Visibility

Estimating the visibility of poster panels for pedestrians

route
outdoor media analytics

Biographies

Dr Paul Barber was employed at Birkbeck in the University of London where for over thirty 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 sixteen 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 the 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 and subsequently Route since 1995, closely identified with its programme of research on poster panel visibility.

Simon Cooper has a BSc in Cognitive Science from Birkbeck and has worked in outdoor research for over twenty years. He was the NOP project manager and architect for the Postar research in the UK in 1996 and before that worked on the original OSCAR research. This connection between academia and commercial research allowed for the integration of eye-tracking studies from Birkbeck to play a role in the development of visibility measurement in outdoor. As part of this early project he co-authored the Postar roadside visibility models with Dr Barber and co-designed all the visibility research between 1995 and 2007.

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Foreword

In February 2013, we republished the very first study that sought to estimate the visibility of posters for car drivers and passengers, "Poster panel visibility for drivers and passengers: a first look".

Encouraged by the response, we now reproduce the initial, and complementary, report of research into pedestrian visibility.

Fieldwork was conducted during the summer of 1998.

Much has changed since then. Our understanding has been refined as the result of conducting a number of subsequent studies, all of which are listed in the appendix. Nonetheless, it is the first look at pedestrian behaviour that helped to guide what followed. To fully understand the matter, it is essential to start with the first steps.

Postar's visibility studies were conducted continuously from 1995 until 2010. The work was undertaken by the Department of Psychology at Birkbeck College, in the University of London. Over time, we gained a deep understanding of the importance of size, distance, angle of presentation and so on. The studies considered what it was like to be a car driver or passenger, a pedestrian or a passenger on board a bus or a train. They looked at illumination, and environment. Most recently, the work sought to appreciate the effect of movement such as that presented by digital screens.

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March 2014

Abstract

Estimating the visibility of poster panels for pedestrians

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Following an investigation to assess the visibility of poster panels for car drivers and passengers, the present study provided data on the visibility of poster panels for pedestrians. The methodology of the previous investigation was deployed again; this involved recording eye movements while photographs of scenes were viewed for the same fixed interval of six seconds used in the previous study on driver visibility. The incidence of fixations on target panels was measured and used to provide a visibility score or *hit rate* for each panel depicted. Mean hit rates were obtained for two panel sizes (6 and 48 sheets). The scenes used were from four *environments;* the same three used in the driver visibility study were used: Arterial, Residential and Shopping; supplemented by one unique to pedestrians, namely Rail (specifically, station concourses).

As in the driver visibility study, it was not possible to assess the joint effects of panel size and environment since the distribution of panels of the two sizes investigated was markedly unbalanced. The results showed that hit rate was lower for the smaller panel size. Hit rate did not reliably vary with Environment, although Arterial scenes appeared to produce the highest hit rates, albeit in purely numerical terms, an effect that was not statistically significant. Hit rate was again found to vary with panel *eccentricity,* tending to decrease as offset from the roadside increased.

The manner in which hit rate accumulates as time since the scene is displayed was analysed. Fixations directed at poster panels tended to occur relatively early in the display interval. Although the growth rate for pedestrian hits was well fit by a power function as was that for drivers and passengers, it is questionable whether this aids the development of a generalizable visibility model. In terms of hit rate growth it seems that the visual behaviour of pedestrians may resemble that of car passengers rather than drivers; however, the more general question of how pedestrians orient visually, and how this may affect poster panel viewing, requires further study. A review of the research on pedestrian behaviour was undertaken and this provided useful background information for the study, but targeted empirical research may be needed to supply a more comprehensive basis for visibility modelling.

Introduction

This study follows an investigation conducted for POSTAR[1] to establish the visibility for car drivers and passengers of roadside poster panels (Barber and Cooper, 1995). The objective of the present study was to obtain data for the visibility for pedestrians of advertising poster panels to complement the information from the driver visibility study (published in 2013 by Route – the first in this series). The same methodology was used and data were acquired for roadside poster panel sites paralleling those in the driver study and with some extensions to exclusively pedestrian areas.

The results of the previous study on driver visibility provided the input for an analytical process to replace the previous system (OSCAR, see footnote) used to assess panel visibility. The data for the modelling process were obtained by recording the eye movements of observers viewing roadside scenes photographed to represent the viewpoint of a driver. Visibility was indexed as the proportion of observers who visually fixated the poster panels on view at each site. These "hit rates" were analysed with respect to relevant site properties including *panel size, eccentricity* (lateral displacement), and *environment.* The last of these comprised the same contrast between roadside panel settings as represented in the driver study (i.e., arterial, shopping and residential), supplemented by a non-roadside setting uniquely experienced by pedestrians, namely railway station concourses. This extension of the scope of the research flags a concern with the wider range of contexts in which pedestrians may encounter poster panels and is a first step towards a more complete and representative assessment of these settings.

By sampling the same stock of roadside panels that is potentially available for inspection by drivers, the viewer on foot was exposed to a relatively restricted environment with a visual trajectory resembling that of a driver. As a result generalization from a driver's visual trajectory to that of a pedestrian may be feasible, at least in terms of geometrical similarity. Similarity of trajectory does not of course mean that equivalence or even similarity of visual behaviour must or may be assumed between pedestrians and drivers. Aside from the obvious contrast in the motion control aspects of driving vs. walking, the visual attentional elements of the tasks are quite different. It is intrinsic to the task that a driver has to pay attention to the road ahead in a visually directed, focused and sustained fashion; in contrast walking imposes a lower attentional burden on the pedestrian – attention generally being less precise and concentrated.

Notwithstanding that the main emphasis of the study was on roadside panels, it was recognized that the environments in which poster panels are encountered by pedestrians are more varied than those met by drivers. While the principal emphasis of the report is on the empirical research using an eye movement recording methodology, an ancillary focal point was on the research literature on the visual behaviour of pedestrians; the latter provided an underpinning for the study and potentially steers the application of the findings of the visibility research. The report continues with a first look at attention and pedestrian behaviour.

Attending to the environment while walking

A thorough literature search for this topic was conducted but few investigations were located that were judged directly applicable to the present study specifically and to POSTAR more generally. It comes as no surprise that pedestrian behaviour has been studied for many years, much of it concerned with crowding/congestion, safety problems and medical aspects. Although little of this research is directly relevant to visibility issues, it is clear that studies to assess walking speed and pedestrian flow density are of interest.

One paper of interest is a report by Cohen and Cohen (1992) in the journal *Forensic Reports* which includes reports from "litigated cases". The title makes the important point that "walking requires your attention" but this was not so much based on evidence as on the authors' engaging discursive account of tripping, slipping and falling accidents that befall pedestrians. Even so it is a useful general review of the "physical and cognitive aspects of walking". The authors asserted that "walkers generally scan about 10-20 feet ahead of them, unless their attention is directed elsewhere", however, no evidence was cited for this claim.

Another particularly promising report is that by Wagner, Baird and Barbaresi (1981) on the "locus of environmental attention". This study used a disarmingly simple method "for exploring the allocation of visual attention in the natural world". The participants in the study walked along a specified outdoor route, and were stopped periodically by a given sound signal and were asked to describe in precise terms what they were looking at. The "size, nature and location" of the reported objects were analysed. It was evident that gaze direction

1 OSCAR (Outdoor Site Classification and Audience Research) was a scheme for calculating the audience for outdoor advertising poster campaigns in the UK. For each panel listed in its database, a measure of visibility was obtained. A team of inspectors assessed each site in terms of degrees of obstruction and deflection (from the line of sight) and competition at its nearest visibility point. The scheme was put into effect in 1985 and was progressively refined by a series of revisions until a radical review was undertaken in 1992 by the UK's Outdoor Advertising Association (OAA), an organization representing a partnership of major players in the industry. The OAA aimed to put the OSCAR system for pricing sites on a sounder empirical basis by commissioning studies to determine (a) poster audience size by modelling traffic flow and frequency; and (b) poster site visibility, using eye movement recording to assess the chances of the site being looked at by passers-by. The result was the Poster Audience Research (POSTAR) system, responsibility for the research having been assumed by a new independent company, Postar Limited, which was succeeded in 2013 by Route Research Limited, with an enlarged scope on all fronts. The present investigation and its precursor were aimed at establishing measures of poster site visibility and were funded by Postar, but this paper was made available under the auspices of Route. In both cases a research agreement with Birkbeck of the University of London was put into effect for the investigation to be conducted in the Department of Psychological Sciences at Birkbeck.

was quite variable, with a strong tendency to look away from the direction of movement (or heading), interspersed by glances a short distance ahead; just 10% of the time was spent looking within 5° of the individual's heading. A similar method was used by Hull and Stewart (1995), who interrupted hikers at various points in a hike and instructed them to photograph what they were looking at. The photographs were analysed in terms of the type and distance of the object that was the focus of the view. They reported that attention was not differentially paid to scenic or ugly views, and often was paid to "ephemeral features", indeed there were "more similarities than differences" in what was viewed.

