Postar Visibility Research

An integrative eye-tracking study of visibility hit rates for poster panels in UK environments

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POSTAR

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Acknowledgements

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Biographies

Dr Paul Barber was employed at Birkbeck in the University of London where for over 30 years he taught courses on perception, psychological statistics and experimental design, computing and ergonomics. He was head of Birkbeck's Department of Psychology from 1988 to 1992. He is now Emeritus Reader in Psychology at Birkbeck. Dr Barber was research supervisor to 16 PhD students, his own doctoral research being on visual input processes. He is an Associate Fellow of the British Psychology Society and is a Chartered Psychologist. He was author/co-author of a number of psychology textbooks and many research papers in refereed scientific journals; he was Psychology Editor for the journal *Ergonomics* for over ten years. He has been a consultant for Postar since 1995, closely identified with its programme of research on poster panel visibility.

Dr Mariana Sanderson obtained a BSc degree in Psychology and an MSc in Ergonomics before studying for a PhD - on the topic of visible speech. Her postdoctoral career has included employment on successive research projects for Postar with responsibility for its visibility research studies. Previously she held posts in research and teaching associated with various aspects of perception and education in research establishments and universities in the UK and Denmark. She has also worked in investment banking, marketing and as a conference organiser.

Dr Adrian Dickenson has a BSc degree in Psychology, an MSc degree in Ergonomics and a Postgraduate Diploma in Evolutionary and Adaptive Systems. He was awarded a PhD for his research on spatial stimulus-response compatibility. His first postdoctoral post was in the area of human-computer interaction, and he has worked as a research officer and technical consultant for several Postar research projects.

Foreword

Postar, which launched in 1996, was the first media research currency to seek to adjust audiences for their likelihood to see an advertising message. Until that point, the level of "proof" required had universally rested on the concept of "opportunity to see". That is the thought that being in proximity of a medium, be it in a room where the television or radio was playing, or passing a poster site on a street, was an adequate proxy for actually encountering the medium and thereby also gaining exposure to the advertising messages displayed therein.

Postar added a further layer, seeking to establish the chance or "likelihood to see" and thus provide audience estimates of actual "eyes-on" the medium as opposed to near proximity to it. Postar's basic measure of visibility is the hit rate for the advertising panel. This refers to the proportion of respondents who fixated (meaning looked at) the panel at least once.

Since its inception Postar, working with Birkbeck (a college of the University of London), has sought to understand how people view their immediate environment and any advertising signage appearing within it. The research work has been conducted by Birkbeck's School of Psychology, led by Dr Paul Barber. Over the years these investigations have provided an extensive understanding of how people see out-of-home advertising.

The most recent research, a report of which is included here, is the first to attempt to bring all the strands together, providing a point of comparison between the three main settings of roadside, tube/rail and retail. In all instances we study the behaviour of pedestrians; for roadside we take into account the driver perspective too.

This is the most comprehensive and therefore complex eye-tracking study undertaken by Postar to date.

A word of caution; it would be misleading to take the bald figures in the report and use them to impute a hierarchy for the varying panel types and locations described. The data represents fixed points in time and space. In reality, one moves in relation to an advertising panel (possibly towards and past it), and consequently creates a series of such points. With movement; the distance, orientation and share of one's field of vision all change. Postar calibrates these factors and weights them by other variables such as the mode of transport and speed of travel. Extensive mathematical modelling is required to calculate an audience estimate for a specific advertising panel that includes an adjustment for its relative visibility.

James Whitmore
Postar
May 2008

Summary

Postar's basic measure of the *visibility* of a poster panel is the *hit rate* for the panel; that is, the proportion of respondents who look at it at least once. This report provides a description of visibility hit rates of poster panels in roadside and non-roadside settings, and from driver and pedestrian standpoints. The data are from the most comprehensive eye-tracking study of outdoor panel visibility conducted for Postar so far. The investigation aimed to provide a common measurement framework for poster panel visibility across settings and perspectives.

The study made use of the established technique of eye movement recording, just as used in Postar's original driver visibility (1995) and pedestrian visibility (1998) databases. Eye movements of respondents were recorded while they viewed photographs of scenes with one or more poster panels; decoy scenes (with no panel) were also used to prevent the focus of the study becoming obvious. There were 90 respondents distributed over the four *conditions* which were each represented by 100-200 scenes:

- Driver - roadside
- Pedestrian - roadside
- Retail
- Tube/Rail

An eye-tracking session, prefaced by an essential equipment-to-respondent calibration session, lasted up to an hour; in the course of which the individual respondent would make in the region of 2,000 or more recorded eye fixations. These fixations were classified as hits if they were on a panel, otherwise as misses. The hit rate per panel was noted and mean hit rates were estimated for each panel type.

The Roadside scenes contained panels varying from 6 to 96 sheets in size, and the key bus panel types. The panels in the Retail scenes were exclusively 6 sheets; those in the Tube/Rail *condition* ranged from 4 to 48 sheets, and escalator/stair panels and tube cards.

The research was specifically designed to assess the influence of viewing distance and panel orientation, so this information is provided as a complement to the hit rate scores. The results demonstrated their effects convincingly; the overall hit rates for the four *conditions* differed markedly, but it was evident that the differences were accompanied by substantial differences in distance and orientation relative to the viewer. A standardisation method has been devised to provide comparisons between panel types allowing for differences in these panel properties; standardising distances of 10 and 35 metres were used along with standardising angles of 0 (head-on), 10 and 45 degrees.

The study provides a comprehensive basis of data on visibility hit rates in general, from which "visibility adjusted contacts" may be derived. It is in addition important to identify what has been and what might also be achieved. The report therefore considers what caveats apply to the study, the results and the conclusions. It also examines some factors that have not been directly addressed (e.g., height and distortion). In some instances diagnostic evidence may now be available (e.g., panel height above ground level). In other cases it is a question of getting better leverage on unresolved questions; for example, the evidence on orientation may provide useful leverage on the vexed question of the critical level of distortion to apply (that is, the point at which at which image distortion becomes unacceptable). It also remains to settle the issues of the respective contributions of clutter

and content, surviving representatives of past controversy; these are briefly reviewed in the context of a discussion of what variation in visibility hit rates remains to be explained.

Final Report

1. Introduction: background and rationale

This report describes the rationale, methodology and results of Postar's most comprehensive eye-tracking study of outdoor poster panel visibility, since and including the original study conducted in 1995 on which Postar's "visibility adjustment contact" scoring was based. Since the 1995 study there have been several expansions of the scope of the visibility component of Postar:

i. In addition to the perspective of the car driver/passenger, visibility from the point of view of the pedestrian can now be incorporated.

ii. Modelling of visibility from the driver perspective accommodates the way in which the driver's attention is distributed in the direction ahead as well as from side to side along the road.

iii. In addition to the stock of fixed poster panels, visibility measures for poster panels on buses are available.

iv. The range of environments in which outdoor advertising panels are found has been extended to include retail and travel environments in addition to the road/roadside environment that was the focus of the original research.

Some of this research for Postar (listed in Appendix 1) is reported in documents available from the Postar website. Eye movement research in general has mushroomed in the past few decades as technical advances have been made and the requisite technology has become more available and affordable. This has been accompanied by a growing interest in related fields, most notably on the topic of scene perception. A substantial amount of basic research that is particularly relevant to the present concerns was summarised by Henderson and Hollingworth (1999) (see also Henderson 2007 for a recent update); another useful source of basic and applied eye movement research is the edited volume by Underwood (1998).

The objectives of the present study, internally referred to as Wave 4, were to bring together roadside and non-roadside environments (both travel and retail) in a common visibility framework, and to obtain up to date data for the road/roadside situation for the two main respondent perspectives (driver vs. pedestrian). The results of the previous studies have proliferated in response to user interest and to fill gaps in the coverage of the research. Latterly the results have been summarised in the form of a "visibility matrix". For these purposes a broad range of panel types (formats) and environmental contexts and sub-categories has to be investigated. To achieve full integration, taking into account all the relevant variables, would be impossible for a single study because of the size of the investigation required. The problem will be illustrated later. In the meantime this account will address the most substantive issues that were identified as core and crucial for Postar's immediate concerns, and that defined the design structure of the present study. Despite the aim of comprehensiveness and inclusiveness, several important variables were unavoidably excluded.

In the discussion of issues surrounding Wave 4, the question of how to represent and assess panel size was initially resolved as requiring a contrast between "small" and "large" panels. Discussions leading up to Wave 4 resolved on a contrast between 6 sheet panels (and their nearest area-equivalents) and 48 sheets (and their nearest area-equivalents also). In the event scenes were photographed containing panels from 4 sheets to 96 sheets, from tube cards and escalator/stair panels to T-sides on buses. Hence a rich data-set of hit rate scores was obtained as a function of panel size and although representation was not numerically well balanced, this was sufficient to estimate hit rate for a graded set of panel sizes. Arguably the importance of panel size in the Postar scheme of things would support the finest possible empirical differentiation of panel types on this dimension in Wave 4, and the research did in practice do much to anticipate this.

