign use in situ in Kenya; therefore, remote eye tracking was used to test sign reading amongst U.K. visitors to other cultural venues (museums, galleries, historic sites). We acknowledge that sign reading may differ between cultures and venues; however, we feel that our findings can still aid general information sign design. This study is one of only a handful to date that tests sign reading within a cultural venue using visitors (not in a laboratory setting).

2. Materials and Methods

2.1. Data Collection

Data were collected between 19 and 23 July 2021 at several cultural venues in the city of Nottingham, U.K. (Nottingham Contemporary Art Gallery, Wollaton Hall Stately Home, Southwell Minster) and three campuses (City, Clifton, and Brackenhurst) of Nottingham Trent University (NTU). As the experiment was conducted during the university summer holidays but before the start of school holidays, mainly day visitors and university staff (including non-academic staff) participated.

We did not collect data on respondents' professions; therefore, we were unable to include this as a factor in our analysis. The age profile across the sites was found to be similar with overlapping means (Appendix A). The modal number of visits to cultural venues was also similar across five of the six sites (2–5 visits per year) but with participants from the Clifton campus having a higher number (10 or more visits). Participants at the Brackenhurst campus had a higher modal education (doctorate level) and may have had more prior awareness about species information signs and information boards given that the campus specialises in animal, rural and environmental sciences and shares a name with the Brackenhurst Botanic Garden. As the city campus includes the school of art and design, it is also possible that participants at this location had some background in sign design. To combat the impacts of prior knowledge, we tested signs and content that had never been displayed at any of these locations.

The experiment was set up in the main corridor of each venue, and the visitors were asked to participate in this study as they passed by. If the individual was part of a group, they participated alone with no assistance from their companions. Once one individual had completed the experiment the next person to pass by was asked to participate. This study took place the first week after coronavirus restrictions were lifted in the U.K.; as such, the number of participants was lower than expected at other times.

The respondents were asked to view four information signs, a map, and a species sign. Four alternative designs were available for each sign/map, and these were rotated among the participants to ensure that all sign designs were viewed a similar number of times and to exclude the impact of viewing order (see Table A3 in Appendix B for the combinations of sign presentations and order of viewing). After viewing each sign design, the respondents answered a question about the information or design that they had just seen.

The signs and questions were presented on a 22″ monitor with a resolution of 1920 × 1080; the same screen was used at all test locations. Although light levels varied at each location, we kept the display settings the same and instead positioned the screen and viewer in a location where the screen was clearly visible and where there was no glare. Whilst visitors viewed the information, their eye movements were recorded by a remote tracking bar (SMI RED remote eye-tracking device [30,31]) attached to the screen. This was calibrated for each individual participant to ensure that their eye movements were tracked effectively. Calibration allowed for differences in an individual's position relative to the screen, including accounting for height differences or being closer or further away. We note some limitations in that if a participant moved substantially away from their initial (calibration) position, their gaze pattern could be lost. Additionally, it was more difficult for the SMI RED to follow individuals with glasses. This meant that respondents were required to sit relatively still during the experiment, which may not reflect natural sign-viewing behaviours. We note that using eye-track glasses (as we recommend for future experiments) could negate the issue of moving out of the viewing zone and allow for a more natural viewing experience. The SMI RED bar in combination with SMI BeGaze 3.6 software [30] provided information about which areas of each sign participants viewed and the duration of viewing.

As the primary aim of this project was to examine viewing behaviour and not to test knowledge, we did not use a pre–post design. It was felt that asking individuals a question before viewing each sign could bias respondents to look for that answer in the sign. As the information presented was about a specific site in Kenya and the respondents were in Nottingham, U.K., it was felt that the information was sufficiently novel to assume that any correctly recalled information was acquired from the sign itself. We acknowledge that some individuals may have had more awareness of sign design or content than others depending on their prior experiences. This was an unavoidable limitation of our study design, and we tried to negate this as much as possible by varying the order that the sign designs were presented.

The signs were presented for 30 s (30,000 ms). This is substantially longer than the typical dwell duration of signage shown by Krogh-Jespersen et al. [27] but similar to the average duration for viewing artwork [32]. We selected 30 s as we did not want participants to feel rushed when presented with information. However, we acknowledge that in situ, the signs would likely be read for a much shorter time. To combat this, we examined which sign sections were viewed first and the time of first fixation.

2.2. Creating the Test Signs

Information Signs

Four information texts, between 156 and 256 words in length (average of 210 words), were created covering the following topics: 1. history of the project, 2. invasive species, 3. restoration ecology, and 4. habitats (with a focus on birds). Each text was then presented as four different sign designs (Table 1), creating a total of 16 different information signs. The four designs represented three commonly used information board design layouts used in zoos, museums, and galleries (author comms.) These included D1. large picture plus side text, D2. central picture with text surrounding, D3. boxes with chunked text and pictures, and D0. black and white plain text used as a control.

Table 1. Variants of each sign design tested in the study.

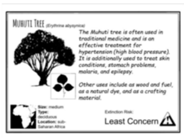
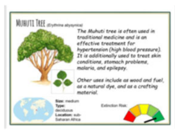
Sign Type	Description	Variants	Example
Information board	Four different texts providing information about the Brackenhurst, Kenya, restoration ecology project. 156–256 words Main font size of 20 Title font size of 40 Themes: 1 = History 2 = Invasive species 3 = Restoration ecology 4 = Habitats	D0 = control (plain text [Arial font] no pictures) Title: top left QR: bottom centre	
		D1= large picture with a single block of text Title: top right QR: top left	
		D2 = central picture with chunked text around Title: top centre QR: bottom centre	
		D3 = chunked text and pictures Title: bottom centre QR: top centre	
Species sign	A species information sign for a tree species included species name (common and scientific), basic description, distribution, and threat status. All signs had the same text content with varying map and threat status. 64 words Main font size of 20 Title font size of 40	0 = control (Word: Least Concern, outline continent map)	
		1 = (IUCN threat bar, continent map with spp. ranges highlighted)	
		2 = (thermometer threat status, globe zoomed to continent, spp. ranges highlighted)	
		3 = (speedometer threat, global map with spp. ranges highlighted)	

Table 1. *Cont.*

Sign Type	Description	Variants	Example
Map	A scale drawing map of the Brackenhurst Kenya site with areas of interest and key species shown with illustrations. Three walking routes were plotted on each map and summarised in boxes under the map (distance, estimated time, elevation gain, and an elevation profile diagram). The respondents were asked to look at the map and select the easiest route.	M0 = control (black and white with routes marked using various dotted lines)	
		M1 = colour map with routes marked using differently coloured solid lines	
		M2 = colour map with routes marked using various dotted lines in a single colour	
		M3 = colour map with routes marked with differently coloured dotted and solid lines	

For each sign design, the size of each text box and image were standardised, and only the textual information was changed. The fonts and colours used were defined by the study site (Brackenhurst Kenya) based on their existing colour schemes. As part of the questionnaire, we asked about attitudes towards this colour scheme and tested colour and font preferences by presenting a choice of fonts (Appendix B.1) and coloured texts on different backgrounds (Appendix B.2) and asking the respondents which they found clearest.