Formal approaches to pedestrian behaviour

Some interesting methodological options are exemplified by other studies, for example, the use of computer simulation and mathematical modelling of pedestrian movement. Thus Helbing (1991) constructed a mathematical model of pedestrian behaviour, with applications among other things to "selection processes among Behavioural alternatives". He contended that "the movement of pedestrians is supposed to show certain regularities, which can best be described by an algorithm for individual Behaviour and are easily simulated on computers". This research is from the University of Stuttgart which is also the home of the neural network software that was used by Simon Cooper in modelling traffic flow for POSTAR. Using a computer simulation technique, Yamori and Sugiman (1992) modelled the influence of the collective pedestrian environment on the extent of information processing of the environment by individuals. This work suggests that pedestrians are less attentive to their surroundings when having to cope with a complex pedestrian flow. Such approaches to pedestrian behaviour will no doubt draw on the general growth of computational techniques for modelling.

Evidence of environmental influences on pedestrian behaviour

In fact there is some empirical evidence of influence of the traffic environment on pedestrian behaviour. Korte and Grant (1980) found that at times of high traffic noise and density, the pedestrians in their study were less aware of novel objects placed on their route, walked faster, and scanned the environment less widely, tending to gaze straight ahead of them. Korte and Grant also interpreted their findings in terms of restricted awareness of the immediate surroundings. This evidence is among the most directly applicable to the concerns of our research.

Rotton, Shats and Standers (1990) found a complex pattern of relationships between walking speed and temperature using experimental and quasi-experimental methods. In one study they report that "pedestrians walked faster in a warm than in a cool setting", but in a second study they stated that "low temperatures were also associated with more rapid movement". In the latter case, it appears that inside buildings, when the temperatures were the same (presumably while the outside temperature differed), walking speed was the same.

In a study assessing the pace of life in "transitional" Poland, Buggie (1993) measured walking speed, and reported that men walked more quickly than women, and that walking speed was significantly slower in the capital city than in provincial cities. The first of these findings was confirmed by Wirtz and Ried (1992), together with the equally unsurprising finding that older people walk slower than young people. However, they also reported that people tended to walk faster in large cities than in smaller ones, which is at odds with Buggie's (1993) results. This study is possibly the more informative in this regard since the measure of walking speed was adjusted for "population composition" (presumably allowing for sex and age ratio differences), and it incorporated measures of the "momentary density of people". Age, sex and environmental congestion were also shown to affect walking speed by Walmsley and Lewis (1989), who found in addition that time of day and weather were influential factors.

Research on crowd behaviour has naturally focussed on safety aspects because of accidents such as the Hillsborough and Bradford football grounds disasters. At another extreme there are everyday situations where dense crowding is normal, and this is relevant to the present research. These situations include travel on underground railways and much has been learned about the relationships between crowd density and flow rates from observational and experimental studies in the UK and Japan (Smith 1995). There are no immediate lessons to be learned from such research but the research serves as a reminder that even in the relatively benign circumstances that would tend to apply to the everyday pedestrian, there will be consequences for walking speed (and visibility) that depend on the degree of crowding to which they are exposed.

This collection of studies serve as a reminder of the complexities of assessing walking speed, and of some of the factors that may need to be taken into account when considering pedestrian traffic flow past sites of interest to POSTAR. The evidence concerning visual attention is rather sparse but it suggests that the focus of attention of pedestrians is variable and may be influenced by several factors.

There is some empirical evidence of influence of the traffic environment on pedestrian behaviour.

Techniques

Methods for assessing pedestrian behaviour are chiefly derived from research on road safety. The techniques are varied but observational methods figure prominently. This may be a useful source of ideas as to how to assess the visual behaviour of pedestrians but little of direct interest was unearthed by the literature search. The focus of the research is on actions such as gap acceptance at road crossings, risk estimation, and so forth. Researchers have devised various methods to classify pedestrian behaviour from mere observations; for instance, Fisher and Nasar (1992) drew conclusions about fear of crime in a public area on the basis of observations of pedestrians. It is unlikely that the present study will need to record details of human locomotion, but it is worth noting that there are standard procedures and apparatus for doing so (e.g., Strelow, Brabyn and Clark, 1976) should this become relevant. Not surprisingly there is a good deal of research on the biomechanics of walking but it does not obviously bear on present concerns (however, the reader may find some interest in the principal finding of one technically sophisticated study that people can't walk in a straight line even when asked; Uetake, 1992).

Sources of visual information involved in walking

Another substantial research area concerned with the guidance of locomotion was also reviewed, not directly relevant to the present study. On the other hand the evidence from this field of research, much of it from studies on targeted walking, does bear on what visual information is used in the control and guidance of walking; and how long information about the visual environment endures in the eye/brain system. The importance of "optic flow" in locomotion is stressed; in essence this is the dynamic flow of visual texture and perspective information as one moves about through the physical environment. More particularly this refers to the use of visual information in locomotion guidance, and the issue is raised of how it is acquired from the central and peripheral fields. There are dozens of papers on these themes, although the literature understandably does not address the question of whether or not articulated objects such as posters come to act as objects capable of guiding eye fixations or capturing attention. Instead the emphasis is on establishing the importance of different "dynamic" sources of information (there are complex theoretical controversies that motivate the research) and any implications for POSTAR are well buried. Yet this research should not be dismissed out of hand as irrelevant since there are suggestive references to "body-scaled eyeheight information", the "construction of spatial representations", and so forth. This section of the literature contains accounts of the visual control of walking, the behavioural context in which the specific visual behaviours that the present study is concerned with are situated. It will be important for any study like this one that seeks to investigate the conjunction of walking and looking to be informed about this more general context.

A study with superficially very tangential relevance is one by Zohar (1978) in which he investigated the conditions under which people bump into objects. He derived what he termed "anthropomorphic bumping likelihood profiles". On the face of it, this has little relevance to POSTAR, however, the author referred to "implications for the design of walking environments" and reported that the incidence of accidents appears to be "a positive function of the distance of the object and the axis of the effective visual field of the walking person". This illustrates one way in which the visual field of the pedestrian may be conceptualized and this certainly is relevant to the present study.

Finally in a study by McDonald, Bahill and Friedman (1983), it was noted that "to visually fixate on an object while walking, compensatory horizontal and vertical eye movements must be made". The authors modelled the behaviour for simple targets and monitored subjects' eye movements for a target tracking task while walking. The technology required to assess this visual behaviour will need to be considered if the present study is to investigate what pedestrians look at when walking. This is a timely reminder of a potentially key item for the agenda here.

In conclusion, it is evident that there are several useful sources that identify factors that influence gross aspects of pedestrian behaviour like walking speed and the breadth of attention. However, it appears that the specific type of enquiry needed to underpin a visibility model for pedestrians has not been undertaken.

Visual inspection of displays and scenes

The method of choice for this and the preceding study entails the use of an eye-tracking device to capture eye-fixation behaviour while viewing scenes. This allowed the focus to be placed squarely on the activity of the visual system in a situation relatively free of constraints on how to proceed. It is appropriate at this point to identify some related topics in preparation for the research, adding some useful background to the review of eye-tracking in the driver visibility study.

An area of concern during World War 2 and for some decades after was inspection and visual search of relatively unstructured scenes and displays. Search for maritime targets and radar screens was of intense practical interest and motivated extensive applied psychological research into practical problems, and which is today still apparent, for example, in the design and use of displays for air-traffic control. Topics of interest included how individuals scanned complex displays when searching for a target item embedded in the display, and how long their visual attention (or vigilance) could be sustained for critical (often faint or near-threshold) signals when continuously inspecting displays for prolonged periods (Davies and Parasuraman, 1982; Warm, 1984). An important result from many such studies on vigilance is that target detection falls markedly in the first 15-20 minutes of a "watch", and such evidence may be used to place a limit on how long a task should be performed without a break.

Another substantial body of research has focussed on the performance of a varied range of tasks involving visual search. This research is an area that was first vigorously explored because of its applicability to a range of real-world and especially military problems (e.g., see Morris and Horne, 1960). A paper by Enoch in this symposium, drawing on a substantial series of studies, illustrates the typical focus of interest of these studies and provides some exemplary findings. The search material consisted of aerial photographs and maps. The efficacy of search performance and eye movements while searching were recorded. Typically there was an initial "orientation phase", evidently lasting for only a few fixations, exploring the display in a fairly regular pattern, specific to the individual. This was followed by a "search phase", elaborating the basic pattern and ending when the target had been located, or the decision that no target existed was made. According to eye movement recordings the decision to end searching was frequently made before the display had been comprehensively examined. There were notable tendencies in the search patterns, with the top-left quadrant of the display neglected and the bottom-right favoured in terms of fixation frequency. In addition – and with some emphasis on this point – Enoch reported that no eye movement record was obtained in which the subject "read" the photograph as if reading a book; thus invalidating a "popular mis-conception". Indeed the results of several separate experiments showed that there was no dominant search pattern, although the centre of the display drew most attention and remarkably search might often only extend to a visual consideration of a mere 50% of the display.