1.1. Some preliminaries on panel classification

The usual classification of poster panel "environments" was reflected in the list of objectives. The classification does not consist of a straightforward hierarchy, with every category "crossed" with every other, and with sub-categories in most cases, the classification is complicated nearly to the point of unmanageability, so that simplification of the scheme could well become a goal in itself.

Poster panels may be classified in terms of their settings as follows:

- Roadside
- Supermarket Car-park
- Shopping Mall
- Pedestrian Precinct
- Rail
- Tube
- Bus

It would arguably be better to treat the last of these as a sub-category of a setting (Roadside) rather than a "setting" in its own right; in this respect it would be better to count it as a sub-category to be contrasted with "fixed panel". This very effectively underlines the fact that in our categorisation of environments we are not dealing with a simple hierarchy. Notwithstanding this is the reality of Postar's domain, and this fact steered the development of the research in its preparatory stages, from the commissioning and selection of photographs through the presentation of images to the first analyses of the data.

This simple scheme could be condensed into a grouped version, with Travel and Retail forming core categories: Travel would consist of Roadside bracketed with Rail and Tube, and Retail would be formed by Supermarket Car-park, Shopping Mall and Pedestrian Precinct subsidiary categories. The Travel-Roadside combination would separately be classified into Driver/Passenger and Pedestrian sub-categories, a subdivision that might arguably also be extended to the instance of Supermarket Car-parks.

Another potentially useful way of classifying the various environments for practical purposes would be to combine the contrast between viewer perspectives (vehicular vs. pedestrian) with a contrast marking a topographical attribute of the environment (linear vs. open). The latter may alternatively be thought of as reflecting a difference in constraints on the viewer's pathway in the environment. The vehicular perspective is in effect exclusively "linear" in nature. The pedestrian perspective is sometimes linear (as in the case of corridors, escalators and stairs) but sometimes open (as in the case of the shopping mall atrium); by similar reasoning platforms and concourses are mixtures of linear and open.

Considerations like these would seem timely and practical given the impending flood of data from Wave 4. The issue of classification is brought into focus again later in the report because of the emerging impetus for hit rate measures to be referred to standard distances and viewing angles. To begin with, however, this account stays with the conventional scheme of classifying poster panels and their environments.

1.2. Preliminaries on method

The generic method chosen to establish visibility scores for the variety of panels of interest was the same as that used in the formative 1995 driver visibility study. This was to measure the visibility of a poster panel in terms of the proportion of people (observers) fixating it while a static photographic scene containing it was exposed for a brief interval. During this interval the observer's eye movements were recorded using an eye-tracking device. The principal differences between the original and the present studies were the eye-tracker (and the associated technology) and the scenes used. Twelve years elapsed between the two studies and one crucial feature of the results to be considered is the agreement between them. One option that could not reasonably be pursued at this juncture was to migrate to a dynamic eye movement recording method (i.e., one that enabled movement on the part of the image viewed, the viewer of the image, or both). This would seem to be premature judging the matter in terms of cross-platform calibration (with respect to hit rate levels, for instance). It would also be prohibitive in terms of scale (and cost) if the scope of Wave 4 were to be preserved; it should suffice simply to envision the task of generating sufficient video material for the planned design categories of Wave 4 (for a video-presentation technique), or the task of engineering of real-time drives past the number of panels and sites involved (in the case of an in-car recording method as used for Postar's driver attention study in 1999-2000).

Technical differences between the original and present studies should not materially affect differentials between "*conditions*" or environmental "sub-categories", nor should historical differences in research personnel, and so forth. However, there may be other salient differences, such as the attention-getting properties of the panels and their advertising content, which may affect the results.

2. Research method

2.1. Research Design

The fully specified design, including all the variables/panel attributes mentioned in previous discussions, could run to many hundreds of *condition* combinations so it was necessary to trim the design radically; sampling some variables (notably panel eccentricity and environment – i.e., shopping/residential/arterial) and excluding others (e.g., illumination). All of the aspects of visibility recognised as important could not be included in the present study, and some were reserved for future consideration; these include eccentricity, distortion, illumination and time allowed for viewing.

2.2. Proposed (final) design

Postar stressed the need for a simplification of the design options to be investigated, to which end a design was proposed to integrate roadside and non-roadside environments (see Table 1). Only a subset of cells in the design (marked by an "x") was to be tested, and further reduction of the design might be expected due to practical constraints. Roadside was to sample shopping, arterial and residential settings, and represents both vehicular and pedestrian perspectives. Non-roadside, also representing the pedestrian perspective, covers other travel settings (tube/rail) as in Wave 1 (Travel), and retail settings (supermarket car-parks and malls/precincts) as in Wave 2 (Retail). Whereas Roadside is exclusively "linear", non-Roadside is a mix of linear and "open" spaces, exemplified by the corridor/atrium contrast in malls and the platform/concourse contrast in rail. Images for these various *conditions* were selected to provide a balance between environments in terms of basic scene/panel characteristics.

The design in Table 1 shows two rows in bold that were meant to serve as “bridge-points”, which were included to provide comparisons between “small” and “large” panels across as many environment/perspective combinations as possible. Measures of all scenes were to be made of the properties of the various panel sites, including distance, offset and distortion (determined by orientation), so that any variance due to these properties could in principle be assessed.

Table 1: Planned research design

		Roadside		Retail				Travel			
		Linear		Open		Linear		Open		Linear	
Panel	Dist (m)	Head-on	Parallel	Head-on	Parallel	Head-on	Parallel	Head-on	Parallel	Head-on	Parallel
6 sheet	10		X	X	X	X	X	X	X	X	X
6 sheet	**30**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
6 sheet	50	X	X	X	X						
48 sheet	**30**	**X**	**X**					**X**	**X**	**X**	**X**
48 sheet	50	X	X						X		X
48 sheet	80	X									
96 sheet	30	X	X								
96 sheet	50	X	X								
96 sheet	80	X									

It was understood that some adjustment of the design might be needed in the light of what would be revealed by an inspection of (a) the Postar database regarding panel site properties and (b) the existing and then-to-be-commissioned photography. Existing images were assessed with a view to their suitability for the research, and pilot eye-tracking work was conducted to make ready for the main study.

3. Eye-tracking methodology

3.1. Overview

Eye-tracking data were obtained from each subject (S) (i.e., respondent) in the course of a recording session of up to one hour. The duration of the session allowed the recording of the positions and durations of about 1,000 eye fixations per S.

3.2. Apparatus

All stimulus presentation and response recording was carried out using a DELL PC interfaced to an eye-tracker (Eyegaze Development System; LC Technologies, Inc.). Picture stimuli were displayed on a 21 inch monitor (visible diagonal 49.5cm) with a screen resolution of 1,024 x 768 pixels. Image onset was synchronised with screen refresh, and refresh rate was 60Hz.

Eye-tracking data were obtained using an Eyegaze Development System, which measures direction of gaze using the “pupil centre corneal reflection” method and does not entail any attachment to the subject’s head. The subject’s eye, illuminated by an infrared LED at the centre of the camera lens, is monitored by a video camera mounted below the computer screen on which images are viewed. The centres of the corneal reflection from the LED and pupil are located by software and these data enable the subject’s gaze-point to be established.

From the set of fixations on the scene from the S's viewing position, the spatial distribution may be derived for each S of the locations fixated for each scene. By pooling over Ss, the joint (x,y) distribution may be formed to show an aggregate view of the locations and objects inspected in each scene; these results are not of principal interest and for illustrative purposes only a sample of them will be presented. The same applies to another aspect of the results, namely the eye-track for each individual when viewing a given image. There will be several thousands of these eye-tracks; this requires representative sampling if the general phenomena of eye-tracking data are to be illustrated, though obviously the full data-set is available.

Each scene was presented for 6 seconds in the present research, so with an eye-position sampling rate of 60 per second, each scene is represented for any given subject by 6 x 60 data points for the (x,y) eye-position coordinates (known as gaze-points). In the course of data collection something like two million gaze-point values were generated. Criteria are applied to these raw data for the purpose of deciding when the eye is fixated and when it is in motion, thus achieving a substantial reduction in the initial data-set. The average number of fixations in an interval of 6 seconds (say) is about 18, so there are then about 2,000 fixations per subject to analyse, a total of over 100,000 datum values for each person.

Further criteria are used to decide whether any of the fixations is on a poster target. The LC Technology system used for Wave 4 records gaze-point data in a manner that facilitates the application of variable criteria. A criterial fixation radius of 20 pixels was adopted, together with a criterion distance from the poster boundary of 12 pixels. Two other criteria are used to specify the status of eye (stationary vs. in motion), namely that there should be input from the video device on at least three successive samples for a fixation (50 ms), but when there are none (also on at least three successive samples) the eye is considered to be in motion. This 20-3-3-12 parameter combination was established by pilot research with a number of observers using poster panels as the observers' visual "targets". This is to ensure that genuine fixations are noted, that adjacent fixations are not inadvertently treated as one, and that a reasonable degree of precision in aiming the eye is achieved. Fine tuning of the parameter settings was carried out to achieve optimal separation of posters in multiple panel arrays. In this extensive exploratory phase the fixation radius was varied from 16 to 50 pixels, the fixation duration from 50 to 100 ms, and the margin around the target from 0 to 15 pixels. Combinations outside this range were also examined to provide a sufficiently broad basis for understanding the effects of the individual parameter settings in the context of the present study.