Each of the information signs included a QR code with a message that viewers could scan for more information. Dummy QR codes were used (leading to a page not found website) as we did not expect them to be scanned during the experiment (we note that none of the participants attempted to scan the QR code during the tests). The QR code was the same size on all signs but was presented in different locations (D0: lower centre, D1: upper left, D2: upper right, D3: lower right). This tested whether the information was viewed and which position received the most attention.

The location of the sign's title also varied across each sign design (D0: upper left directly above the main text, D1: upper right directly above the main text, D2: upper centre, in its own box, and D3: lower centre in its own box).

To test the impact of a sign's location on readability, we created a test image showing the four signs in location (affixed to a gazebo at the end of a forest trail) (Figure 1). The order of signs was rotated among the participants. The eye-tracking software then recorded which order the signs were viewed, allowing us to test whether it was the sign or the location that impacted viewing preference.

2.3. Maps

Four maps of the Brackenhurst forest and trails were created, each with the same general appearance and content but with varying presentations of trails.

Unlike the other signs, the participants were prepped before seeing the map and given a task, to 'start at the gazebo (clearly marked on all maps) and look for the easiest trail to walk'. We did not specify what was meant by 'easiest' as we wanted to test whether the respondents looked at the route drawn on the map or whether they focused on the summary information about gradient, elevation, distance, and time. One route (the Meru Oak Trail) was notably easier than the others (shortest route, lowest elevation, and flattest elevation gradient profile). The respondents were asked to state which route they chose and explain why.

Figure 1. Example of signs in location. Respondents' eye movements were tracked to test the order in which the signs were viewed.

2.4. Species Signs

In addition to information boards and maps, we tested how species information signs are read, in particular, how threat status is interpreted. Four species information signs were created, all containing the same text (64 words) and content information but with varying presentations of extinction threat status. These included using the International Union for the Conservation of Nature (IUCN) threat status diagram, presenting threat as a thermometer, as a speed dial, and as the word 'Least Concern' (Table 1). Species information signs were based on the basic requirements for species information according to U.K. zoo licencing [9], but instead of an animal species, we depicted the Muhuti tree (*Erythrina abysynica*), a key species found in the Brackenhurst Botanic Garden.

2.5. Questionnaire

A 23-item questionnaire was designed to gather information about the participants' recall of information and attitudes towards each sign's design.

Recall questions asked a simple factual question that could be answered by recalling the information from the sign. The respondents were given a choice of five possible response options and asked to select one. The questions were based on information found in the top, middle (words 50–70), and end sentences of the information signs, and the respondents were also asked to recall threat status from species signs and identify the easiest route from maps.

In addition to recall questions, we used 7-point Likert scales with a balance of positive and negative phrased questions to test the respondents' attitudes to the different sign designs.

Demographic information was collected regarding each participant's age, gender, education level, frequency of visiting cultural venues (botanic gardens, museums, galleries, or zoos) and stated likelihood of reading signage when visiting a new venue.

Finally, the respondents were given two open-ended questions asking, 'what, if any, information can you recall from any of the signs?' and to provide 'any additional comments that would help us improve the sign design'.

2.6. AOI and Gaze Analysis

Gaze analysis was conducted using SMI BeGaze 3.6 [30] software, which allowed areas of interest (AOIs) to be identified. We created an AOI around each sign section (for example, see Figure 2). Each time a participant looked within that AOI, it was counted as a fixation, and the total dwell time and average fixation on each AOI were then calculated. Hotspot maps showing the most frequently viewed areas were also created.

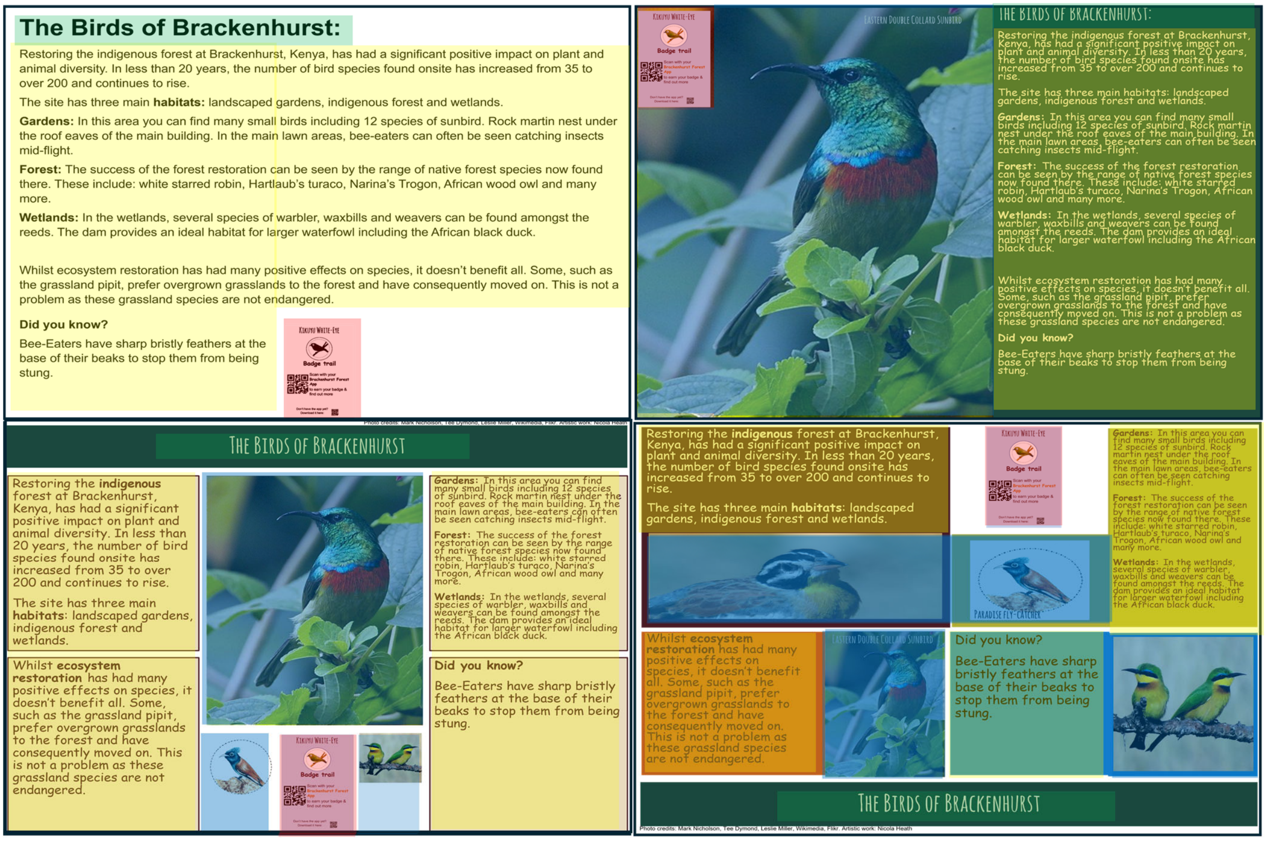


Figure 2. Examples of areas of interest AOIs identified on signs. Green = title, yellow = main text red = QR code, blue = image.

2.7. Data Analysis

We conducted the basic analysis using Excel (Microsoft 365), R (CRAN-r version 4.3.3), and BeGaze [30] (SMI) software. R was used to conduct bootstrapping of averages to determine 95% confidence intervals, and the package mgcv (https://doi.org/10.32614/CRAN.package.mgcv, accessed on 5 July 2024) was used to conduct GLMs. Statistical significance was determined using alpha False Discovery Rate at a threshold of between 0.05 and 0.005 (see Table A4 in Appendix C).