We could express the concern of our research as involving incidental visual attention.

Visual search paradigms were also taken up by experimental psychologists as a vehicle for investigating basic issues to do with human information processing. Neisser (1964) reported the results of a variety of laboratory-based studies using character displays (letters and digits) as search material. Developments of the search paradigm owe much to studies in which feature search (e.g. finding a green target in an array of red non-target forms); feature-based search has been heavily researched (e.g., Treisman and Gelade, 1980). This research raises questions about the nature of search processes (are these processes conducted serially or in parallel; is search exhaustive or self-terminating?)

The fields of study mentioned are not so much separate strands of research as topics having different roots and emphases. The techniques and materials used also tend to differentiate them; the more applied strands used relatively unstructured displays and permitted the adoption of more "natural" search techniques, while the more academic strand has been disposed to use structured search arrays with more severe time and accuracy constraints. What may be learned from this research is limited by a key factor; it is intrinsic to the vast majority of the many studies in these fields that those participating as subjects are instructed to search deliberately and consciously for a target of some kind. For the purpose of the foundational research represented by the present study and its predecessor, we may consider a poster advertisement as a "target" for the purpose of analysis but we must not make this apparent to our research participants. Searching for advertisements is not among the tasks that pedestrians (or drivers in our previous study) ordinarily embark upon whatever else they may have in view. Indeed, drawing on this point, we could express the concern of our research as involving incidental visual attention. That is, we must acknowledge that people go about their everyday business as pedestrians (or vehicle occupants) with aims and objectives that define what they are looking for, or need to look at, and that influences the viewing frequency with which they look at the objects that are of interest to us and that we wish to know about – namely advertising poster panels. It remains for us to establish what properties of those panels and their locations incidentally influence their behaviour. It is important to note that paying attention in this fashion seems to be some way distant from what has been considered in visual search or any related field of vision research, in which the "target" is imposed by the investigation.

Method

Methodological overview

The method used was effectively the same as that used for the POSTAR driver visibility experiment. The observers again viewed a series of still photographs while their eye movements were recorded, however, there were two main differences with respect to the driver study. First, the research participants were asked to consider themselves as pedestrians rather than drivers when viewing the photographs. Second – springing directly from the change in mental set – the images used were photographs depicting scenes from the perspective of a pedestrian rather than a driver. Most of the scenes were of roadside settings but some were of railway station concourses; moreover, while a majority of the scenes contained advertising posters, a proportion of the scenes – as in the driver study – contained no poster panel and thus served as “decoys”. It was important that the observer did not actively look for advertising posters so the decoy scenes were employed with the aim of obscuring the actual purpose of the study. At the end of the eye movement recording phase the observers were questioned about what they had seen. For the purpose of the recording of eye movements, the observers were asked to view the pictures (which they saw for six seconds each) as if they were a pedestrian in the setting portrayed in the photograph. No reference was made to advertising posters.

As noted in the previous paragraph the research method differed very little from that of the driver visibility study. Some minor variations are described below, including the number of scenes and the range of panel sizes. In addition greater control was exercised over the lateral distribution of panels. Notwithstanding the relative insignificance of these minor variations, the method will be described fully so the earlier report does not have to be consulted for this purpose.

Materials: Scene photography and scene selection

There were 56 scenes in total, comprising 40 images containing a “target” panel and 16 “decoy” scenes with no target. Of the 40 scenes containing a target, there were 24 with a 6 sheet panel and 16 with a 48 sheet panel.

As the subjects in the present study were asked to view the scenes as if they were pedestrians at the depicted location, it was important that the photographs convincingly represented the viewpoint of a pedestrian, and this required the acquisition of a sizeable new pool of candidate photographs. The images were drawn from a folder of 143 photographic scenes commissioned by POSTAR for the study and supplied on photo-CD: 70 included at least one 6 sheet; 49 included at least one 48 sheet; the remaining 24 decoy candidates contained no poster panel. The photographer for the images was carefully briefed to capture scenes containing poster panels of the specified sizes which were “natural” and representative of scenes that a pedestrian would typically encounter; it was stressed that “marketing shots” of panels would not be acceptable. The distance from viewer to panel was to be 30 metres.

The selection of images for the study was made so that the lateral locations of the targets were balanced as far as possible. The resulting distribution of panels across the visual scene is shown in Table 1. It was possible to make a selection of panels for the 6 sheet condition so there were 8 on the left, 8 on the right and 8 directly ahead (in the “line of sight”). This could not sensibly be fully implemented for the 48 sheets since for the line of sight location they dominated the scene and thus made the purpose of the study difficult to conceal. Six random sequences of these images were created to define the presentation orders for the study.

Table 1: Classification of scenes containing posters by panel size and poster location

Panel type/location	Left of centre	Line of sight	Right of centre
6 sheet (24/70 candidates)	8	8	8
48 sheet (16/49 candidates)	8	-	8

Equipment

The same equipment was used as for the driver visibility study. Each subject's eye movements were recorded using a Skalar IRIS eye tracking system interfaced to a Mac Quadra 950, fitted with a National Instruments Lab-NB board for additional input/output operations. A standard monitor was used that supported displays of 768 x 512 pixels. The subject was also supplied with a microswitch to trigger successive trials. Custom-built software was used to control the experiment, data collection and data analysis.

Notwithstanding the fact that computerization of the eye movement record was intrinsic to the Skalar system used, scoring of the data for a single subject was not fully automatic (see Data Analysis section) and took about 45 minutes per subject. A comprehensive description of the visual behaviour was supplied for further analysis, including the coordinates of the screen locations visited by each subject's eyes. It was thereby possible to identify the incidence and duration of fixations on any poster panel contained in a scene.

Despite recent developments in eye-movement recording techniques not all subjects are usable for the eye movement recording process. The basis for eliminating subjects is partly to do with the calibration process (for example, some are unable to comply with the calibration procedure, possibly because they have difficulties in exerting the conscious control over their eye movements that is required for equipment calibration), or because of structural factors, or because they wear spectacles (which impede the recording process). The expected wastage/rejection rates are about 10-20 per cent. The restriction on wearers of spectacles may be expected to be removed in future studies once the technical platform for eye movement recording is upgraded.

Procedure

On arrival the participants were given a printed instruction sheet briefly outlining the nature of the study and instructing them as to their task. The printed instructions are included as Appendix B. The participants were invited to ask questions about the task before the session was under way. The session was subsequently divided into two main phases: (1) the eye movement study; and (2) the interview. Assistant experimenters were used to run the study as before but they were supported rather more rigorously by the provision of instructions to underline their responsibilities (Appendix A). This minor procedural tightening-up allowed this important aspect of the study to be more clearly documented. The assistants shared the tasks of meeting and greeting the subjects, instructing and debriefing them, performing the calibration process, running the experiment, and analyzing the raw data to generate an input file for each subject for further processing and analysis.

(1) Eye movement study

As noted above the equipment used and its deployment were the same as for the driver study. The first procedural step was to calibrate the equipment relative to the individual's eye structures and eye movements. To this end a series of circular targets was presented on the 16 inch (40.6 cm) diameter screen of the Macintosh at random locations sampled from a rectangular matrix spanning the area on the screen on which the poster scenes were to appear. This enabled the data from the sensors mounted on the monitoring frame (head-set) worn by the subject to be interpreted. Each subject sat facing the screen at a distance of 40 cm, using a chin-rest mounted on the edge of the table to support the head and to restrict any head movements tending to destroy calibration settings. Initial adjustments of the headset were made to ensure comfortable viewing conditions. Calibration ensued with readjustments (and further calibration) of the frame as necessary. This phase was sometimes protracted as subjects adjusted to the equipment, and the experimental situation. The longest calibration phases were about 15 minutes. Calibration was subsequently checked after every 15 images during the experimental phase.

The scale of the study was adjusted to accommodate the structure of the research design, and this was somewhat smaller than that of the driver study. The 56 poster scenes were presented in four blocks, the first three comprising a sequence of 15 scenes and the last comprising 11 scenes. Each scene was displayed for 6 seconds and the subject's eye movements were recorded during this time. The screen was then blank until a small black square appeared in the centre of the screen as a fixation guide. When ready to proceed the subject pressed a micro-switch key placed on the table in front of the screen and the next scene appeared. Between blocks the subject's comfort and the equipment calibration were checked. At the end of the study the monitoring equipment was removed and the subject went to the interview room.