The most important role of the fixation data is to provide a basis for estimating the proportion of subjects who fixate key objects (i.e., poster panels). This proportion, or hit rate, was obtained for each scene, and summary results were calculated for each design category of interest.

Depending on the design *condition*, the subject served as a car driver (Driver - roadside) or as a pedestrian (Pedestrian - roadside, Retail or Tube/Rail), the relevant "mental set" being established by careful instruction of the subject (see Appendix 3).

3.3. Materials

Photographs of scenes were used for each of the four environments, drawn either from the existing Postar archive of images (OLD - Travel and Retail Studies, and Wave 3) or provided by a professional commercial photographer (NEW). The composition of the set of images for each *condition* is shown in Table 2. Most of the scenes contained one but many contained more than one poster panel; while yet others - serving as decoys for the purpose of the research - contained none.

This table indicates how many scenes were presented to the individuals serving as research subjects in each *condition*.

Table 2: Number and source of images per environment

Environment	Source of images	Number of images
Driver - roadside	OLD (Wave 3) NEW	180
Pedestrian - roadside	OLD (Wave 3) NEW	180
Retail	OLD (Retail)	100
Tube/Rail	OLD (Tube/Rail + Wave 3) NEW	120

In obtaining photographic images of poster panels, whether fixed in position by the side of a road, on the side of a bus, on a wall in a shopping mall or in an underground corridor, it is crucial for the credibility of the research that the images captured represent typical rather than idealised views. That is, the camera viewpoint should show what (a) the occupant of a vehicle or (b) a pedestrian would see in the course of his/her passage into the scene depicted. The photography was done using criteria specified by a guidelines document (for Wave 3) indicating the viewpoints to be depicted (Appendix 2). This was developed because photographers generally succumb to the temptation to allow the target panel to become less incidental to the scene that it should be. The same photographer was used for Wave 4 as for Wave 3, so guideline instructions were directly transferable.

3.4. Subjects

Recruitment of research subjects was done using posters positioned in the vicinity of Birkbeck supplemented by the Birkbeck Psychology subject panel. Allocation of subjects to the four basic *conditions* of Driver - roadside, Pedestrian - roadside, Retail and Tube was random, subject to the requirement that there were results for at least 20 individuals per *condition*. In the event there were 23 datasets for each of the first two *conditions* and 22 each for the other two *conditions*. The subjects' mean age was 33.7 years; 58% of them were women and 72% were drivers. The men were significantly older (36.4 years) than the women (31.6 years), and drivers were older (35.3 years) than non-drivers (29.5 years). About half of the subjects (43/90) were allowed to be tested on more than one *condition*, but to minimise fatigue or boredom they had to return on a different occasion. The subjects' occupations inevitably reflected where they were recruited but were nonetheless varied[1], and while just over one in three was a student, this does not seem to amount to serious over-representation (only 8% were undergraduates).

All reported normal or corrected-to-normal vision, and they were paid £10 for completing a session. One session lasted about 45-60 minutes, the variation partly depending on the number of images seen but also on the time taken to complete the eye-equipment calibration process and how long the subject took as rest breaks between the blocks of images into which a session was divided. Subjects were given an informed consent form which indicated the nature of the task and stated that they would be free to terminate the session and leave at any time (Appendix 4).

[1] administrator, artist, ballet teacher, book keeper, caterer, customer service, director, engineer, HR assistant, IT officer, lecturer, needs assessor, office clerk, personal assistant, photographer, receptionist, security officer, solicitor, student, teacher, telephone interviewer, waitress

3.5. Procedure

A series of images was presented divided into a number of blocks of 20 images, the number depending on the *condition*. Each image was displayed for a maximum of 6,000 ms, during which time the subject was asked simply to inspect the scene depicted in accordance with the instructions. The order in which the images were presented was randomised independently for each subject. No immediate response was required but the instructions included the injunction to consider for each scene whether it included was a hazard to the safety of a driver or pedestrian negotiating his or her way ahead. The occurrence of any hazards noted was reported after the presentation of all the scenes to be viewed. Calibration of the equipment-eye relationship was done before the eye-tracking commenced and the equipment setting was checked between blocks. A single experimenter (MWS) was responsible for the eye-tracking sessions.

The intended focus of interest (for the observer) was the scene as representing a situation with a route imminently to be followed, which might be a road, pavement or corridor with a relatively obvious pathway, or an open space to traverse with more alternatives. This required careful instruction; Appendix 3 provides a detailed note of the spoken and written instructions used.

3.6. Sample eye-track and contour map

The subjects generated 90 datasets between them and saw 13,120 images from the 580 scenes. Hence a set of 360 gazepoints for each of 13,120 images was generated in the course of the study. The full complement of eye-tracks would amount to 13,120 gazepoint tracks and thus 13,120 fixation sequences.

Figure 1: Eye-track for a single observer: platform cross-track condition - image 4509 (fixations on panels are in yellow, others in red)

The observer of the scene in Figure 1 has fixated the 12 sheet panel on the left, some passengers and the information signage. Some features of the pattern are evident in Figure 2.

Figure 2: Distribution of gaze-points for platform cross-track condition - image 4509 (aggregated over 22 observers)

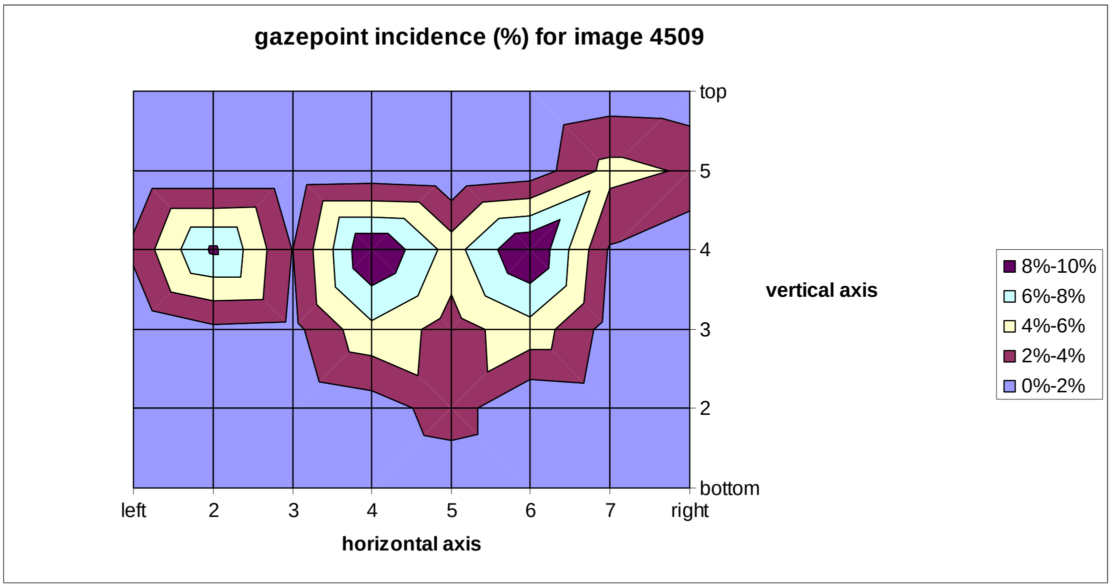

Figure 2 shows the locations of all the gaze-points for all 22 viewers of the scene in Figure 1. In this aggregated form, the main attention-getting features are evident: there are three peaks, on the 12 sheet panel, the man in the centre of the picture and the bunch of passengers standing on the right; the information signage on the right appears to have lesser visual salience, as does the group of passengers seated on the right.

4. Preliminary analysis of image properties

4.1. Image property analyses

The images used in the present research were full colour photographs of real-world settings obtained using a range of digital cameras, reflecting the range of image providers and photographers. For the purpose of the study, many images needed to be trimmed or resized to a common 4 x 3 format (1,024 x 768 pixels).