Data from the eye-track analysis were used to determine the duration of viewing, order of viewing, and gaze hotspots. Where a respondent's gaze tracking failed to be recorded (this sometimes occurred if a respondent was wearing glasses as the glare on their lenses prevented eye tracking), the lines of data were removed from the analysis.

Thematic analysis was conducted on longer responses to survey questions. This identified trends in sign design preference. These were then calculated as a percentage of the total number of statements given to determine how prevalent each view was.

Generalised Linear Models (GLMs) were conducted on survey data to test if design preferences and correct responses were correlated with demographic factors (respondent age, education, frequency of visiting cultural sites, likelihood of reading signs) (see Tables A1 and A2 in Appendix A). The data were checked for skew and heteroskedasticity prior to testing and including variables in models. Variables were only included in the same model if they had a Pearson's coefficient r = < 0.7 and a Variance Inflation Factor < 2 [33].

3. Results

Surveys were completed by 51 participants. When non-viable eye-track recordings were removed, the total data set included 38 species sign recordings, 167 information sign recordings, and 38 map recordings.

3.1. Information Signs

There was no statistically significant difference between the sign designs and the amount of information correctly recalled. However, there was a difference in the amount recalled and the position on the sign. Information found on the middle lines (70th and 50th words) of the sign had the highest recall in three out of the four sign types (Figure 3). For signs where information was chunked (D3), the top line (20 words) and mid-line (50 words) had the highest recall. In contrast, information found on the end line (150th word) had a much lower correct recall rate, with none of the respondents who viewed the control sign (plain text) being able to recall information from the last line of the sign correctly (Figure 3). The pattern of viewing can be examined further in the heat maps (hotspots) (Figure 4). These indicate a tendency to read from left to right and top to bottom (regardless of the content). Text in a single block was read for the longest (av. dwell 14,905 ms, 95%CI: 12,858–16,915 ms, modal viewing order: first). The next longest dwell times were for text in the upper left corner (av. dwell 6008 ms, 95%CI: 5042–7025 ms, modal viewing order: second) and text in the lower left corner (av. dwell 5585 ms, 95%CI: 4644–6545 ms, modal viewing order: fifth). Text and pictures in the lower right corner were the least dwelled upon (text: av. dwell time 3244 ms, 95%CI: 2465–4080 ms, modal viewing order: seventh; picture: av. dwell time 840 ms, 95%CI: 553–1146 ms, modal viewing order: eighth). The areas with the highest percentage of no views in the given time were pictures in the lower right (75.61%), pictures in the lower left (65.85%), and text in the lower right (52.33%).

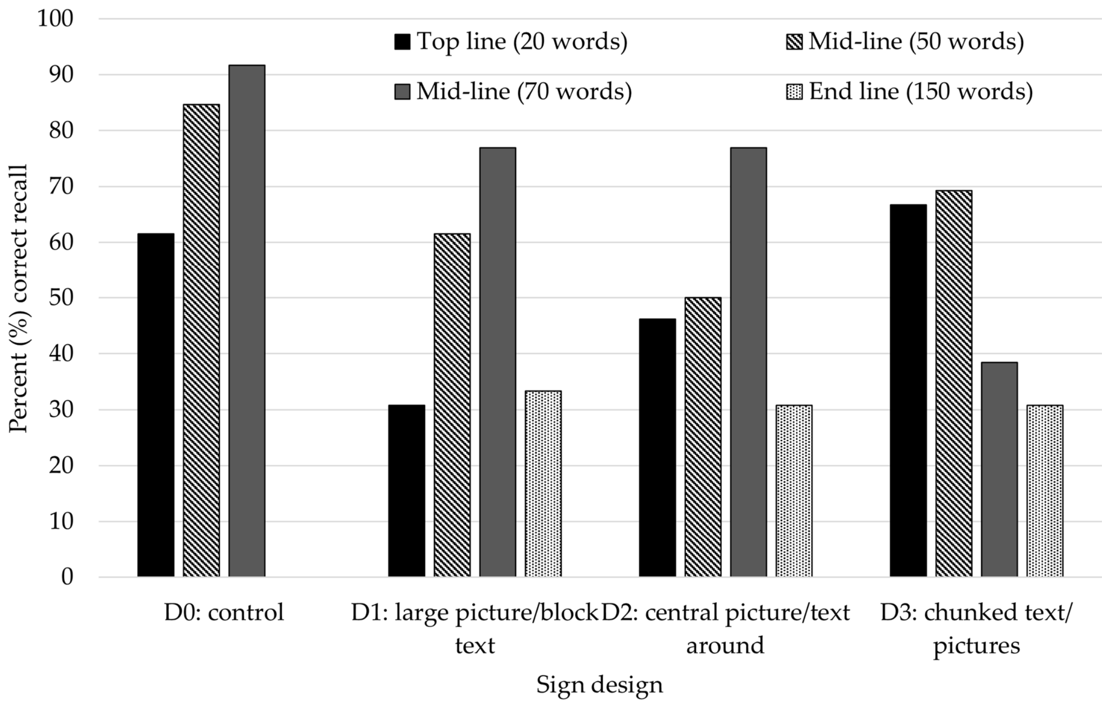


Figure 3. Percent (%) of information (question responses) correctly recalled according to where information was found on the sign and the sign design.