(2) Interview

The post-experimental briefing was the same as for the driver study. The subject was debriefed relative to the purpose of the study immediately after the eye movement phase, so that the interview could focus on the presence of advertising posters in the scenes that had just been viewed. The subject was asked to report anything seen during the slide sequence or walkthrough that directly related to the instructions given at the outset of the study, hence to report information about any hazards to a pedestrian they had noticed. The responses typically referred to obstructions, cars pulling out behind other vehicles, people crossing the road, and so forth. These responses were not analysed since the task was only to ensure that the subject paid due and normal attention to the visual scene.

Method
continued

Data analysis

The analysis of the data was the same as for the driver study. The eye movement recordings were analysed by a semi-automated procedure. For each subject's data on a given trial the software displayed a thumbnail sketch and a synchronized record of the subject's horizontal and vertical eye movements. Such recordings typically contain occasional artefacts resulting from eye-blinks and the software included automatic procedures to recognize and ignore these sources of error. However, the recognition algorithm was not perfect and the operator had to intervene manually when an eye-blink artefact was not picked up by the software. This was achieved by using a function key to ignore any affected tract of data. This facility was infrequently required. The visual appearance of an eye-blink is quite evident to an operator, being characterized by a sharp divergence normally in the vertical record, the trace commonly disappearing off the edge of the screen. The output of the analysis program was a list of locations fixated and fixation durations in sequence. Each fixation was automatically tagged as a "hit" or a "miss" by reference to a set of target locations, corresponding to the coordinates of the corners of the poster. These coordinates were established separately using a procedure that allowed the operator by manipulating a cursor on the screen to note the locations of the corners of the poster panel with the image in situ in the host scene.

Subjects

For the random scenes condition 28 subjects were tested, and 20 each for the two walkthrough conditions. Recruitment criteria were applied in order that a socio-economically representative sample of subjects was tested. The eye movement equipment necessitated an additional recruitment criterion, namely that subjects could only participate in the experiment if they did not need to wear spectacles (contact lens wearers were not excluded).

A total of 97 individuals were recruited for the study; 29 of them were unsuccessfully tested – a very high failure rate of 30%. This was due to three main problems. The biggest of these (accounting for 12 "lost" subjects) was caused by a computer hard drive failure that only came to light when the raw data were processed. The data for another 8 subjects were not collected because of problems with their initial calibration for the use of the equipment; this is a loss rate of 8% which is an average result (as foreshadowed earlier in this report). The data for 4 others were not usable for various reasons (e.g., one subject had an infected eye and could not complete the calibration process, one who gave up because of a persistent cough, one who moved excessively, and one who failed to follow the instructions). The reason for rejecting 5 other subjects was not recorded.

The responsibility for recruitment was in the hands of an agency employed by NOP Solutions and they supplied most (60%) of the subjects, but to achieve optimal usage of the research laboratory and personnel, this was supplemented by the research team's efforts in the University campus (40%). Of the 68 who successfully took part in the study, there were 6 classified as social class B, 47 C1, 11 C2 and 4 DE. Testing took place from July to September 1998.

An interesting sidelight on the subjects is supplied by their responses to a set of questions devised to explore the nature of their activities as pedestrians. This recruitment questionnaire included the following items about each subject's walking habits.

Q1 = "how often do you walk anywhere out of home for more than 5 minutes?"
never = 1, 1-2 per month = 2, 1-2 per week = 3, every day = 4

Q2 = "do you walk part or all of the way to work?"
never = 1, rarely = 2, often = 3, always = 4

Q3 = "do you walk part or all of the way when you go shopping?"
never = 1, rarely = 2, often = 3, always = 4

Q4 = "how often do you go for a walk for its own sake?"
never = 1, 1-2 per year = 2, 1-2 per month = 3, 1-2 per week = 4, every day = 5

The responses averaged over the 68 successfully tested subjects were 3.84 for Q1, 2.02 for Q2, 1.67 for Q3 and 2.41 for Q4. Table 2 shows the frequencies of each response pooled over subjects. Clearly a considerable majority walked "out of home" at least once a week. The single subject who never walked out of home for more than five minutes was a bicycle mechanic whose "often" response to Q2 (walking to work) qualified him as a pedestrian. Q2 suggests that a sizeable minority (35%) often or always walked at least part of the way to work, but unsurprisingly this minority dropped considerably in Q3 (14%) when the question was about shopping. The last item Q4 is included for the record, and is perhaps less of interest since it may reflect walking as a leisure or exercise pursuit and possibly somewhere apart from advertising poster panels. In any event the data confirm the pedestrian status of the subjects.

Table 2: Frequencies of responses to walking habits questions (n=66 respondents)

Response	Q1	Q2	Q3	Q4
1	0	24	29	18
2	1	18	28	35
3	7	17	8	8
4	58	6	1	3
5	n/a	n/a	n/a	2

Experimental design

The core design of the study is much simpler than that of the driver study. Subjects serve as pedestrian viewers of a set of scenes containing poster panels, and in the course of this process see scenes which include a number of 6 sheet and 48 sheet poster panels.

As described in Table 1 in the above Materials section, there were sixteen 6 sheet and sixteen 48 sheet panels that were located systematically such that any effect of lateral position would be evenly distributed. There were eight of each panel size on the left and eight on the right, and for the 6 sheet condition a further eight panels were located directly ahead (referred to as line-of-sight or los).

The set of scenes in the core study were presented to each subject according to a schedule using six independently randomized orders.

An ancillary concern of the research was to determine any change in the visibility hit rate in the course of a passage (described as a "walk-through") effectively taken by the subject towards the poster panel. This was achieved as described above. There were two walkthroughs and each subject taking part in this experimental condition was shown both walkthrough sequences. The results for this condition, which was run at the same time as the core study conditions, will be reported in a supplementary paper.

Results

Preliminaries: Final design and raw data preparation

For the random scenes part of the final experimental design, 56 photographs of street scenes were presented to each of the 28 “pedestrian” subjects, tested independently. Of this set of images, 40 contained poster panels, and 16 were decoys with no poster panel in view. The presentation order for a given subject was taken in rotation from a set of six independently randomized sequences. The fixations and saccades made by each subject were recorded and later analysed to remove eye-blinks and other noise, leaving a data set when aggregated and transferred to a spreadsheet of some 25,811 rows, each row containing among other information the chronology and screen coordinates of that fixation. These fixations were then overlaid by computer onto the target posters in the photographs and a hit or miss recorded; for the main purpose of this study any secondary hits were ignored. For visibility measurement the focus was on the question of whether or not they looked at the target, not on the associated dwell time (which is likely to be affected more by content).

The photographs were then analysed to record the distance from the road centre line to the leading edge, and the x and y coordinates of the corners of each target billboard. From this information each billboard was assigned to an eccentricity band, which increased in steps of 10 degrees eccentricity from the judged centre of the visual field. The width and height and subsequent area of each billboard were then calculated in pixels as well as the angle subtended at the eye. Table 1 in the Method section shows how the panels were located laterally – balanced between left and right sides of the visual field depicted.

Two eye-tracks grabbed by the analysis software for the same subject but viewing a 6 sheet panel and a 48 sheet panel in different settings are presented as Figures 1 and 2. In both cases the subject has fixated the panel but has also explored the environment but by no means having sampled it fully. The locations fixated all appear to qualify as relating to objects of potential visual interest.

Figure 1: An illustrative eye-track for a 6 sheet panel in a roadside setting (the arrowhead shows the default position of a cursor used in analysis)

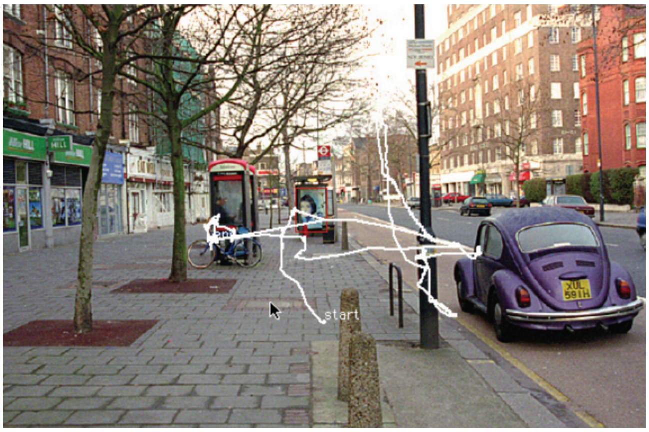


Figure 2: An illustrative eye-track for a 48 sheet panel on a station concourse

Main findings: Effects of panel size, environment, and eccentricity

The key factor whose effect on visibility needs to be estimated is panel size, however, this may depend *inter alia* on factors such as road environment (or clutter), visual field side (or lateral position, aggregated over eccentricity) and eccentricity (aggregated over side). The data for panel size are presented first.