A set of photographs of 6 sheet panels at 10 metres (in portrait mode) were used as "calibration shots", to enable a mapping of distances on the display monitor on to distances in the real world. By locating the corners of a target panel in terms of their screen coordinates, it is a simple matter to obtain various useful estimates of panel properties, including distance from and orientation to the camera as well as projected area on the screen. It has to be assumed that poster panels are erected to stand upright, even if their orientation to the viewer may vary (e.g., from head-on to parallel). The vertical extent of a panel on screen (P_{SCREEN}) reflects its real vertical size (P_{REAL}). Essentially all that is required is the assumption that proportions of rectangular shapes are preserved in the photographs and the application of standard geometrical rules. The actual optical geometry is not exactly as assumed but the error is small in the context of the precision of measurement required (say, to the nearest metre in the case of distance or the nearest 5 degrees in the case of angle). To obtain an estimate of actual camera-panel distance, the measure of on-screen vertical extent P_{SCREEN} can be compared with the equivalent measure for the 6 sheet calibration panel $P_{CALIBRATION}$ at 10 metres. Panel orientation can also be obtained using the corner coordinates to provide on-screen measures of horizontal and vertical extent. A third measure of interest is the area covered on the screen by the projected image of the panel. This measure supplies a basis for estimating the hit rate for a panel if eye fixations are entirely random, whence it is possible to gauge the "added value" of the panel.

Many scenes contained more than one panel which is reflected in the panel count (see Table 3 for a detailed breakdown). The first target in assembling images for each *condition* was the number of scenes, shown in the right hand column. A second target was a satisfactory number of scenes containing panels in each of the key formats of interest (referred to as the prime panel). Inevitably – and true to the reality of how poster panels are situated by site owners - many scenes contained more than the prime panel; this is reflected by Table 3. A third target was an adequate number of decoy scenes, that is, scenes containing no poster panel. This number was partly dictated by the number of formats in the various *conditions*. Table 3 shows that the proportion of decoys and the number of panels per scene were quite similar for the two Roadside *conditions*. Retail and Tube differ from one another and from the other two; Retail contains just one format, whereas Tube/Rail formats are more numerous and the environment is more crowded with signage. The average numbers of panels per scene (excluding decoys) for Driver – roadside, Pedestrian - roadside, Retail and Tube/Rail were 1.63, 1.35, 1.01 and 2.50 respectively. Competition among panels would thus have been most severe for Tube/Rail scenes, least for Retail, with the two sets of Roadside scenes between these extremes.

Table 3: Number of scenes containing 0, 1, 2, 3 and 4 or more panels for each condition

Condition	0 (decoy)	1	2	3	4 or more	Total
Driver - roadside	45	74	43	13	5	180
Pedestrian - roadside	30	65	60	17	8	180
Retail	10	89	1	0	0	100
Tube/Rail	22	23	29	15	31	120

Table 4 provides a summary of three important attributes of the panels depicted in the scenes for each *condition*. Panel distance, orientation and screen area were not drastically different for the two Roadside *conditions*. However, bus panels were rather closer on average than the fixed panels. Moreover the area covered on the screen by bus panels was rather less than for fixed panels, which is partly a consequence of their actual sizes being less than the fixed panel sizes (the *weighted* average of panel size as sampled was just over 16 sq metres for fixed panels and just over 3 sq metres for bus panels). More importantly the Retail and Tube/Rail panels were considerably closer on average than Roadside panels, indeed they were less than one third of the distance away. A direct consequence is that the screen areas were much larger for Retail and Tube/Rail than for Roadside; inevitably this confers a visibility advantage on the former, tempered by the fact that Tube/Rail panels were less head-on (i.e., having larger orientation values) than Roadside. In contrast Retail panels were more head-on than panels in any of the other three *conditions*. Pooling this information would tend to support the expectation that Retail should score higher than panels of the equivalent real area in any other *condition*. The greater proximity to the viewer of the panels in Tube/Rail and Retail could simply reflect a choice of distance on the part of the photographer but it is more likely a result of structural factors in these two cases, being enclosed environments with different architectural constraints to exterior settings.

Table 4: Summary statistics for some key image properties for each condition (distances in metres, angles in degrees and areas in pixels)

Condition	Measures	Fixed panels	Bus panels	Tube panels
Driver - roadside	Mean panel distance	40	28.7	
(135 scenes with panels)	Mean orientation	37.3	33	
	Mean panel area	5,719	3,583	
	Count of panels	208	32	
Pedestrian - roadside	Mean panel distance	40.4	23.2	
(150 scenes with panels)	Mean orientation	28.5	39.4	
	Mean panel area	6,653	4,423	
	Count of panels	104	72	
Retail	Mean panel distance	12.6		
(89 scenes with panels)	Mean orientation	17.6		
	Mean panel area	10,905		
	Count of panels	90		
Tube/Rail	Mean panel distance	11.9		4.9
(98 scenes with panels)	Mean orientation	52.8		51.2
	Mean panel area	19,775		10,067
	Count of panels	129		116

It remains to index the amount of screen area occupied by poster panels of all types treated as an aggregate for each *condition*. The areas for Roadside panels were 0.69% and 0.64% for Driver and Pedestrian perspectives respectively. The area for Retail was 1.39% and for Tube/Rail it was 1.49%. This adds support to the idea that the images in the two Roadside *conditions* were well matched. It also suggests how much more prominent panels were likely to be in the Retail and Tube/Rail *conditions*.

5. Results

5.1. Unadjusted hit rates and moderating variables

Although the study was limited in its scope, as described above, it is the most comprehensive and therefore complex eye-tracking study undertaken by Postar to date. The eye movement data depend on the various attributes of the poster panels displayed that are of direct interest (including panel size and location) and on the many other attributes of the panel sites and their settings. These attributes may moderate the levels of the principal measures of interest (e.g., visibility hit rate) in an empirical study; the present investigation is no exception to this. Accordingly the presentation and description of the results is organised so that any moderating influences can be readily appreciated.

This first section presents an account of the visibility data for the many panel types represented in the study. It begins with summary findings for hit rate as a function of panel type for the four main *conditions*. "*Condition*" here is defined as a combination of "environment" and "perspective". Roadside panels were presented as viewed from the driver and pedestrian perspectives. Scenes for Retail and Tube/Rail panels were presented from the pedestrian perspective. The four resulting *conditions* for summarising the results were therefore Driver - roadside, Pedestrian - roadside, Retail and Tube/Rail.

Postar's basic measure of the *visibility* of a poster panel is the *hit rate* for the panel. This refers to the proportion of respondents who fixated (i.e., looked at) the panel at least once. Table 5 presents an overall picture of the results for all "cells" containing 6 or more observations (this is a rather liberal criterion for inclusion but provides a defensibly comprehensive picture of the results). There are several measures[2] of "visual performance" in general but the most important and useful for Postar's concerns is "hit rate"; in the tables it is averaged over all respondents and all scenes in the particular category (e.g., 6 sheet).

The table classification is by *condition* and panel type and it contains other vital information in addition to hit rates. Panel size is the basic panel property of interest, but because the panels were shown at varying distances and in varying orientations to the viewer, information on these variables is also supplied, and the hit rate scores are aggregated over distance and orientation. In the tables hit rate (HR) is the *raw* visibility score for the *condition* tabulated. This is the basis for visibility modelling over an extended interval (e.g., as a driver/pedestrian passes or is otherwise in the presence of the panel with an opportunity to see it). Notice that HR variations may naturally be accompanied by variations in panel distance (in the photographs), orientation (head-on = 0 deg; parallel = 90), and the area on the screen as viewed (in pixels). It is because of these co-variations that *raw* HRs must be interpreted with care. This applies to the following tables too.

Other than HR and the number of panels on which each HR is based, there are three measures in Table 5 that relate to important real physical properties of the panels as depicted on the screen. The first two are directly linked to the third:

i. Panel distance (in metres) is estimated from the photographic image and is measured as the distance from the viewer (i.e., where the photograph took the shot) to the panel.

ii. Panel orientation is the angle (in degrees) through which the panel is turned relative to the viewer (zero meaning "head-on" and 90 meaning "parallel").

[2] Other important measures that can be derived from the eye-tracker output are the time to initiate the first fixation to the scene, the duration of the first fixation on the panel, the total number of fixations on the panel (hence counting any multiple fixations for all individuals), and the total time spent fixating the panel.

iii. Screen area is the area occupied on the screen (in number of pixels) by the image of the panel. This is related to the first two since when both distance and angle of a given panel are increased, the area on the screen covered by the image of the panel is decreased. Obviously a large panel at a particular distance and angle projects a bigger area than a smaller panel at the same distance and angle.

The variation in average hit rates between the "cells" in the matrix is likely to be partly "explained" by the corresponding variation in these panel properties which is why this information is supplied in the spreadsheet. One illustration of this is the variation in hit rates in the 48 sheet column; the highest hit rate is for the Tube "*condition*", but the panels in this case are much closer to the viewer than the panels in either of the Roadside *conditions*. Data for 12 sheet and 16 sheet Tube panels were combined to achieve the minimum cell size of 6.