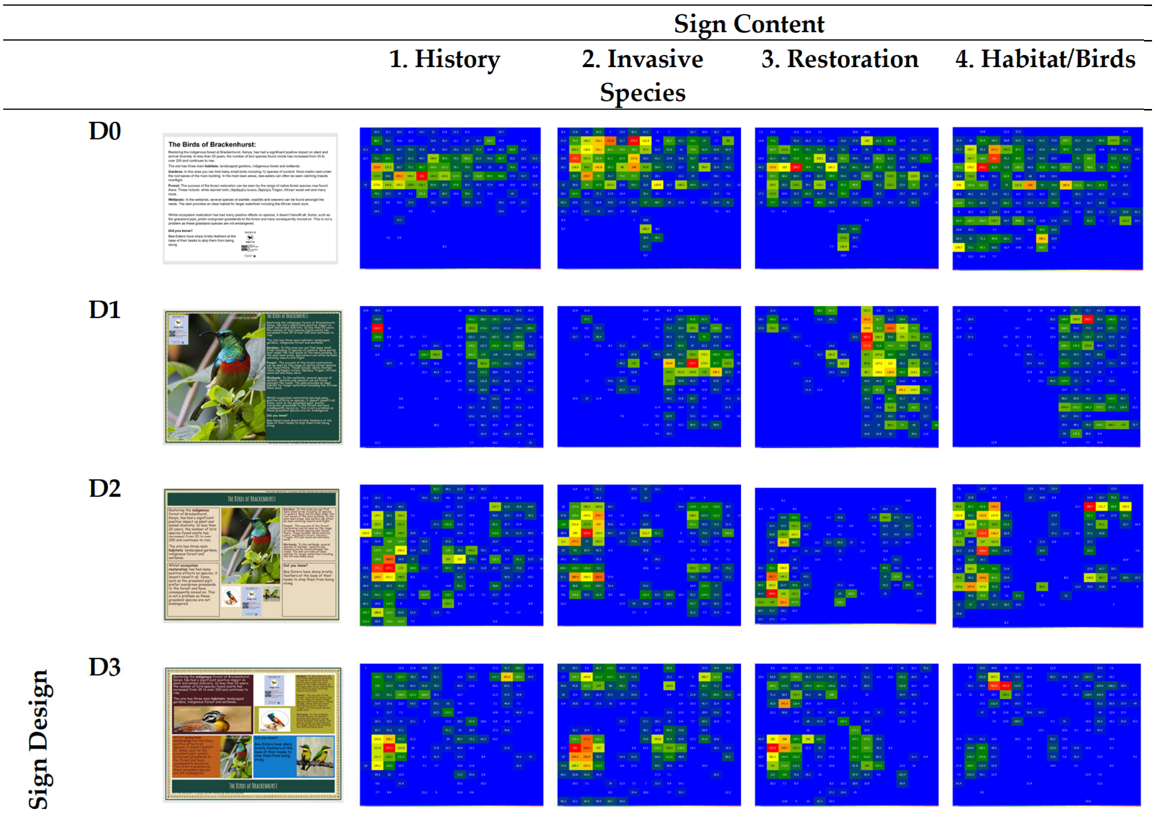


Figure 4. Average gaze hotspot maps according to sign design. Red, orange, and yellow represent areas of more frequent viewing, and green, dark green, and blue represent areas of less frequent viewing.

Titles and QR Codes

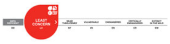
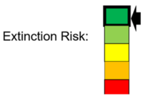
Titles written at the top of the sign (D2) were viewed between 523 and 1198 ms (average 833 ms) compared with between 344 and 788 ms (average 558 ms) when written at the bottom of the sign (D3). In 47.9% of the cases, the title was not viewed at all. Similarly, QR codes were viewed for the longest when positioned in the top left-hand corner; however, 60.48% of the respondents did not look at the QR code, and one participant even recommended that we should use QR codes on our signs without realising that all the signs she had viewed already had QR codes.

3.2. Species Signs

The respondents who viewed species signs predominantly focused on the text and picture first (50% of the respondents dwelled first on the text, and 31.5% of the respondents dwelled first on the picture). The sequence of sign viewing (modal frequency) was first, text; second, picture; third, common name; fourth, key (fun) facts; fifth, threat status; sixth, species distribution map; and seventh, scientific name. The average dwell time on the species sign text (64 words) was 11,910 ms (95%CI: 9902–13,773 ms), and on the species sign picture, it was 1698 ms (95%CI: 1228–2236 ms).

Species threat status was viewed by most respondents (72.7–87.5% of the respondents), and recall was generally high (54.5–75.0% of the respondents could correctly recall the information) regardless of how the information was represented (Table 2). Correct recall was highest and dwell time was longest when threat status was presented as a thermometer. The speedometer representation had the second-highest correct recall. The number (%) of respondents viewing and correct recall was the lowest for the IUCN threat status representation of extinction risk despite this being the most common presentation of threat status on U.K. species signs. Stating threat status as a word (control condition) produced the fastest time of first fixation, and the respondents felt that it was the clearest to understand.

Table 2. Comparison of representations of species threat status (extinction risk).

Style	Example	% Who Viewed	% Correct Recall	Av. Dwell Time (ms) (95% CI)	Av. Time of First Fixation (ms) (95% CI)	Comments	% Who Strongly Agree Extinction Risk Information Is Clear
Control		87.5	62.5	1208 (431–2129)	97.8 (86.9–112.1)	'extinction risk information is clear.'	91.7
IUCN threat status		72.7	54.5	1975 (994–3084)	150.1 (98.1–227.3)	'extinction risk information is clear'	69.2
Thermometer		87.5	75.0	2432 (1617–3297)	147.8 (114.4–181.0)	'I assume green is of lower concern, but I would put thermometer the other way up.'	84.6
Speedometer		81.8	72.7	1765 (1056–2562)	137.1 (108.4–173.2)	'green to red speedometer is clear'. 'colours clear but could do with text to explain meaning.'	69.2

3.3. Maps

Most of the respondents quickly focused on the map itself (18.42% viewed the map first, 52.63% viewed the map second) and on the word 'gazebo' (10.53% viewed first, 13.16% viewed second) (which was the starting location that we asked respondents to find on the map) with a minority viewing the trail information box (2.63% viewed first, 7.89% viewed second). Almost three-quarters of the respondents (71.05%) did not look at the elevation graphic at all.

When asked to 'look for the easiest route', 50.9% of the respondents said they looked for the shortest route (Table 3). Map 1 (solid multi-coloured lines) was identified as the easiest to read and produced the highest number of correctly identified 'easiest' routes. Maps with only a single coloured dotted or dashed line were identified as the most difficult to interpret.

Table 3. Number of correct responses to map route questions, reasons for selecting routes, and whether the map design was easy to interpret. There were 13 respondents for maps M0, M1, and M2 and 12 respondents for M3.

Map	No. (%) of Respondents Who Correctly Identified the Easiest Route	No. (%) Who Slightly–Strongly Agree the Route Was Easy to Read	Reason for Choosing Route	No. of Respondents (Total)	No. of Respondents (Correct Responses Only)
M0	6 (46.2)	7 (53.8)	Flattest	3	1
			Shortest	4	3
			Easiest to follow	4	2
			Another reason	2	-
M1	10 (76.9)	10 (76.9)	Flattest	1	1
			Shortest	8	8
			Easiest to follow	2	1
			Another reason	2	-
M2	6 (46.2)	7 (53.8)	Flattest	-	-
			Shortest	7	5
			Easiest to follow	5	1
			Another reason	1	-
M3	7 (58.3)	7 (58.3)	Flattest	2	1
			Shortest	7	6
			Easiest to follow	-	-
			Another reason	3	-

3.4. GLM Analysis

After Endpoint adjustment, GLM analysis found that no significant variables (age, gender, number of cultural visits, or education) predicted the correct recall or dwell time of any of the sign sections with the exception of identifying the shortest route on the map, where there was a negative correlation with gender, but this did not explain any model deviance (male [-] p= 0.023, %D = 0, AIC = 68.29).

3.5. Order of Viewing Signs In Situ

The average order of sign viewing when the signs were situated on a path was 1. left centre, 2. right centre, 3. far left, and 4. far right. The sign designs were read in the following order: D3: chunked sign, D1: large picture/block text, D2: central picture with text around, and lastly, D0: control.

3.6. Survey Findings and General Comments

There was an overall preference for sign titles (51%) and main texts (31%) to be in Arial or a similar font. Colour contrast tests revealed preferences for black text on a white background (23.50%) and white text on a blue background (21.60%).

Sign design D1: large image/block text was preferred by 43.14% of the respondents. Of those who preferred Sign 1, the main reasons stated were that ‘it had one big image’ (n = 8), that ‘the colour scheme of white writing on a dark green background was very clear’ (n = 7), and that ‘the text information was all in one place’ (n = 6). Of the four participants who self-declared as dyslexic, three selected D1 as their preference with one individual stating that ‘white [writing] on green [background] was recommended to help dyslexics retain information’. We acknowledge that this finding is anecdotal (the sample size is too small to draw conclusions about dyslexic reading behaviour, and this is not something we intended to test); however, we included this finding as it suggests that preferences for high contrast texts may be universally favoured, which warrants further investigation for future studies.