As for the driver study the visibility of a panel is indexed by its visibility hit rate, calculated as the proportion of subjects with at least one fixation on the panel, and this is the dependent variable in the following analyses. The tables show mean hit rates, aggregated over subjects and panels for the various panel properties and categories. The tables also show the standard deviations and number of entries per cell.

Table 3: Hit rate as a function of panel size

Panel size	6 sheet	48 sheet
Mean hit rate	**0.539**	**0.724**
Standard deviation	0.177	0.223
Number of panels	24	16

An analysis of variance of hit rate with panel size as the only factor showed that Panel Size was statistically significant ($F(1,38) = 7.750$; MS error = 0.0425; $p=0.008$).

The scale of the study (and research design) did not comfortably accommodate convincing statistical analyses of interaction effects (e.g., for Environment or Eccentricity) with Panel Size. Consequently the following analyses focus on these two important independent variables considered in their own right and in the absence of panel size as a potential interacting factor.

Hit rate as a function of environment/clutter is examined next. Table 4 presents the mean hit rates along with standard deviations and cell counts. One way analysis of variance showed that the main effect of Environment was not significant ($F(3,36) = 2.189$; MS error = 0.046; $p=0.11$). The largest hit rate (0.75) was for Arterial scenes, arguably the least cluttered of the four settings, with the other three scoring below 0.60, but this superiority was not significant. Bonferroni tests between the means indicated no significant difference between the four environments.

Table 4: Hit rate as a function of environment

Environment		
Roadside – arterial	**Mean hit rate**	**0.746**
	Standard deviation	0.217
	Number of panels	11
Roadside – residential	**Mean hit rate**	**0.522**
	Standard deviation	0.271
	Number of panels	7
Roadside – shopping	**Mean hit rate**	**0.543**
	Standard deviation	0.203
	Number of panels	9
Rail station	**Mean hit rate**	0.597
	Standard deviation	0.183
	Number of panels	13

Eccentricity, the next factor to consider, was characterized as the least tractable of the factors under review in the driver study. The difficulty of exercising control over it in combination with panel size and other factors was noted in the previous study. The assignment of panels into 10 degree eccentricity bands was done once the selection of scenes had been made. A one-way analysis of variance was performed, showing that Eccentricity was highly significant ($F(3,36) = 27.12$; MSerror = 0.017; $p<0.001$). Table 5 presents the mean hit rates for the four eccentricity bands (pooled over panel size).

Table 5: Hit rate as a function of eccentricity (banded)

Eccentricity band	10°	20°	30°	40°
Mean hit rate	**0.722**	**0.732**	**0.318**	**0.310**
Standard deviation	0.102	0.126	0.193	0.110
Number of panels	18	11	7	4

The effect of eccentricity was concentrated in the contrast between inner and outer pairs; this was confirmed by Bonferroni comparisons between the four means. The hit rates for the two inner bands were virtually the same, and this was essentially so also for the two outer bands.

Additional measures

What has been termed visibility hit rate was chosen as the most pertinent measure with which to respond to commercial interest regarding the attentional efficacy of a poster panel. Other measures of some but lesser relevance are possible, and they go some way to completing the empirical description of eye-tracking behaviour. These measures, which concur with the approaches taken in basic eye-tracking studies, include mean eye-movement latency (how long on average does it take to fixate the object of interest for the first time) and the mean target fixation duration (how long on average do initial fixations last). These two measures were obtained for the two panel sizes used in the study. Analysis of variance for the first measure – that we refer to as Avstart – was significant ($F(1,38) = 16.43$; MS error = 329413, $p<0.001$); mean latencies were 2.27 and 1.52 ms for 6 and 48 sheet panels respectively. Analysis of variance for the second measure – referred to as Avdur[2] – was significant ($F(1,38) = 34.85$; MS error = 33893; $p<0.001$); mean fixation durations were 501 and 852 ms for 6 and 48 sheet panels respectively. Clearly the advantage to the larger panel size when assessed by the hit rate measure is repeated for these additional measures. The larger panels are visually located sooner and fixated longer than their smaller counterparts. This is not surprising given the considerably larger visual surface that is projected by the larger panel set.

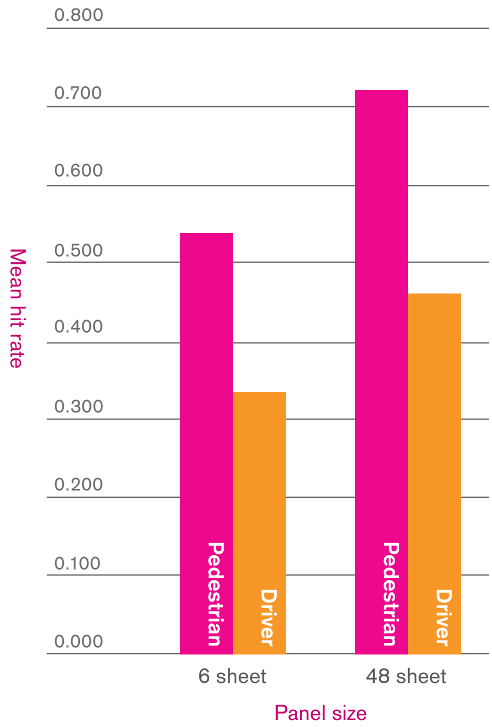
Comparisons with driver study

Any comparison between the pedestrian and driver parts of this research would have to be tentative, and qualified in a number of respects. For one thing the mental set of a pedestrian – and that required of our research participants in viewing the scenes presented as quasi-pedestrians (as if they were pedestrians viewing those scenes) – are quite different to those of drivers or quasi-drivers. In addition the comparability of the scenes used is also doubtful. The results are presented without the support of formal statistical analysis because the two studies differ in too many ways for sensible analysis.

Driver vs. pedestrian perspectives: Effect of panel size

Figure 3 depicts the mean hit rates for the present study together with the corresponding data from the driver visibility study. The hit rates for drivers were clearly lower than those for pedestrians for both 6 sheets and 48 sheets; the respective differences (0.201 vs. 0.259) are almost the same when expressed in percentage terms (63% vs. 64%).

Figure 3: Hit rate as a function of panel size for pedestrian visibility study averaged over scenes and subjects, with matching results from driver visibility study



Driver vs. pedestrian perspectives: Effect of panel eccentricity

Hit rate for pedestrians at angles beyond 20° dropped much more precipitously than in the driver study where the decline in hit rate was quite gradual by comparison. Differences between driver and pedestrian viewpoints (not assessed statistically) may well account for the differing results between the two types of observers. It was judged inappropriate to include panel size in this analysis because of the small cell sizes when size and eccentricity were combined, however, inspection of the results for 6 and 48 sheets does suggest that the same general profile of the mean scores applied for both cases. Comparing these results with those from the driver study is difficult because the locational sampling of panel sizes was unavoidably different in the two studies.

Table 6: Hit rate as a function of panel eccentricity for pedestrian visibility study averaged over scenes and subjects, with matching results from driver visibility study

Eccentricity band	10°	20°	30°	40°
Pedestrian	0.722	0.732	0.318	0.310
Driver	0.360	0.473	0.446	0.367

2 This measure refers to one sense of the term "dwell time" meaning how long the eye rests on an object; thus it does not mean (from its advertising usage) how long the observer is in the vicinity of the object i.e., panel.

Driver vs. pedestrian perspectives: Effect of location (side of road)

Images were selected to provide a balanced allocation of panels on the left and right side relative to the observer's viewing position (Table 1) and the apparent pathway they would follow into the scenes depicted. This was easiest to achieve for roadside scenes because of their topography with a pavement (and direction to follow) on the left or right. For the station images, left and right are not defined in this fashion so they were excluded from the analysis, as were images with panels in the line of sight. The net effect of these restrictions is to reduce the sample sizes precariously, although the design was still suitably balanced. A one-way analysis of variance was performed with Location (side of road) as the sole factor, with the result that the effect of Location was statistically significant ($F(1,24) = 7.180$; MS error = 0.049; $p=0.013$). Hit rates for panels to the left and right of centre were 0.733 and 0.501 respectively. However, it was noted that the eccentricity value for the left-side panels was noticeably less than that for right-side panels (12.5 vs. 18.9). To assess the possibility that this biased the results, eccentricity was entered as a covariate in an analysis of covariance; with this adjustment Location now just fell short of significance ($F(1,23) = 2.828$; MS error = 0.023; $p=0.060$). It appears that even greater care is required in the selection of images than was possible on this occasion, and it is not clear whether there is a reliable difference between left and right sides.