Table 5: Mean visibility hit rates for poster panels as a function of panel type and condition (means are also shown for panel distance (in metres), panel orientation (in degrees) and the screen area of the panel (in pixels). The number of panels on which these results are based is also shown in each case)

Condition	Measures	4 sheet	6 sheet	12 & 16 sheet	48 sheet	96 sheet	Tube car panel	Escalator & stair	Bus rear panel	Superside	T-side	Total
Driver - roadside	**Mean hit rate**		**0.286**		**0.343**	**0.485**			**0.356**		**0.377**	**0.352**
	Mean panel distance		24.2		46	55.8			27.6		30.3	38.4
	Mean orientation		35.3		39.5	35.6			11.6		64.3	36.6
	Mean panel area		3,616		5,885	9,278			1,485		6,649	5,412
	Count of panels		75		93	40			19		13	242
Pedestrian - roadside	**Mean hit rate**		**0.43**		**0.452**	**0.586**			**0.239**	**0.375**	**0.512**	**0.418**
	Mean panel distance		30		44.2	53.3			15.5	21.8	31.7	32.3
	Mean orientation		12.4		44.7	26.5			7.9	54.8	51.7	34.6
	Mean panel area		3,321		7,844	10,924			3,180	5,023	4,912	5,505
	Count of panels		41		43	20			22	26	24	185
Retail	**Mean hit rate**	**0.575**	**0.477**	**0.651**	**0.635**		**0.259**	**0.235**				**0.409**
	Mean panel distance	6.6	12.8	11.2	17.8		4.1	5.9				8.6
	Mean orientation	53.9	47.2	61	58.8		40.3	65.7				52
	Mean panel area	18,361	12,531	20,564	35,880		14,521	4,189				15,179
	Count of panels	37	54	11	27		66	50				245
Tube/Rail	**Mean hit rate**		**0.677**									**0.677**
	Mean panel distance		12.6									12.6
	Mean orientation		17.6									17.6
	Mean panel area		10,905									10,905
	Count of panels		90									90

Table 6 presents results for the sub-categories of the Retail *condition*. The mean hit rates are very similar but as in Table 5, there are differences in distance and orientation that need to be taken into account. The panels in the Retail *condition* were all 6 sheets. The HR differences appear to be marginal, even so it will be seen that HR increases as distance decreases and area increases, evidently producing small but reliable differences between *conditions*.

Table 6: Hit rates and panel properties as imaged for Retail condition sub-categories (distances in metres, angles in degrees and areas in pixels)

Sub-condition	Measures	Total
Mall	**Mean hit rate**	**0.675**
	Mean panel distance	9.7
	Mean orientation	25.6
	Mean panel area	15,668
	Count of panels	28
Shopping	**Mean hit rate**	**0.682**
	Mean panel distance	15.5
	Mean orientation	11
	Mean panel area	7,055
	Count of panels	19
Supermarket	**Mean hit rate**	**0.677**
	Mean panel distance	13.1
	Mean orientation	15.3
	Mean panel area	9,504
	Count of panels	43

Table 7 is for the sub-categories of the Tube/Rail *condition*. The different sub-categories were differently composed, with a variable mix of panels. The column "Total" shows the data aggregated over panel sizes where appropriate (i.e., platform, cross-track, corridor, concourse) so any differences in panel sizes between sub-categories affect the totals. This is illustrated in the body of the table which breaks the results down to give a classification by sub-category and panel size. The tube-car interior setting is divided into three sub-categories: cross-car refers to the view from a seated position directly across the car to the facing wall; in-car seated is the view down the length of the car from a seated position; and in-car standing is the view down the length of the car from a standing position.

The detailed results in the five columns in the body of the table show what variation there is in panel size, and how distance may affect this too. The 4 sheet panels in corridors had higher hit rates than their 6 sheet counterparts but they were less than half the distance away. Several cells were omitted from the body of the table because of the "6-or-more" criterion for inclusion. However all of the data were used to form the Totals, as can be seen from the values under "Count of panels".

Table 7: Hit rates and panel properties as imaged for Tube/Rail condition sub-categories (distances in metres, angles in degrees and areas in pixels)

Tube sub-category	Measures	4 sheet	6 sheet	48 sheet	Tube card	Escalator & stair	Total
Platform	**Mean hit rate**	**0.555**					**0.611**
	Mean panel distance	5.6					5.7
	Mean orientation	62.3					59.7
	Mean panel area	19,414					22,772
	Count of panels	20					24
Cross-track	**Mean hit rate**		**0.566**	**0.647**			**0.619**
	Mean panel distance		14.9	17.2			15.4
	Mean orientation		15	57			43.6
	Mean panel area		6,757	36,415			24,107
	Count of panels		10	21			43
Corridor	**Mean hit rate**	**0.64**	**0.413**				**0.483**
	Mean panel distance	5.7	13.4				11.2
	Mean orientation	55.2	54.4				56.6
	Mean panel area	20,639	12,230				16,090
	Count of panels	12	37				54
Cross-car	Mean hit rate				0.548		0.548
	Mean panel distance				2		2
	Mean orientation				12.7		12.7
	Mean panel area				34,342		34,342
	Count of panels				21		21
In-car seated	Mean hit rate				0.104		0.104
	Mean panel distance				5.6		5.6
	Mean orientation				61		61
	Mean panel area				3,793		3,793
	Count of panels				31		31
In-car standing	Mean hit rate				0.169		0.169
	Mean panel distance				3.9		3.9
	Mean orientation				36.1		36.1
	Mean panel area				8,543		8,543
	Count of panels				14		14
Escalator & stair	Mean hit rate					0.235	0.243
	Mean panel distance					5.9	5.9
	Mean orientation					65.7	64.6
	Mean panel area					4,189	4,574
	Count of panels					50	51

Table 8 presents the data for the Roadside *condition* aggregated over panel sizes and over bus panel types. The results are shown separately for the Driver and Pedestrian perspectives. Roadside panels received higher scores when viewed from a pedestrian viewpoint and on average were viewed at the same distance. Hit rates for bus panels were about the same but a fuller picture is supplied by Table 5.

Table 8: Hit rates and panel properties as imaged for Roadside condition from Driver and Pedestrian perspectives (distances in metres, angles in degrees and areas in pixels)

Condition	Measures	Panel	Bus
Driver - roadside	**Mean hit rate**	**0.35**	**0.364**
	Mean panel distance	40	28.7
	Mean orientation	37.3	33
	Mean panel area	5719	3583
	Count of panels	32	32
Pedestrian - roadside	**Mean hit rate**	**0.469**	**0.379**
	Mean panel distance	40.4	23.2
	Mean orientation	28.5	39.4
	Mean panel area	6653	4423
	Count of panels	104	72

The health warning that applies to the above results due to the evident relation between hit rate and distance and orientation should not be disregarded. Differences within the various tables should not be considered without considering any associated differences in panel distances and orientations. The next section considers if anything can be done to remove the effects of these moderating variables.

5.2. Adjusting hit rates: standardisation by distance and orientation

The calculations for the tables in this section were done using the statistical technique of multiple regression analysis. For present purposes this can be viewed as providing a basis for predicting hit rates from a chosen combination of variables. The principal variables of choice were panel distance (from viewer to panel) and panel orientation (to the viewer's line of sight to the panel), both estimated from the photographs. For each of these variables, target values were chosen (by Postar's Visibility Subcommittee) for the purpose of standardising the results: these were distances of 12 and 35 metres, and orientation/angle values of 0˚, 12˚and 45˚. To apply the results to the panels that figured in the image set for Wave 4, the real area of a panel was included in the analysis as well as its distance and orientation. In principle this enables the application of a predictive equation for hit rate as a function of distance, orientation and area in order to obtain estimated hit rates for a specific panel (with a known real area) at the standardisation values of distance and orientation. These are the quantities reported in the above Tables.

After some exploration of the analytical options, and various ways of combining the *conditions* and sub-categories, three newly defined "environments" were chosen for the application of the analysis. The choice was dictated by a combination of practical and statistical considerations. The contrast between open and closed (i.e., exterior vs. interior) environments was used in conjunction with the distinction between driver and pedestrian perspectives (which has hitherto only affected the Roadside *conditions* in Wave 4).

Accordingly, the three subsets of the Wave 4 data were:

i. Open environment: driver perspective - roadside only. This simply consists of the data for all panels in the Driver - roadside *condition* in Wave 4. (See Table 9)

ii. Open environment: pedestrian perspective - roadside and exterior retail. This incorporates all of the data from the Pedestrian - roadside *condition* together with the Supermarket car-park and Pedestrian Precinct sub-category data from the Retail *condition* in Wave 4. (See Table 10)

iii. Enclosed environment: interior retail and tube/rail. This was composed of the data for all enclosed *conditions* (hence interior), and so combined the Tube/Rail data with the Mall sub-category data from the Retail *condition* in Wave 4. (See Table 11)

The hit rates for each of these environments were subjected to multiple linear regression analysis with panel distance, panel orientation and actual panel area as independent variables. Regression coefficients are shown in the following equations:

```
Open-Driver
Predicted HR = 0.463 - 0.0044 x Distance - 0.0018 x
Orientation + 0.0087 x Area

Open-Pedestrian
Predicted HR = 0.651 - 0.0059 x Distance - 0.0030 x
Orientation + 0.0101 x Area

Enclosed-Pedestrian
Predicted HR = 0.700 - 0.0126 x Distance - 0.0049 x
Orientation + 0.0286 x Area
```

Standard errors of estimate for the respective coefficients were as follows:

```
Open-Driver: 0.0264, 0.0006, 0.0004, 0.0010

Open-Pedestrian: 0.0263, 0.0009, 0.0005, 0.0016

Enclosed-Pedestrian: 0.0385, 0.0028, 0.0006, 0.0033.
```

(These values may be used to set confidence limits on the coefficients).