The three most common recommendations were for less text (n = 19), chunks of information (n = 9), and more images (n = 8).

3.7. Information Recall

The respondents’ recall of sign information at the end of this study was coded into themes (Table 4). Intra-rater reliability was calculated using Cohen’s kappa at 0.96 (very reliable).

Table 4. Content recalled from information signs.

Theme Recalled	Number of Respondents (%)	Example Statements
Nothing	4 (7.84)	‘not a lot’, ‘nothing’
Pictures	25 (49.02)	‘illustrations’, ‘Photos’ ‘really nice images’
Conservation/restoration	11 (21.57)	‘Gone from 35 to 200 birds’; ’restoration’; ‘increased species’
Habitat types	10 (19.61)	‘Forests, wetland, grassland’; ‘ecosystems’ ‘biodiversity’
Invasive spp. (Eucalyptus)	17 (33.33)	‘Eucalyptus is invasive’ ‘invasives’
Birds	26 (50.98)	‘birds’, ‘bee-eater’
Monkey	5 (9.80)	‘monkeys’, ‘colobus images’
Historic information	8 (15.69)	‘General info on Brackenhurst history’, ‘founded as a coffee plantation’
Map	16 (31.37)	‘map’
Elevation	3 (5.88)	‘Elevation profiles helpful’
Trail	6 (11.76)	‘Three trails’
Species sign (Muhuti Tree)	11 (21.57)	‘Muhuti tree’
Medicinal use	6 (11.76)	‘Muhuti tree, helps blood pressure, used as medicine’
Extinction risk	3 (5.88)	’Least concern’, ‘extinction grading’

Most of the respondents (94.12%) were able to recall something from the signs. The main themes recalled from the signs were the images (49.02% of the respondents) and information about birds (50.98% of the respondents). However, this information was very limited (Table 4). Extinction information was only recalled by 5.88% of the respondents and conservation information by 21.57%. The respondents recalled information without prompt, and it is possible that if asked specific questions, they may have remembered more.

4. Discussion

The finding that visitors tend to read signs from left to right and top to bottom (regardless of cultural venue, age, gender, education level, or frequency of cultural venue visits) suggests that sign reading may follow cultural reading patterns. Our study was conducted in the U.K. with English speakers. English is read left–right and top–bottom, mirroring the same viewing pattern as was seen in our sign reading. However, this reading pattern is not universal. Other languages, for example, Arabic and Hebrew, are read right to left and some Asian dialects are read vertically in columns [34]. This concept of reading direction was investigated by Spalek and Hammad (2005), who used eye-tracking to compare English-speaking (left–right) and Arabic-speaking (right–left) individuals and examined their response to viewing an image. The English speakers were shown to have a bias towards viewing the left side of the image first, and the Arabic speakers favoured the right first [35]. This has important implications for sign design as, if we design signage based on left–right reading patterns, they may not be read in the same way in cultures where text flows right to left (or in another direction). Given that Arabic is the fourth most spoken language in the world (362 million native speakers) [36] and is one of several right–left languages, this is a significant consideration. Therefore, when translating for different audiences, the whole layout of the sign should be considered and not just what text is written.

Our study also found that text tends to be observed before pictures, regardless of layout. Eye-tracking studies from advertising campaigns in China found similar results, with respondents viewing text before an image no matter the position or orientation [37]. Given that China has a different cultural reading pattern than the U.K., this finding is interesting as it suggests that text-first observation may be culturally universal. As such, consideration should be given to what textual information is to be conveyed and its purpose or objective. As sign viewing times are short (a few seconds) [27], the text needs to be to the point to convey a specific message quickly.

The pattern of reading behaviour, focusing first on the top left and reading downwards, with the least likely viewed area being the bottom right, is significant when deciding how to display key information or images to visitors. This is independent of whether text or images are being presented. For left–right reading audiences, key information should be situated towards the top left of the sign. However, for best recall, core information should be presented at around words 50–70 within the text. Our findings support other studies suggesting that signs should be short (around 30–100 words) [13–16,19] and confirm suggestions that individuals often do not read to the end of texts [18].

We also found that the respondents looked first at the signs when positioned directly left and right of the main footpath before looking at those positioned to the sides. This supports the concept of the General Value Principle [17,19] that individuals will prioritise acquiring information from the easiest-to-access sources. This also supports findings that visitors most frequently read information in the line of sight [14]. We support suggestions [5,17,19] that signs should be positioned directly along a path in a position of easy viewing.

QR codes may be useful for providing extra information to visitors without overcrowding a sign with information. However, a third of the visitors did not look at the QR code. This may be influenced by factors such as culture or nationality and how present QR codes are in an area; however, this was not tested. If QR codes are to be used, the best position for them is in the prime position of the top left when presenting to a left–right reading audience. Similarly, titles, if used, are best at the top of the page.

Sign preferences were for designs with minimal text in one block and with large images. Font preferences were for simple, clear fonts and high-contrast text. These preferences mirror recommendations for presenting signs to those with visual impairments [38,39]. This suggests that creating inclusive signage is likely to benefit all visitors.

The need for high contrast was also noted in map designs, with preference given to differently coloured routes rather than those defined by different patterns only. The respondents selected walking routes by focusing on the map itself and not by reading textual information regarding routes and gradient profiles. Whilst providing this additional information may be helpful, it appears that a clear map visual was critical and was the prime focus for respondents.

One of the key aspects tested was how to best present species threat status information. As more species are becoming vulnerable to extinction, presenting this information clearly to the public is critical. We found that green–red thermometer-style presentations were the best way to present extinction threat, generating the longest dwell time, highest number of views, and greatest correct recall. Thermometer-style presentations were also reported to be one of the easiest to interpret (even when the red–green colouration was reversed), second only to when a threat status was written in word form. In contrast, the IUCN threat status diagram performed the worst in terms of recall, had the fewest viewers, and had the slowest time of first fixation. This suggests that it may not be the best way to present a species' threat as many visitors may miss this information if only glancing at a sign. If sites wish to use (or are required to use) the IUCN red status, it may be preferable to apply a traffic light approach (green for Least Concern and red for Critically Endangered) to convey the concept to their visitors.

Delayed recall of information was good, with most respondents able to recall some information. The quality of information recalled was limited and restricted to single statements such as remembering there were pictures of animals. This is similar to findings from other studies [40]. Despite this, some specific facts were recalled including information about conservation efforts and species threat status. This confirms that signs can effectively convey information to visitors and supports findings from other studies [4,11,12,41].

Additionally, asking a visitor to view a sign directly in front of them for 30 s is not the normal way of viewing interpretation boards. We acknowledge that visitors are more likely to view signs for a much shorter time [6,27]. Additionally, because of COVID-19 restrictions, we presented signs on a digital screen using a remote eye-tracking device (SMI RED) and presented information about a different cultural venue to the one the respondents were visiting. This may have resulted in a different interaction than what would have occurred with an in-context information board. We therefore propose that future eye-tracking research should examine sign use in context, preferably with eye-tracking glasses to allow the respondent to engage freely with an exhibit and its interpretation. This would additionally allow the impact of the exhibit to be tested and whether seeing the exhibit draws attention away from (or potentially towards [29]) the sign information. Asking eye-tracking glasses users to comment retrospectively on why they gazed at a particular sign at a given point would also improve our understanding of sign usage. This would establish whether interpretive signs meet their goal of helping to interpret an exhibit [2].