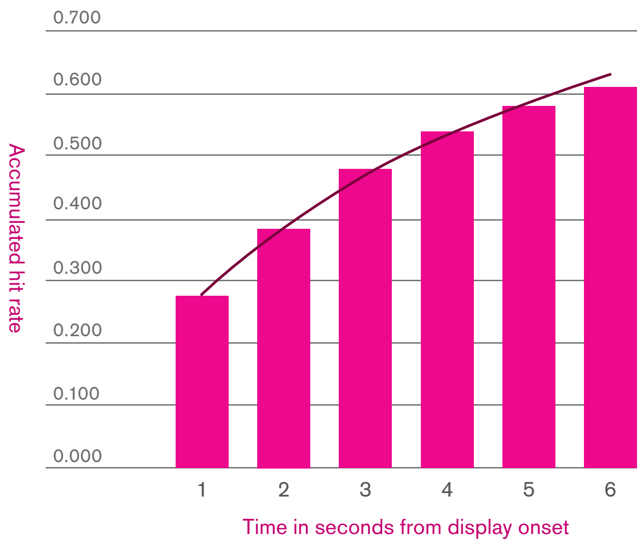
Growth of hit rate over time

It was evident from the driver study that fixations on target panels were most likely to occur early in the display interval. This skewed distribution of hits was mirrored in the present study. Altogether the 28 subjects in the random sequence condition scored 1376 hits; of this total 682 were first hits and 694 were contingent hits (second or later). The distribution of these hits over the 6-second display interval is of interest. The lower or first quartile (25% percentile) of the "first hits" was achieved after 0.42 seconds, the median (50% point) was reached after 1.23 seconds, and the upper or third quartile (75% percentile) was reached after 2.79 seconds. These values are much earlier in the display interval than for driver subjects in the driver study (respectively 0.95, 2.18 and 3.68 seconds) but they are very similar to those achieved by the passenger subjects (0.42, 1.16 and 2.90 seconds), albeit for a different set of pictures. Of the 694 contingent hits 359 were second hits, and their quartiles were reached at 1.05, 2.16 and 3.75 seconds.

This suggests that as in the driver study the subjects' inspection of the scenes was skewed towards the first two or three seconds of the display interval. This is reinforced by the fact that aggregate mean latency for first hits, pooled over subjects and pictures, was 2.27 and 1.52 seconds for 6 and 48 sheet panels respectively, both means being well below the midpoint of the display interval.

Hit rate growth functions were reported for the driver study and the corresponding results for pedestrians are provided below, showing more detail of the distribution of fixations on target objects during the presentation interval. Hit rate can of course only grow (or remain constant) as the display interval proceeds, reaching its final value after the six seconds allowed for viewing the photographs. The build-up of hits is shown in Figure 4, in which the hit rate is shown at the end of successive seconds. It can be seen that hit rate, which reaches a high of 60.9% after six seconds is well on the way (over 25%) by the end of the first second, with progressively smaller increments thereafter. These successive increments from the first second on are 10.9, 9.2, 6.5, 4.3 and 2.9. Midway through the display interval hit rate has reached just over three-quarters of its final value of 60.9%.

Figure 4: Hit rate accumulated as a function of exposure time (seconds) pooled over conditions; hit rate is also shown as a power function estimated from the data



As was the case for the driver study, hit rate is well expressed as a power function of time (hit rate = $0.279\ T^{0.456}$) as shown by the overlaid curve (r=0.997; N=6). By extrapolation on this function, the hit rate reaches 100% after 16 seconds. Other functions do also supply a good fit but a power function typically works well in all circumstances assessed.

Comparison with the power function analysis for the driver data (hit rate = $0.173\ T^{0.537}$) suggests that the "intercept" value (the starting value when T = 0) is numerically rather higher for the pedestrian data, and the growth parameter (the "slope" of the curve) is slightly less (reaching its final value at a somewhat lower rate).

If this is extended – with due caution because of the sample sizes involved – to the data for panel size, very similar profiles are obtained (see Figure 5). To avoid unnecessary clutter the equations of the curves are not shown but they both are associated with very high correlation coefficients (more than 0.994); by extrapolation, hit rate for 6 and 48 sheet panels reaches 100% after 16 and 14 seconds respectively. A power function was used as in the driver study for the purposes of comparison and because it provided a very good fit to the recorded data.

An alternative way of viewing how hit rate progresses is to decompose the accumulated hit rate data for each second of exposure as shown in Figure 6; with the scores pooled across panel sizes. This is repeated to show the equivalent pictures for each panel size (Figure 7). The data points are simply the increments second by second derived from the data in the previous figures. These figures more effectively portray the decline in hit rate over time. Hit rate is highest in the first second and there is a substantial drop between the first two seconds, and a mere 3% is added to the hit rate in the last second of the viewing interval. A power function is overlaid on the data, again fitting the data well. Nonetheless other more complex functions need to be explored.

Figure 5: Hit rate accumulated as a function of exposure time (seconds) for each panel size (pooled over environments)