The results of tests of statistical significance for regression by analysis of variance were as follows:

```
Open-Driver
F(3,236) = 31.89; MS error = 0.026; p<0.001

Open-Pedestrian
F(3,243) = 29.60; MS error = 0.035; p<0.001

Enclosed-Pedestrian
F(3,269) = 42.14; MS error = 0.035; p<0.001
```

Table 9: Open environment: Driver perspective - Roadside only

		Standard distance of 12m			Standard distance of 35m		
Panel type	**Panel areas (sq m)**	**0 degrees**	**10 degrees**	**45 degrees**	**0 degrees**	**10 degrees**	**45 degrees**
4 sheet	1.536	0.424	0.406	0.341	0.323	0.305	0.24
6 sheet	2.16	0.43	0.411	0.347	0.329	0.31	0.246
48 sheet	18.581	0.573	0.554	0.49	0.472	0.453	0.389
96 sheet	37.161	0.734	0.716	0.651	0.633	0.615	0.551
T-side	6.119	0.464	0.446	0.381	0.363	0.345	0.28
Superside	4.019	0.446	0.427	0.363	0.345	0.326	0.262
Bus rear	0.554	0.416	0.397	0.333	0.315	0.296	0.232

No data were obtained in Wave 4 for 4 sheet panels but the *condition* is included for possible extrapolation from these results.

Table 10: Open environment: Pedestrian perspective - Roadside and Exterior Retail

		Standard distance of 12m			Standard distance of 35m		
Panel type	**Panel areas (sq m)**	**0 degrees**	**10 degrees**	**45 degrees**	**0 degrees**	**10 degrees**	**45 degrees**
4 sheet	1.536	0.596	0.566	0.461	0.461	0.431	0.326
6 sheet	2.16	0.602	0.572	0.468	0.467	0.437	0.332
48 sheet	18.581	0.767	0.737	0.633	0.632	0.602	0.497
96 sheet	37.161	0.954	0.924	0.819	0.819	0.789	0.684
T-side	6.119	0.642	0.612	0.507	0.507	0.477	0.372
Superside	4.019	0.621	0.591	0.486	0.485	0.456	0.351
Bus rear	0.554	0.586	0.556	0.451	0.451	0.421	0.316

No data were obtained in Wave 4 for 4 sheet panels but the *condition* is included for possible extrapolation from these results.

Table 11: Enclosed environment: Interior Retail and Tube/Rail

		Standard distance of 12m			Standard distance of 35m		
Panel type	**Panel areas (sq m)**	**0 degrees**	**10 degrees**	**45 degrees**	**0 degrees**	**10 degrees**	**45 degrees**
4 sheet	1.536	0.594	0.545	0.374	0.305	0.256	0.085
6 sheet	2.16	0.612	0.563	0.392	0.416	0.39	0.298
12 sheet	4.645	0.683	0.634	0.463	0.437	0.411	0.32
16 sheet	6.194	0.727	0.678	0.507	0.45	0.424	0.333
48 sheet	18.581	1	1	0.861	0.556	0.53	0.439
Escalator	0.24	0.557	0.508	0.337	0.399	0.373	0.282
Card	0.171	0.555	0.506	0.335	0.399	0.373	0.281

Two entries for 48 sheets were limited to the maximum value for a proportion because predicted exceeded 1.0.

The effect of standardisation will be evident if these results are compared with the Table 5 in the first part of the Results section. There is a general tendency for hit rates to decrease as the distance to the panel increases and as the panel becomes increasingly angled from the line of sight (i.e., as the angle moves from head-on to parallel). When distance and angle are standardised, *conditions* that in effect were respectively penalised/rewarded by being more/less remote or more/less angled are positively/negatively compensated. The revised tables are “fairer” in having the appropriate direction and amount of compensation applied to the set of panels, with the adjustments geared to the level required by the actual surface area of the particular panel size.

The standardisation treatment has not at this juncture been extended to the environment sub-categories represented in Tables 6-8. The question is whether it makes sense to generate scores for the standard distance-orientation combinations in the environment sub-categories beyond what is in Tables 6-8.

5.3. Visibility hit rates compared

A number of eye-tracking studies have been conducted by Postar in support of its visibility modelling project. As noted in the Introduction there are several differences between the previous research and the present study. The question arises as to whether the outcomes are substantially different. It would be surprising if there was parity in the overall hit rate levels and in the hit rate differences between all aspects of the studies: panel types and panel sizes, environments, environmental sub-categories, and observer perspectives. The first part of the Results section of this report has clearly shown that direct comparisons between hit rates in different studies are difficult to make because of concomitant differences in the panel attributes (including distance and orientation) as well as the composition of the images/scenes and advertising content. It is important nonetheless to document the comparative data as fully as possible.

Table 12 therefore provides information about the Wave 4 results in comparison with Postar’s previous eye-tracking results (i.e., the original 1995 driver visibility study and the 1998 pedestrian visibility study). The table presents the results from equivalent *conditions* from three eye-tracking studies, together with a chart (in alternative formats for clarity) depicting the data trends for hit rate vs. panel size. Mean hit rates for Wave 4 are shown before and after distance-orientation standardisation. It is clear now that the hit rates in Table 5 are so different from the 1995 scores largely because of the marked differences in panel distances (possibly this applies to orientation too but figures are only available for Wave 4).

The strategy of standardisation to agreed normative distance and orientation values is well justified by the outcome of the regression analyses. The chief interest in Table 12 very likely lies in the comparison between hit rates for the driver perspective for 1995 vs. 2007. The biggest difference of 8% is for 96 sheets, which in 1995 were only represented by 6 images so the hit rate would not have been as precisely estimated as in Wave 4. Any difference will among other things be subject to random influences. On the face of it the result is quite remarkable; the trends with panel size are sustained (indeed the new data are clearer because they now include 96 sheets for the pedestrian viewpoint), and the actual hit rate levels are strikingly similar. Of course the acid test is whether the differences are sizeable from an applications point of view and this is a practical matter outside the remit of this report.

Table 12: Comparisons between visibility hit rates for Postar eye-tracking studies (distances in metres)

Study	Measures	6 Sheet	48 sheet	96 sheet
Driver study (1995)	Mean hit rate	0.354	0.481	0.712
	Mean distance	34.6	35.2	35.2
	N images	27	43	6
Wave 4 (2007) standardised Driver - roadside	Mean hit rate	0.329	0.472	0.633
	Mean distance	35	35	35
Wave 4 (2007) before standardisation Driver - roadside	**Mean hit rate**	**0.286**	**0.343**	**0.485**
	Mean distance	**24.2**	**46**	**55.8**
	N images	**75**	**93**	**40**
Pedestrian visibility study (1998)	Mean hit rate	0.507	0.696	
	Mean distance	22.9	36.4	
	N images	24	16	
Wave 4 (2007) standardised Pedestrian - roadside	Mean hit rate	0.467	0.632	0.819
	Mean distance	35	35	35
Wave 4 (2007) before standardisation Pedestrian - roadside	**Mean hit rate**	**0.43**	**0.452**	**0.586**
	Mean distance	**30**	**44.2**	**53.3**
	N images	**41**	**43**	**20**

6. Discussion, recommendations and caveats

The results as described above more or less speak for themselves; the relevant qualifications have been expressed, and little or no further explanation is needed. However, we reach a position where we can assess other factors that are determining hit rates in the passive eye-tracking task used for these investigations.

The factors of interest that have been established as key contributors to the variation in hit rates are panel distance from the viewer, orientation relative to the viewer and panel size. These factors in combination “explain” about 40% of the hit rate variance, so some 60% remains to be accounted for. There is a longer way to go than has been travelled to the present point. One factor that has not been fully assessed is aspect ratio (i.e., the panel’s height to width ratio). Others that may be testable include offset (for roadside scenes, this would be from the road centre, for example) and screen area; the former is an actual property that could reasonably be part of the specification of a panel for visibility adjustment, whereas the latter is a feature unique to the method of presentation on screen and could not be. Other potentially important properties that may contribute significantly to the hit rate variance include panel sub-category values and environment sub-categories.