The other key aspect for future research is to test sign reading in different parts of the world and with different reading patterns to determine if cultural reading patterns do indeed impact the order and position of sign reading as our study appears to suggest. There may be other aspects of sign design, such as colour preferences, which are also impacted by culture. It is accepted that colour can be perceived differently by different people (such as those with colour blindness) and in different contexts (for example, when viewed in a sunny environment versus indoors or on a digital screen) or under different emotional states [42]. As such, understanding how colour impacts reading may be a useful aspect to test. In addition, understanding how signs age and weather in different environments is important. These are all areas still to be investigated.

Eye tracking has great potential for helping us understand sign use and interaction with exhibits in cultural venues. As this technology becomes more accessible, it is hoped that more sites will engage in similar studies and strengthen the available guidance for interpretation sign design.

5. Conclusions

We suggest that information signs should be designed with a focus on the text presented in the 50th–70th word of the sign as this section is most accurately recalled and is focused on before images. This text should convey the key message or objective of the sign. For left–right reading audiences (e.g., English speakers), sign design should prioritise content in the top upper left, with the least important content in the lower right. These positions may need to be reversed for right–left reading cultures, such as Arabic speakers, but more research in this area is needed. Threat status was best presented using colour thermometers showing threat levels, e.g., green (Least Concern) and red (Critically Endangered). In addition, clear fonts with large pictures and blocks of text were well-received by our respondents.

We note that this is a relatively small study of 51 individuals who tested sign reading presented on a digital screen. While the respondents were visitors to cultural venues, this way of viewing does not represent natural sign-reading behaviour and is thus a limitation of this study. We therefore recommend that future research employs eye-tracking glasses to examine reading behaviour within the context of an exhibit.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Respondent demographics.

Variable	Description		Number of Respondents (as %)
Age	Respondents' age brackets	18–25	8 (15.7)
		26–33	10 (19.6)
		34–41	9 (17.6)
		42–49	8 (15.7)
		50–57	3 (5.9)
		58–65	6 (11.8)
		66 or above	7 (13.7)
Gender	Respondents' genders	Male	23 (45.1)
		Female	28 (54.9)
		Prefer to use own term	-
		Prefer not to say	-
Education level	Respondents' highest levels of education	No qualifications	2 (3.9)
		GCSE/O-level or equivalent	8 (15.7)
		A-level or equivalent	8 (15.7)
		BA/bachelor's degree or equivalent	17 (33.3)
		Master's degree or equivalent	10 (19.6)
		Doctorate degree	6 (11.8)
No. of cultural visits per year	'In a normal (non-COVID-19) year, how often do you visit a museum, gallery, botanical garden, historic property, or zoo?'	This is my first visit to such a venue	-
		Once per year	2 (3.9)
		Two–five times per year	27 (52.9)
		Six–nine times per year	7 (13.7)
		10 or more times per year	15 (29.4)

Table A2. Demographic split across test locations.

Location	Description	No. Participants	Demographics	
University: Brackenhurst Campus	Situated outside the city in a rural location and specialising in animal, rural, and environmental sciences.	9	Average age (95% CI)	39 (30.9–47.8)
			% female	55
			Modal education	Doctorate
			Modal no. cultural visits in 12 months	Two–five times
University: Clifton campus	Just outside Nottingham city centre. Specialised in engineering, healthcare, and sport.	4	Average age (95% CI)	44 (34–56)
			% female	50
			Modal education	GSCE/Bachelors/ Masters/Doctorate
			Modal no. cultural visits in 12 months	10 or more
University: City campus	Situated in Nottingham city centre. Six academic schools are based here including art and design, social sciences, law, and business.	11	Average age (95% CI)	41 (33.6–48.9)
			% female	63
			Modal education	Bachelors
			Modal no. cultural visits in 12 months	Two–five times

Table A2. *Cont.*

Location	Description	No. Participants	Demographics	
Southwell Minster	Historic cathedral with visitor centre.	8	Average age (95% CI) % female Modal education Modal no. cultural visits in 12 months	49 (39–59) 38 GCSE Two–five times/six–nine times
Nottingham Contemporary	Art gallery in Nottingham city centre.	7	Average age (95% CI) % female Modal education Modal no. cultural visits in 12 months	38 (25.4–52.9) 57 Bachelors Two–five times
Wollaton Hall	Stately home, museum, and gardens close to the city centre.	12	Average age (95% CI) % female Modal education Modal no. cultural visits in 12 months	46 (36.7–55.3) 58 A-level Two–five times

Appendix B

Table A3. Question sets presented to each respondent and the time each sign/question was presented in milliseconds. Sign text (1: history, 2: invasive species, 3: restoration ecology, 4: habitats), design style (D0: control, D1: large picture large block text, D2: central image with chunked text, D3: small chunks of text with accompanying images).

Screen	Content	Test Set A	Test Set B	Test Set C	Test Set D	Time Presented in ms
1	Sign 1: History	D0 control—plain text no pictures	D1 large picture large block text	D2 central image with chunked text	D3 small chunks of text with accompanying images	30,000
2	Question 1	Recall Top line	Recall Top line	Recall Top line	Recall Top line	10,000
3	Question 2	Likert questions relating to sign readability and ease of understanding	Likert questions relating to sign readability and ease of understanding	Likert questions relating to sign readability and ease of understanding	Likert questions relating to sign readability and ease of understanding	10,000
4	Sign 2: Invasive species	D1 large picture large block text	D2 central image with chunked text	D3 small chunks of text with accompanying images	D0 control—plain text no pictures	30,000
5	Question 3	Recall mid-line (approx. word 70)	Recall mid-line (approx. word 70)	Recall mid-line (approx. word 70)	Recall mid-line (approx. word 70)	10,000
6	Sign 3: Restoration ecology	D2 central image with chunked text	D3 small chunks of text with accompanying images	D0 control—plain text no pictures	D1 large picture large block text	30,000
7	Question 4	Recall end line	Recall end line	Recall end line	Recall end line	10,000
8	Sign 4: Habitats	D3 small chunks of text with accompanying images	D0 control—plain text no pictures	D1 large picture large block text	D2 central image with chunked text	30,000
9	Question 5	Recall mid-line (approx. word 50)	Recall mid-line (approx. word 50)	Recall mid-line (approx. word 50)	Recall mid-line (approx. word 50)	10,000