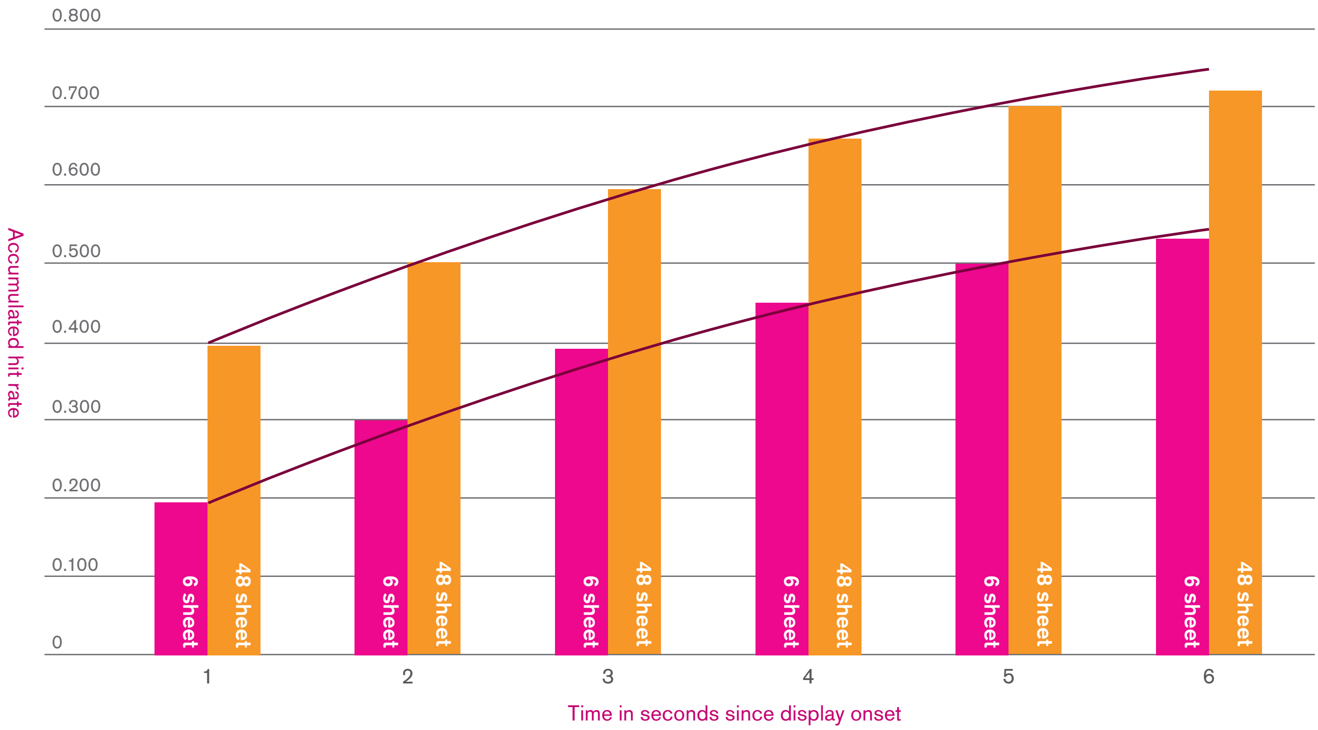


Figure 6: Hit rate per second of exposure, aggregated over panel sizes

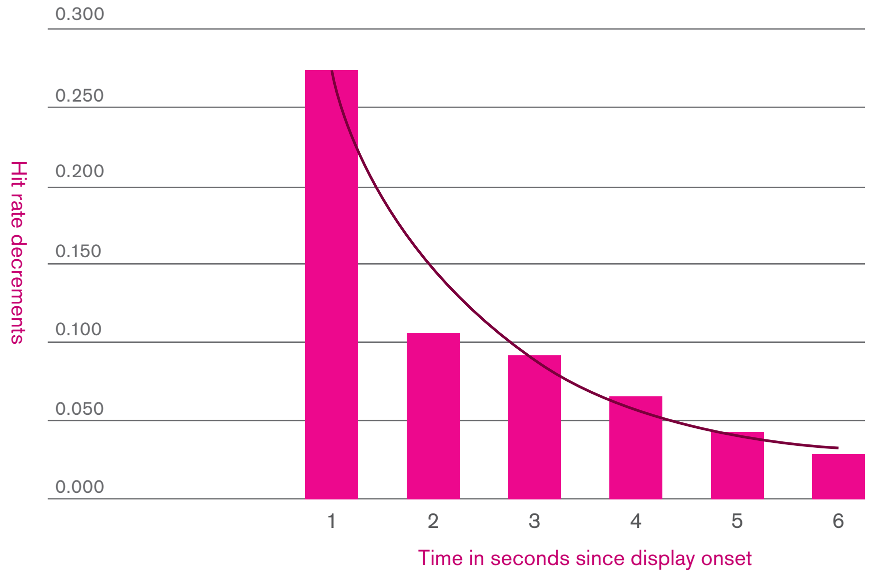
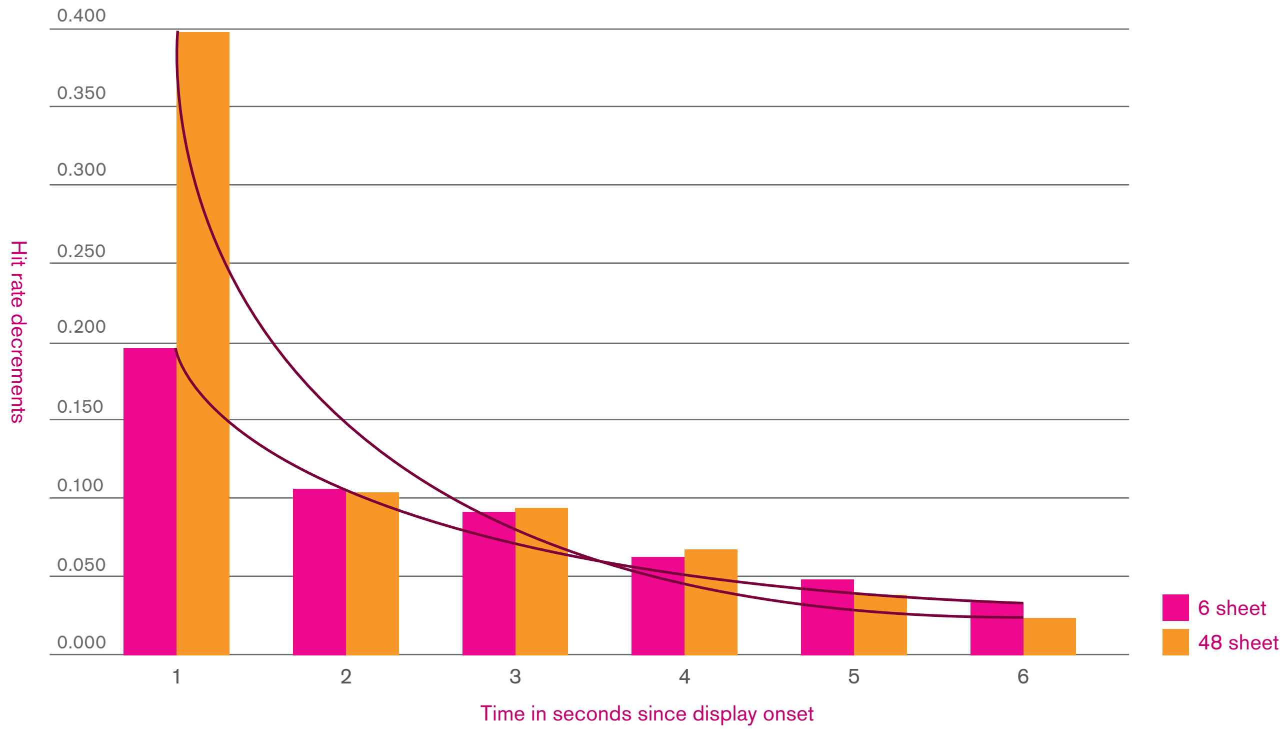


Figure 7: Hit rate per second for the two panel sizes: curves shown are for power functions of hit rate vs. time



Considerations regarding visibility modelling

The previous section ended with a descriptive account of the pedestrian hit rate results, using a simple power function for the data depicted in Figures 4 to 7. Although this function may be a standard option for the treatment of data that reflect a growth process, it was in the present case no more than a convenient descriptive device. It provides a very good fit to the observed data according to the correlation coefficients between aggregated hit rate and time. Notwithstanding, it would not be suitable for the purpose of process-modelling in the present case because it has no upper bound. Predicted hit rate elegantly approaches 1.0 but when extrapolated for durations beyond the 6 seconds allowed for viewing each image, it eventually exceeds this value. This is of course impossible for a probability score, for which purpose a bounded growth function is required.

It is therefore of interest to explore some hypothetical options as to the stochastic aspects of scene inspection and eye-tracking. The literature provides several leads to explore, and a brief though belated review of some of these directions will be helpful at this point.

The report by Enoch (1960), cited in the Introduction, is useful as a counterpoise to an idea that was evidently found to be theoretically attractive at the time, namely that a display might be explored by a random walk, that is, search might be a random process. Indeed this chimes with the findings from the present study, and the general thrust of experimental psychological research on visual search. Nevertheless there may be an element of chance in image inspection and the random sampling of locations to be examined provides a tractable baseline from which to view the evidence generally.

Poster panels are viewed as incidental components of this environment and are not themselves an object of deliberate search.

We should reiterate at this juncture that the topics reviewed at the end of the Introduction entailed the deliberate conscious deployment of the visual system to locate a target. This contrasts with how a pedestrian (or a driver in the previous study) could be considered to deal with poster panels as “targets”. Indeed the quotation marks around “target” are essential: pedestrians most of the time have no specific target at all, and are simply engaged in negotiating their way around using the visual input from their environment as effectively as possible. Poster panels are viewed as incidental components of this environment and are not themselves an object of deliberate search. The incidental character of visual inspection relative to what we conceive as “targets” cannot be emphasised enough; the individual viewer of a scene is not generally looking for advertisements. This changes the entire thrust of any analysis we might undertake of visual behaviour and of how we can think about object visibility. It potentially also reinstates randomness of the application of visual resources as a factor in the explanation of poster panel visibility. It seems likely that even deliberate visual search in a moderately well-structured display with a large number of elements (say more than 30) might involve an element of randomness; after all, to remember every location examined – if the display is organized so that systematic scanning is ruled out – would be a daunting task. The limit on short-term memory capacity for digits is considered to be on the order of seven plus or minus two (Miller, 1956). Memory span for display locations inspected is unlikely to exceed this, and forgetting of what has been examined would seem quickly to become a factor in the search of complex multi-element arrays unless an effective strategy for remembering is adopted. Arguably this is one reason, aside from salience and interest, why regular scan-paths are found as people inspect natural scenes (Noton and Stark, 1971).

The challenge of modelling pedestrian visibility has not been addressed in this report. Roadside environments do provide restrictions on pedestrian movement and hence on their visual behaviour. As argued in the Introduction the attentional demands on a person walking are liable to be laxer than on someone driving a car, but this is not guaranteed and should be assessed on the basis of the evidence. Notwithstanding a promising starting-point for the development of a pedestrian visibility model would be that proposed for the driver study (Barber, 1995). It could be applied with more confidence to roadside panels viewed from pavements flanking the road because of the operative similarity of the geometrical properties of the scenes in question. If regular trajectories of a relative linear kind can be defined for panels in non-roadside settings, then the model might also be applied more widely. For such an application the model would have to be adjusted to incorporate assumptions about walking speed and the time spent looking ahead.

Conclusions and recommendations

The principal objective of the study was to obtain, using eye movement recording apparatus, visibility hit rate data for poster panels as viewed by observers adopting the role of pedestrians while viewing photographic scenes. This is a supplement to the previous study in which data were obtained for car drivers and passengers.

The key findings of the study were that:

- Hit rate was larger for 48 sheet panels than for 6 sheet panels
- Hit rate did not vary significantly between panels located in the four settings used (Arterial, Residential, Shopping and Rail)
- Hit rate tended to decrease as angular offset from the centre of vision increased; this was mostly due to a sharp decline beyond about 20° offset
- Hit rates achieved by Pedestrians in this study tended to be greater than those achieved by Drivers in the previous study but this was not tested statistically
- Hit rate accumulated most rapidly in the first second or two of the viewing interval and the rate of growth declined as the viewing interval proceeded, and was slightly less than that for Drivers in the previous study.