There is another factor, environmental clutter, which has regularly featured in Postar deliberations about visibility. It has always been seen as a potentially very important influence on panel visibility, and this was originally recognised by the inclusion of site classification as a simple means of indexing it; classifying a site by a three-way split between Shopping, Arterial and Residential was intended to indicate the decreasing amount of clutter associated with these three environments for roadside panels. Accordingly visibility hit rates would (and did) increase as “clutter”, so defined, decreased. The issue was not directly addressed further by the design of Wave 4, however, it is important to check the balance of scenes/panels selected for investigation for the Roadside *conditions* on the present study, given that clutter is recognised as a factor likely to influence visibility. This incidentally makes the point that the contribution of clutter has not been explicitly addressed for any environment but Roadside, and this in only an *ad hoc* fashion, with no empirical footing for the classification originally employed.

Aside from clutter, a number of other factors and issues were reserved for future possible research including time of exposure (or OTS duration) and illumination (day-time vs. night-time). Duration here is not a reference to "dwell time" in the real environment but is the time for which a scene is viewed in the eye-tracking study. For previous eye-tracking work, as in the present study, this was set at 6 seconds. It was judged important to ascertain whether the results were affected by the choice of duration, and the possibility of incorporating a manipulation of this variable in Wave 4 (using other values such as 3 and 10 seconds as well as 6 seconds) was mooted, but reserved for later research; this research has since been completed and is being written up for report. In Postar deliberations, illumination has often been used to refer to the intrinsic properties of a panel (e.g., back-lighting and other forms) and this is likely to influence visibility. The contribution of transient day-time light levels external to the panel is also a potentially significant source of hit rate variance; light level varies naturally and some sense of the strength of its contribution may be obtained by applying a simple scale of measurement (e.g., clear/dull/rainy) to assess the images used in Wave 4.

Eccentricity (i.e., displacement from some agreed reference point - such as the centre of the road in the Roadside *condition*) is another variable that would merit inclusion in a fully specified design. This was not feasible for the Wave 4 study if all other factors were also to be represented since the overall design would become unmanageable. Although distance, orientation and eccentricity could in principle be independently manipulated, when combined with panel size the number of images required would be excessive; for three values on each of these factors, the design for Roadside (where all these factors are represented) has 81 "cells", each requiring say 20 images, so the number of images for the environment would be 1620. In the event eccentricity had to be omitted (consensually) from the list of factors to be fully sampled in the design, its contribution to be examined as it varied concomitantly with other factors. Hence it remains an important variable (as established by the 1995 study, see also Cole and Hughes, 1984) whose effect on visibility hit rates has not been reassessed, and would necessarily have to be based on the 1995 estimates.

The data from Wave 4 – along with the results from the earlier studies – clearly amount to a substantial resource. The analyses reported here are some distance from exhausting the potential yield of the research. The point was made at the start of this section that there must be many variables that contribute in determining hit rates. Some of them may be identifiable from the existing data. These include aspect ratio, offset and panel height above ground level. An interim report on the effect of height was distributed partly based on the present data; the outcome generally was not entirely clear-cut but there is sufficient evidence that height would be one of the factors to be included in a full list of contributing variables. The point of pursuing this would be to identify such variables and to ascertain whether any exist that warrant serious attention. Possibly each of these candidates contributes a mere two or three percent of the variance and could be ignored if in the practical scheme of things measurement on the scale required would be exorbitant. On the other hand there may exist variables that are known (like aspect ratio) or easily assessed and play a significant part in setting the hit rate value of a panel.

Other issues that have not been fully settled include the critical level of distortion and the role of content. An interim report on distortion was distributed and the data from Wave 4 can add substantially to the understanding of this variable. Content has long been sidelined as a concern of Postar visibility research; the question of how much is added or subtracted to hit rates by poster content will no doubt continue to be revisited as long as it has not been addressed, so arguably some effort should be invested in assessing its contribution. It is possible that content accounts for most of the residual variance in the regression analyses, maybe very little; there is a vacuum where there could be substance, which would reduce uncertainty by reducing the hit rate variance left to explain.

7. References

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Appendix 1: Chronology of Visibility Studies

Driver visibility study (1995-1996): OSCAR 2 measuring visibility hit rates of roadside panels, using infra-red eye-tracking methodology. Introduced the basic concept of visibility hit rates for poster panels. Modelled visibility in terms of panel size, eccentricity (offset from road) and distance. Respondents: drivers and passengers.

Maximum visibility study (1996-1997): assessing the furthest distance at which a panel can be seen with full concentration on the panel, using psychophysical methods.

Pedestrian visibility study (1998-1999): measuring visibility hit rates for poster panels in roadside and pedestrian environments, using infra-red eye-tracking methodology. Respondents: pedestrians.

Nottingham driver attention study (2000-2001): establishing how drivers' & passengers' attention is distributed down the road ahead – using real-world in-car eye camera technology. Respondents: drivers and passengers.

"Inclusivity" pilot (2002): comparing a set of active search methods as alternatives to passive eye-tracking methods (for speed, convenience and portability).

Wave 1 (aka Travel Wave) (2003-2004): using an active search method selected on the basis of the "Inclusivity" pilot to estimate hit rates for panels from transport media (buses, tube, rail, taxi). Respondents: pedestrians.

Wave 2 (aka Retail Wave) (2003-2004): using the active search method to estimate hit rates for panels in retail environments (supermarket car-parks, malls, pedestrian shopping precincts, petrol stations, phone-boxes). Respondents: pedestrians.

Video analysis of driver eye behaviour (2004-2005): using video analysis of gaze data from Nottingham driver attention study to assess hit rates on roadside panels and buses. Respondents: drivers and passengers.

Pedestrian visual behaviour: walking speed and head-up study (2005): specifying key aspects of walking for use in pedestrian visibility modelling via literature searches and observational data.

Wave 3 (2006): using the active search method to provide supplementary data on panel hit rates in key transport environments (buses and tube). Respondents: pedestrians.

Wave 4 (2007): using a passive eye-tracking method to estimate panel hit rates in key transport environments, with contemporary roadside panels, providing an up-to-date database across environments with new eye camera technology.

Appendix 2: Guidelines for Postar Photographic Work

1. Underground and rail stations

1.1. General considerations

The general location of each poster site will be specified for the photographer by the specialist responsible for the site, or by the Postar visibility representative. There will be some flexibility as to the specific location with certain locations (e.g., underground stations) to allow for photographic factors (lighting, obstruction); thus the photographer may need to select which corridor/passageway/tunnel, which escalator, which platform to use.

Above all, it is important to keep in mind that this is not a photo-opportunity for posters. Glamour shots or poster portraits are **not** what is required! They will be rejected. Each photograph should therefore be composed taking into account what travellers/pedestrians see in approaching a poster, as a routine part of the journey, looking directly ahead of themselves. The viewpoint must be what someone would see as they walk with purpose through the environment. It should always be assumed that the person whose viewpoint is to be captured is **not** looking for posters.

It is important that the poster concerned is not in the centre of the scene unless it has to be there, as in the case of a poster facing the traveller at the end of an underground link tunnel.

Take several/many pictures as you walk through the environment with the posters at varying distances from several to 40 metres. The numbers of pictures listed below is our final requirement; we will pick these from the sample you provide, so you can take as many as 30 pictures for each environment, to allow us a reasonable choice and prevent a re-visit being required.

There are two types of scenes, poster scenes and decoy scenes, explained below:

1.2. Poster scenes

Each of the following should be supplied containing one or more poster. The distance will sometimes be dictated by the context, but should generally be several metres from the poster.

i. Surface entrances/ticket/booking halls/concourses: on entry, various representative locations, as if moving to the ticket machines/booking office or the automatic gates (tube) or platform gates (rail) (12)
ii. Surface entrances/ticket/booking halls/concourses: On exit, various representative locations, as if moving to exit via the automatic gates (tube) or platform gates (rail) (12)
iii. Down escalators: top looking ahead/down, from midpoint of step (12)
iv. Down escalators: half-way down looking down, from midpoint of step (12)
v. Up escalators: bottom looking, ahead/up, from midpoint of step (12)
vi. Up escalators: half-way up, looking ahead/up, from midpoint of step (12)
vii. Link tunnels: Various locations, looking directly ahead (12)
viii. Platforms: Cross-track - various representative positions, e.g., where travellers stand, including ahead of and between billboards (12)

ix. Platforms: Along platform - various locations as if moving from the entrance down the platform, or from the alighting point to the exit or transfer tunnel, and looking directly ahead (12)

1.3. Decoy scenes

Where possible, 6 scenes from each of the above are required but which do **not** include a poster.

2. Surface travellers (for buses)

2.1. General considerations

The general location of each poster site will be specified for the photographer by the specialist responsible for the site, or by the Postar visibility representative. There will be some flexibility as to the specific location to be used (e.g., bus routes) to allow for photographic factors (lighting, obstruction). Thus the photographer may need to select which location on which bus route to use, but the routes on which bus advertising is used will be specified. It is preferable for there to be no competing advertising signage in view.

Above all, it is important to keep in mind that this is not a photo-opportunity for posters. Glamour shots or poster portraits are **not** what is required! They will be rejected. Each photograph should therefore be composed taking into account what travellers/pedestrians see in approaching a poster, as a routine part of the journey, looking directly ahead of themselves. The viewpoint must be what someone would see as they walk with purpose through the environment. It should always be assumed that the person whose viewpoint is to be captured is **not** looking for posters.