Table A3. *Cont.*

Screen	Content	Test Set A	Test Set B	Test Set C	Test Set D	Time Presented in ms
10	Sign 5: Species information	Threat status speedometer	Threat status thermometer	Threat status IUCN	Threat status word: 'Least Concern'	30,000
11	Question 6	Recall species threat status	Recall species threat status	Recall species threat status	Recall species threat status	10,000
12	Question 7	Likert questions relating to sign readability and ease of understanding	Likert questions relating to sign readability and ease of understanding	Likert questions relating to sign readability and ease of understanding	Likert questions relating to sign readability and ease of understanding	10,000
13	Sign 6: Map	M0: black and white with dotted routes	M1 = colour map with coloured solid lines	M2 = colour map with same coloured dotted lines	M3 = colour map with differently coloured dotted and solid lines	30,000
14	Question 8	Recall the easiest route	Recall the easiest route	Recall the easiest route	Recall the easiest route	10,000
15	Question 9	'Why did you select this route?'	'Why did you select this route?'	'Why did you select this route?'	'Why did you select this route?'	10,000
16	Photo of four signs in location	Order: D0 control, D1 large picture/text, D2 central image, D3 chunked image/text	Order: D1 large picture/text, D2 central image, D3 chunked image/text, D0 control	Order: D2 central image, D3 chunked image/text, D1 large picture/text, D0 control	Order: D3 chunked image/text, D0 control, D1 large picture/text, D2 central image	5000
17	Question 10	Which of the 4 sign layouts do you prefer?	Which of the 4 sign layouts do you prefer?	Which of the 4 sign layouts do you prefer?	Which of the 4 sign layouts do you prefer?	10,000
18	Font card	Font test card	Font test card	Font test card	Font test card	5000
19	Question 11	Which font do you prefer?	Which font do you prefer?	Which font do you prefer?	Which font do you prefer?	10,000
20	Colour test card	Colour test card	Colour test card	Colour test card	Colour test card	5000
21	Question 12	Which colour scheme do you prefer?	Which colour scheme do you prefer?	Which colour scheme do you prefer?	Which colour scheme do you prefer?	10,000
22	Question 13	What, if any, information can you recall from any of the signs that you have seen?	What, if any, information can you recall from any of the signs that you have seen?	What, if any, information can you recall from any of the signs that you have seen?	What, if any, information can you recall from any of the signs that you have seen?	10,000
23	Question 14	Any other comments?	Any other comments?	Any other comments?	Any other comments?	10,000

Appendix B.1 Font Test Card

Arial

Brackenhurst forest is a 30-year restoration project. To date, 25-hectares of forest have been actively restored with over 650 species of indigenous trees and shrubs. Black and white colobus monkey and Sykes monkey are now found onsite along with many other native animal species.

Comic Sans

Brackenhurst forest is a 30-year restoration project. To date, 25-hectares of forest have been actively restored with over 650 species of indigenous trees and shrubs. Black and white colobus monkey and Sykes monkey are now found onsite along with many other native animal species.

Century Gothic

Brackenhurst forest is a 30-year restoration project. To date, 25-hectares of forest have been actively restored with over 650 species of indigenous trees and shrubs. Black and white colobus monkey and Sykes monkey are now found onsite along with many other native animal species.

Helmet

Brackenhurst forest is a 30-year restoration project. To date, 25-hectares of forest have been actively restored with over 650 species of indigenous trees and shrubs. Black and white colobus monkey and Sykes monkey are now found onsite along with many other native animal species.

Helvetica

Brackenhurst forest is a 30-year restoration project. To date, 25-hectares of forest have been actively restored with over 650 species of indigenous trees and shrubs. Black and white colobus monkey and Sykes monkey are now found onsite along with many other native animal species.

Amatic

Brackenhurst forest is a 30-year restoration project. To date, 25-hectares of forest have been actively restored with over 650 species of indigenous trees and shrubs. Black and white colobus monkey and Sykes monkey are now found onsite along with many other native animal species.

Figure A1. Font Test Card.

Appendix B.2 Colour Contrast Test Card

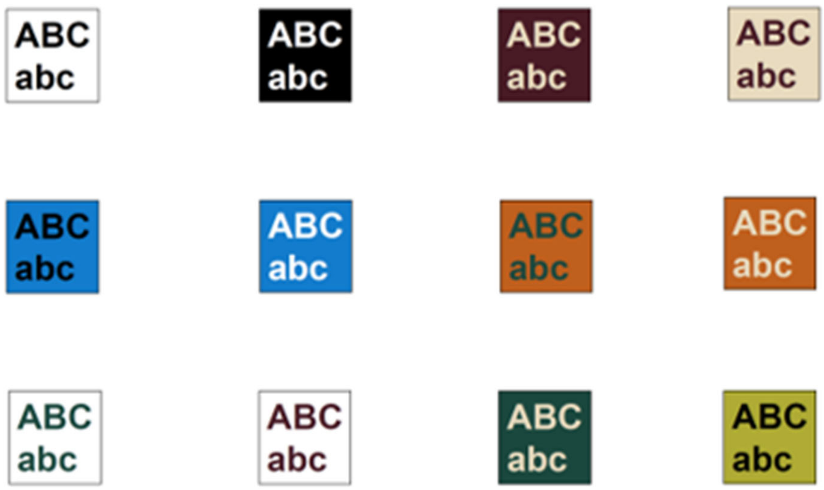

Figure A2. Colour Contrast Test Card.

Appendix C

Table A4. Outputs from GLMs relating to respondent factors affecting sign recall.

Sign Section Tested	Significant Variable and Model Statistics
Recall Top line	No significant variables [AIC 80.65, %D = 17.02, αFDR = 0.005]
Recall mid-line (approx. word 50)	No significant variables [AIC 64.59, %D = 18.99, αFDR = 0.02]
Recall mid-line (approx. word 70)	No significant variables [AIC 60.30, %D = 15.36, αFDR = 0.05]
Recall End line	No significant variables [AIC 49.13, %D = 33.28, αFDR = 0.008]
Recall species threat status	No significant variables [AIC 66.67, %D = 17.04, αFDR = 0.01]
Recall the easiest route	[-] Gender (Male) $p = 0.023$, %D = 0 [AIC 68.29, %D = 7.81, αFDR = 0.023]

Variables tested: respondent's age, gender, education, frequency of cultural visits, stated likelihood of sign reading.

References

1. Hall, T.E.; Ham, S.H.; Lackey, B.K. Comparative Evaluation of the Attention Capture and Holding Power of Novel Signs Aimed at Park Visitors. *J. Interpret. Res.* **2010**, *15*, 15–36. [CrossRef]
2. Honig, M. *Making Your Garden Come Alive!—Environmental Interpretation in Botanical Gardens*; Sabonet: Pretoria, South Africa, 2000.
3. Clayton, S.; Fraser, J.; Saunders, C.D. Zoo Experiences: Conversations, Connections, and Concern for Animals. *Zoo Biol.* **2009**, *28*, 377–397. [CrossRef] [PubMed]
4. Moss, A.; Jensen, E.; Gusset, M. Evaluating the Contribution of Zoos and Aquariums to Aichi Biodiversity Target 1. *Conserv. Biol.* **2015**, *29*, 537–544. [CrossRef] [PubMed]
5. Martin, R. A Study of Public Education in Zoos with Emphasis on Exhibit Labels. *Int. Zoo Educ. J.* **2012**, *48*, 55–59.
6. Edney, G.; Smart, T.; Howat, F.; Batchelor, Z.E.; Hughes, C.; Moss, A. Assessing the Effect of Interpretation Design Traits on Zoo Visitor Engagement. *Zoo Biol.* **2023**, *42*, 567–576. [CrossRef] [PubMed]
7. Gusset, M.; Dick, G. The Global Reach of Zoos and Aquariums in Visitor Numbers and Conservation Expenditures. *Zoo Biol.* **2011**, *30*, 566–569. [CrossRef] [PubMed]
8. Jensen, E. Evaluating Children's Conservation Biology Learning at the Zoo. *Conserv. Biol.* **2014**, *28*, 1004–1011. [CrossRef] [PubMed]
9. DEFRA. *Secretary of State's Standards of Modern Zoo Practice*; Department for Environment Food and Rural Affairs: Bristol, UK, 2012.
10. Fraser, J.; Bicknell, J.; Sickler, J.; Taylor, A. What Information Do Zoo & Aquarium Visitors Want on Animal Identification Labels? *J. Interpret. Res.* **2009**, *14*, 7–18. [CrossRef]
11. Thompson, D.; Bitgood, S. The Effect of Sign Length, Letter Size, and Proximity on Reading. In *Visitor Studies: Theory, Research and Practice*; Bitgood, S., Ed.; Centre for Social Design: Jacksonville, FL, USA, 1988; pp. 101–112.