In the driver study, hit rate accumulated at a somewhat lower pace for passengers than for drivers. This was also the case here for the Pedestrian data relative to the Driver data, and it seems that pedestrians may resemble passengers rather than drivers in their deployment of visual attention.

It is therefore of interest that this is reinforced by the distributions of times at which first hits occurred. Table 7 brings together the lower quartile, median and upper quartile times for hits aggregated over the viewing interval. The quartiles for Pedestrian subjects were remarkably similar to those of Passenger subjects in the driver visibility study, and much earlier than those for Driver subjects. On this basis it seems that the visual exploration of a pedestrian is more like that of a passenger in a car than its driver. Clearly greater insight into the participants' visual behaviour is obtained by examining data other than the key hit rate results.

Table 7: Times (in seconds) at which the lower quartile, median and upper quartile times were reached for first hits as a function of viewer role for Drivers and Passengers, and Pedestrians

	Lower quartile	Median	Upper quartile
Driver	0.95	2.18	3.68
Passenger	0.42	1.16	2.90
Pedestrian	0.42	1.23	2.79

Conclusions and recommendations

The panel formats investigated in this study represented the most numerous of the available stock at this point in time. It would be unwise to over-generalize from these findings to other formats; additional research would be required as a basis for extending the results. If in due course an expansion of the scope of the research is undertaken, the research design and portfolio of poster panel exemplars would need to be adjusted; it should include the present formats but with contemporaneous executions (and panel structures if substantive changes had taken place, say, in border styles or colours).

The pedestrian scenes we have used often have more than one exit point, particularly those depicting station concourses, and the balance of passages towards them has to be taken into account in visibility modelling. Relative frequency of use data for the various passages would be required for modelling to succeed. Such data are not routinely available and so a methodology for establishing balance of use would be needed. One solution – probably time-consuming, costly, and fraught with logistical obstacles – would be to conduct an audit of pedestrian activities in the actual settings depicted in the scenes. An alternative more immediate approach would be to ask people to point to all possible exit points in a scene and then to indicate their likelihood of use. This would be allied to an assumption that the pathway from the initial viewing position would have road-like geometrical directness to the exit.

Evidence on pedestrian visual behaviour considered with a broader focus than has been appropriate here would seem highly relevant to present concerns, and especially in relation to the application of the findings; a preliminary review of research was included in the Introduction. In order to answer core questions in our research we have abstracted slices of the behaviour in which poster panel viewing takes place: the relevant visual behaviour is clearly embedded in a complicated behavioural and perceptual flux, though not one that necessarily exposes the viewer to our “targets” continuously. The pedestrian looks ahead some of the time, but looks down (or to the side) some of the time. This intermittency should be reflected in any model of pedestrian poster panel visibility. Moreover it is important also to establish some more general facts about pedestrian behaviour, including walking speed and variables that influence it since this will be a parameter in a visibility model whether it is applied to drivers or pedestrians.

The pedestrian looks ahead some of the time, but looks down (or to the side) some of the time.

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Acknowledgements

Catherine Pierce provided invaluable assistance in reviewing the research literature on pedestrian behaviour. Katie Barnard, Charlotte Golding and Sanya Krlyes were in charge of data collection and the preliminaries of data preparation, and Brian Aviss provided essential technical support for hardware aspects of the study. Tim Hodgson was responsible for the software to run the eye-tracker and initial data processing tasks. Thanks are due to all of those contributing to the study.

Appendix A: Instructions for assistant experimenters

i: General instructions for pedestrian visibility study

Begin with Walkthrough1, and use it for a day. Go on to Walkthrough2 for a day, then the Random walk for a day, etc. When you've gone through them once, work back down, beginning with Random for a day, Walkthrough2, and Walkthrough1, etc. each for a day. Remember when testing Ss in the Random condition, that there should be equal number for each sequence order. Thereafter, accumulate Ss until you have filled each condition with 20 Ss for each drive. If you are very careful about calibration, and very lucky to get Ss with good eyes for calibration, you should not to do more than 22-24 in any one condition to reach the target. We expect to lose about 10% because of calibration difficulties. Keep a careful eye on the balance of men and women in each condition (a one to one ratio should be the target, but this does not have to be exact).

Keep a record of the study using the tables provided. There is an example that shows how the sequence continues when there is a failure to calibrate (or for some other reason the S cannot be tested). The subject numbering continues, but the same condition is repeated. There are three record sheets, one for each drive. There is a line to remind you about the target, but you will generally have to go a little beyond the line to have successfully tested 16 Ss for that drive.

There is also a sheet of instructions for the S to read before beginning the experiment. Get them to relax as much as possible, and let them read the instructions first. You should then talk them through the instructions to make sure they fully understand what they have to do and what will happen during the experiment.

Post-experimental questionnaire

In addition to the NOP questionnaire, ask the Ss what they saw during the walk that related to the instructions given to them, and make a note of the Ss' comments. Also note whether or not they spontaneously comment about the underlying purpose of the study (e.g., that it was really about seeing posters).

ii: Supplementary oral instructions for subjects in pedestrian visibility study

Before each scene there is a small black dot which you should look at steadily before pressing the start switch. When you do so, the scene will come up on the screen and you should begin looking at it. Your task is simply to look for all possible ways that a person walking into the scene could go, and to decide which – everything being equal – is the most likely one that you would take. You shouldn't speak because that will upset the equipment. I will later ask you about what you saw in the scenes. Make sure that you're looking at the black dot before pressing the switch each time.

Appendix B: Instructions for subjects

These consisted of a sheet of printed instructions (in italics) and supplementary instructions given orally by the research assistant. The oral instructions are shown with quotations marks.

Experiment on visual behaviour of pedestrians

This experiment is to discover what people look at when out walking in the street and other places like stations and shopping areas. We are doing this by recording eye movements using an infrared eye movement tracker. This sends out a very faint harmless infrared signal (less than a domestic radiator) that is reflected off the dark edge of the eyeball and is detected by a tiny sensor on the tracker. This is a safe and standard procedure. To set up the equipment before the pictures are presented, we have to go through a short calibration sequence. This is so that the computer can interpret the signals that the tracker picks up from your eyes, which are unique to each individual. The calibration sequence is a series of circles on the screen which you have to look at in a certain pre-set order. This is a rather boring but essential part of the experiment that may take as long as 15 minutes. It takes time to be precise. Once that's done the experiment will begin.

In the experiment, while your eye movements are being recorded, you will be shown a series of about 50 to 60 scenes.

Think of yourself as out walking, in the scene depicted on the screen, deciding where you're going and watching where you walk as usual. You'll be looking about you in the normal way. For each scene, make up your mind as soon as you can where you're heading, whether there are any obstacles in your way, and then carry on viewing whatever catches your eye. You will have a few seconds to look at each picture, and we'd like you to view the scene each time, just as you would if walking in the place shown on screen.

Keep in mind what you observed and we'll ask you about it later. The computer will display a small black square after each picture and you should press the grey plastic switch when you are ready for the next picture. Every so often there will be a short break to check the settings of the eye tracker.

"Do you understand what's involved?

Do you have any questions?... Then let's begin by calibrating the equipment.

You are of course free to leave at any time you wish."

End/Debriefing

"That's all. Thank you very much for taking part. Your results will be put together with those of about 50 others to draw up a final picture of what people look at under these circumstances, and particularly whether they look at the poster signs in the displays."

Issue payment and get signature.

Appendix C: Visibility studies undertaken to date

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' and 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, telephone kiosk). 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 (2007-2008): using a passive eye-tracking method to estimate panel hit rates in key transport and retail environments, with contemporary roadside panels, providing an up-to-date database across environments with new eye camera technology. Respondents: drivers and pedestrians.

Wave 5 (2008): a passive eye-tracking method to update estimates of panel hit rates for telephone kiosks and taxis. Respondents: drivers and pedestrians.

Dynamic Imagery Research Phase 1 (2008-2009): Pilot study to explore technology for presenting moving images (scrolling displays) while recording eye movements. Respondents: unclassified.

Dynamic Imagery Research Phase 2 (2009): Investigation of effect of dynamic images (scrolling poster panels and bus panels) on hit rates, using a stationary view of the scene. Respondents: pedestrians.

Dynamic Imagery Research Phase 3 (2009-2010): Investigation of effect of dynamic imagery (scrolling and digital poster panels, and bus panels) on hit rates, using a dynamic view of the scene. Respondents: drivers and pedestrians.

Visibility of poster panels seen through bus and train windows (2010): using a passive eye-tracking method to estimate panel visibility when viewing through a bus or train window. Respondents: pedestrians and public transport passengers.

route

outdoor media analytics