It is important that the poster concerned is not in the centre of the scene unless it has to be there, as in the case of a poster on the rear of a bus facing a driver in a car directly behind the bus.

3. Vehicular Posters: Buses

Photographic scenes taken from a pedestrian viewpoint are required, as if walking along a pavement, crossing a road, etc, also the viewpoint of someone travelling in a vehicle (which could be the view from a car, van, bus or taxi), etc. Three quarters of the scenes should contain a bus, half on the left, and half on the right of the viewpoint. About two in three of these vehicles should have a visible poster on the side or rear. About one in three of these should **not** have a poster on the side or rear. The distance from the viewer should be between 25 and 70 metres. A quarter should be taken in the same general area, on the same kind of street, but should contain no bus within 100 metres.

Note that there should be no roadside poster panel in view.

Take several/many pictures as you walk through the environment with the posters at varying distances from several to 40 metres. The numbers of pictures listed below is our final requirement; we will pick these from the sample you provide, so you can take as many as 30 pictures for each environment, to allow us a reasonable choice and prevent a re-visit being required.

There are two types of scenes, poster scenes and decoy scenes, explained below:

3.1. Poster scenes

Each of the viewpoints represented should be supplied containing one or more poster. There should be about 30 of each viewpoint.

3.2. Decoy scenes

Where possible, 12 scenes for each viewpoint are required but which do **not** include a poster.

Appendix 3: Instructions for Wave 4 (Spoken and Printed)

Preselect the version of the program to be run. Enter and sit the subject (S) at the small table – experimenter (exptr) sits at the test table. Ask particulars, nationality, occupation, age, driver/non-driver and check and enter the S's name on the sheet and the date. Give the S the following printed instructions to read (in italics).

All of the photographs you will see were taken in everyday environments in the UK, and are representative of what someone could encounter on their day-to-day travels. Many are of road scenes, some are in commercial settings, and some on the Underground in London. So sometimes you will need to think of yourself travelling in a car, driving or being driven, and looking at the scene ahead as naturally as you would in a car. When the scene is a pedestrian view, however, you should think of yourself as making your way into the scene ahead, looking where you are going but doing so as naturally as possible in that setting.

This experiment is to discover what people look at in photographic scenes. We do this by recording eye movements using a small video camera that tracks the reflections from your eye. It is a safe and standard procedure.

Before any of the scenes are presented, we have to make sure that the camera is in focus on your eye. We then go through a short calibration sequence, so that the computer can interpret the signals that the tracker picks up from your eyes. The nature of these movements is unique to each individual.

After the calibration is complete, you will be shown a few 'practice' scenes so you understand the nature of what we are doing.

In the experiment itself, while your eye movements are recorded, you will be shown a series of groups of scenes, 20 per group. Each scene is shown for a few seconds. There will be about a dozen groups in all, and the experiment will take about 45-55 minutes.

When you are ready, the researcher will give you detailed instructions on what to do.

The important thing to remember is that when each picture comes up, it is important that you look first at where you would be focussing if you were a driver/passenger/pedestrian. Then carry on looking at anything else that you might normally view when driving/travelling/walking in such a scene.

I hope that was clear or have you any questions?

Now, I shall ask you to sit comfortably on this chair with your forearms on the table, resting your chin gently on the chin rest, like this. First we have to have the camera focussed on your eye by adjusting the equipment and asking you to move to the best position for the camera. (The experimenter now sits at the testing table, resting arms on table and shows how the eye is in focus and points out the 'focus bar').

Then we will calibrate the computer. A sequence of small yellow circles will appear at different places on the screen which you have to look at carefully. This is an essential part of the experiment that may take as long as 10 minutes. During the calibration it does not matter if you blink but please keep your head still and do not talk as talking makes your head move.

Now would you like to sit in front of the computer, please?

Calibration

Right, you can relax and look around and talk now, the computer is calibrated to you.

Next, you will be shown a few 'practice' scenes so you will see and understand the nature of what we are doing. Rest your chin, please check the focus, and remember not to talk during the session but do blink when you want to.

Practice

Now, in the experiment, you will be shown a series of groups of 20 scenes. Each scene is shown for a few seconds and followed by the next scene after a few seconds break, so be ready!

Before each image appears, a red cross appears in the middle of the screen.

There are about a dozen groups of scenes and there is a break between each group.

Remember: When each picture comes on, it is important that you decide and look first at where you would be focussing if you were a driver/passenger/pedestrian in that scene. You have a few seconds to look at each scene and we would like you to look at each just as you would when driving/travelling/walking in such a scene.

Drivers

Now remember, for each driving scene, imagine of yourself as the driver of a car, having to look at the road ahead, steer the car and watch out for hazards etc. in the normal way. You will have a few seconds to look at each scene and we'd like you to view it just as you would when driving.

Pedestrians

For each pedestrian scene, imagine yourself as walking into the scene on the screen. You have to decide quickly where you're going, watching out where you walk, looking about you in the normal way. You will have a few seconds to be in each scene, and we'd like you to look at each one, just as you normally would, making your way about town.

Do you understand what's involved? Do you have any questions?

End/Debriefing (to be spoken)

That's all. Thank you very much for taking part. Your results will be put together with those of several others to draw up a final picture of what people look at under these circumstances, and particularly what their scanning patterns are in the different situations, what objects capture attention, and what are the differences between different built environments.

Check respondent details:

- Gender
- Age
- Occupation
- Driver/non-driver
- Nationality
- Familiarity with London (very/moderately/not-at-all familiar)
- Purpose in London (leisure-tourism/study/work)

Ask for comments on the research, and enable the respondent to say what he/she thought the experiment was about. Answer any queries.

Appendix 4: Informed Consent Information

Visual Perception Experiment

School of Psychology, Birkbeck College, University of London

Drs. Mariana Sanderson and Paul Barber are doing a series of experiments into what people look at in various urban environments.

This requires the participant to look at a series of images as if they were travelling in a car, walking, or travelling on the Underground.

The images are displayed on a computer screen and we record your eye movements using a small video camera that is placed below the computer screen. It is a standard (and safe) procedure.

About a dozen groups of scenes will be shown, each scene for a few seconds, with optional rest breaks between groups. The experiment will take between 45-60 minutes

Of course if at any time during the experiment you feel you would prefer not to continue, you would be free to leave.

The experiment will be with Dr. Sanderson and it takes place in:

Senate House
Malet Street
London
WC1E 7HX

Telephone: 020 7631 6202
E-mail: m.sanderson@bbk.ac.uk

Appendix 5: Additional Eye-track Images from Wave 4

This collection of images has been selected to illustrate some of the eye movement patterns that were found as observers viewed the scenes used in the present research. These eye-tracks, with an observer's fixations and saccades superimposed on the corresponding scenes (with hits coded in yellow), show a degree of consistency between observers reflecting the relative salience of different objects and the overall visual structure of the scene. Figures 1 and 2 show eye-tracks for the same scene for two different observers; the patterns are different but show similarities with respect to objects fixated. Figures 3 and 4 show the same scene for two different observers whose eye-tracks have a number of common features, but one of them fixates the panel and the other does not. The remaining figures are of different scenes and a sample of different observers. The selection should not be thought to represent the hit rate level achieved in any case; it is intended to convey the nature of the eye movement patterns that occur during scene viewing. Some images have been included in which the observer did not fixate the poster panel(s) on display.

Figure 1: Tube Corridor – Observer A

Figure 2: Tube Corridor – Observer B

Figure 3: Bus rear (pedestrian) – Observer C (hit)

Figure 4: Bus rear (pedestrian) – Observer C (no hit)

Figure 5: Roadside 48 sheets (driver) – the observer looks down the road and fixates the lower panel but not the upper one

Figure 6: Roadside 96 sheets (driver) – the observer mostly looks down the road again but also fixates both panels on the right

Figure 7: Bus rear panel (driver) – the observer trapped behind the single deck bus gazes left and right but mostly at the rear of the bus, including its poster panel

Figure 8: Roadside 6 sheet (pedestrian) – the observer on the pavement fixates people and signage including the 6 sheet in the clutter ahead

Figure 9: Roadside 48 sheet (pedestrian) – the observer on the pavement fixates a wide area including the raised 48 sheet on the left

Figure 10: Bus T-side (pedestrian) – the observer facing a crossing fixates the T-side panel on the bus passing directly ahead

Figure 11: Retail Mall – the observer facing the atrium fixates people and structures ahead, and the 6 sheet panel on the left

Figure 12: Retail Supermarket Exit – the observer viewing people exiting ahead fixates them and the raised 6 sheet on the right

Figure 13: Tube/Rail Concourse – the observer fixates the people on the concourse and two of the three large billboards ahead

Figure 14: Tube Car Interior – the observer looks at the people opposite, including the man or the right's newspaper, and the signage above them, including two tube card panels

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