12. Bourdeau, L.; Chebat, J.C. The Effects Of Signage And Location Of Works Of Art On Recall Of Titles And Paintings In Art Galleries. *Environ. Behav.* **2003**, *35*, 203–226. [CrossRef]
13. Wandersee, J.H.; Clary, R.M. Learning on the Trail: A Content Analysis of a University Arboretum's Exemplary Interpretive, Science Signage System. *Am. Biol. Teach.* **2007**, *69*, 16–23. [CrossRef]
14. Bitgood, S. Deadly Sins Revisited: A Reveiw of the Exhibit Label Literature. *Visit. Behav.* **1989**, *4*, 4–11.
15. Bitgood, S. The Role of Attention in Designing Effective Interpretive Labels. *J. Interpret. Res.* **2000**, *5*, 31–45. [CrossRef]
16. Screven, C.G. Motivating Visitors to Read Labels. *ILVS Rev.* **1992**, *2*, 183–211.
17. Bitgood, S.; Dukes, S.; Abbey, L. *Interest and Effort as Predictors of Reading in a Simulated Art Museum*; Southern Society for Philosophy and Psychology: Charleston, SC, USA, 2006.
18. McManus, P. Watch Your Language! People Do Read Labels. *ILVS Rev.* **1990**, *1*, 125–127.
19. Bitgood, S. An Analysis of Visitor Circulation: Movement Patterns and the General Value Principle. *Curator Mus. J.* **2006**, *49*, 463–475. [CrossRef]
20. Falk, J.H. An Identity-Centered Approach to Understanding Museum Learning. *Curator Mus. J.* **2006**, *49*, 151–166. [CrossRef]
21. Spooner, S.L. *Evaluating the Effectiveness of Education in Zoos*; University of York: York, UK, 2017; Available online: https://etheses.whiterose.ac.uk/20370/ (accessed on 29 May 2024).
22. Counsell, G.; Moon, A.; Littlehales, C.; Brooks, H.; Bridges, E.; Moss, A. Evaluating an In-School Zoo Education Programme: An Analysis of Attitudes and Learning. *J. Zoo Aquar. Res.* **2020**, *8*, 99–106. [CrossRef]
23. Ross, S.R.; Lukas, K.E. Zoo Visitor Behaviour at an African Ape Exhibit. *Visit. Stud. Today* **2005**, *8*, 4–12.
24. Ross, S.R.; Gillespie, K.L. Influences on Visitor Behavior at a Modern Immersive Zoo Exhibit. *Zoo Biol.* **2009**, *28*, 462–472. [CrossRef]
25. Mason, L.; Pluchino, P.; Tornatora, M.C.; Ariasi, N. An Eye-Tracking Study of Learning From Science Text With Concrete and Abstract Illustrations. *J. Exp. Educ.* **2013**, *81*, 356–384. [CrossRef]
26. Dondi, P.; Porta, M.; Donvito, A.; Volpe, G. A Gaze-Based Interactive System to Explore Artwork Imagery. *J. Multimodal User Interfaces* **2021**, *2022*, 55–67. [CrossRef]
27. Krogh-Jespersen, S.; Quinn, K.A.; Krenzer, W.L.D.; Nguyen, C.; Greenslit, J.; Price, C.A. Exploring the Awe-Some: Mobile Eye-Tracking Insights into Awe in a Science Museum. *PLoS ONE* **2020**, *15*, e0239204. [CrossRef] [PubMed]
28. de la Fuente Suárez, L.A. Subjective Experience and Visual Attention to a Historic Building: A Real-World Eye-Tracking Study. *Front. Archit. Res.* **2020**, *9*, 774–804. [CrossRef]
29. Heim, A.B.; Holt, E.A. Staring at Signs: Biology Undergraduates Pay Attention to Signs More Often than Animals at the Zoo. *Curator* **2022**, *65*, 795–815. [CrossRef]
30. Gaze Intelligence. SMI-Software. Available online: https://gazeintelligence.com/smi-software-download (accessed on 29 May 2024).
31. SMI RED—iMotions. Available online: https://imotions.com/products/hardware/smi-red/#product-specifications (accessed on 28 June 2024).
32. Smith, L.F.; Smith, J.K.; Tinio, P.P.L. Time Spent Viewing Art and Reading Labels. *Psychol. Aesthet. Creat. Arts* **2017**, *11*, 77–85. [CrossRef]
33. Zuur, A.F.; Ieno, E.N.; Elphick, C.S. A Protocol for Data Exploration to Avoid Common Statistical Problems. *Methods Ecol. Evol.* **2010**, *1*, 3–14. [CrossRef]
34. Koyfman, S. Why Is Most Language Read from Left to Right? Babbel. Available online: https://www.babbel.com/en/magazine/right-to-left-languages (accessed on 3 July 2024).
35. Spalek, T.M.; Hammad, S. The Left-to-Right Bias in Inhibition of Return Is Due to the Direction of Reading. *Psychol. Sci.* **2005**, *16*, 15–18. [CrossRef] [PubMed]
36. Lane, J. The 10 Most Spoken Languages in the World. Babbel. Available online: https://www.babbel.com/en/magazine/the-10-most-spoken-languages-in-the-world (accessed on 3 July 2024).
37. Yuhao, S. Eye-tracking: The influence of picture and text layout on the effect of commercial advertising. *SADI Int. J. Soc. Humanit.* **2022**, *9*, 1–5.
38. RNIB. *"See It Right" Clear Print Guidelines*; RNIB: London, UK, 2023.
39. Murphy, L. How to Design for the Blind and Visually Impaired. National Council on Aging. Available online: https://www.ncoa.org/article/helping-people-with-blindness-and-vision-loss-continue-to-participate-in-everyday-activities (accessed on 3 June 2024).
40. Spooner, S.L.; Jensen, E.A.; Tracey, L.; Marshall, A.R. Evaluating the Effectiveness of Live Animal Shows at Delivering Information to Zoo Audiences. *Int. J. Sci. Educ. B Commun. Public Engagem.* **2021**, *11*, 1–16. [CrossRef]
41. Moss, A.; Esson, M. The Educational Claims of Zoos: Where Do We Go from Here? *Zoo Biol.* **2013**, *32*, 13–18. [CrossRef]
42. Hurlbert, A.; Ling, Y. Understanding Colour Perception and Preference. In *Colour Design: Theories and Applications*; Woodhead Publishing: Sawston, UK, 2012; pp. 129–157. [CrossRef]