Daily newspaper layout – designers' predictions of readers' visual behaviour - a case study

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Abstract To what degree can newspaper designers predict the visual behaviour of their readers? Is it especially difficult to predict the effect of certain layout elements? With the advent of advanced eye-tracking equipment that allows for recording of readers' visual behaviour in an ecologically valid set up, these questions have now become assessable. In addition to the technical requirements for recording eye-movements during reading a further precondition for testing designers' assumptions and heuristics is that these are described in a way that allows for an objective comparison with the actual visual behaviour of readers. The present case study constitutes an example of how designers' predictions and readers' visual behaviour might be compared. This analysis focuses on the role of local layout factors (as e.g. colour and bold drop quotes). Other highly relevant aspects as e.g. the interaction between layout and content of articles, the overall composition of a spread and the design of the newspaper as a whole are not assessed in the present paper.

17 Scandinavian daily newspapers participated in this case study. Designers of each newspaper chose two spreads of their paper and provided predictions concerning the readers' visual behaviour when regarding respectively reading the spreads. Predictions were given by first partitioning each spread into up to 16 areas of interest (AOI) - e.g. articles, fact boxes or adverts - and then predicting two parameters for each AOI:

1. Prediction of the ***rank in the temporal order*** at which the area is observed by readers
2. Prediction of the ***dwell time*** for which readers attend the area.

The visual behaviour of 26 participants when regarding the selected spreads was recorded with an eye tracking system resulting in a total of 246 recorded scan-paths.

For data analysis all AOIs were described with regard to local layout factors (e.g. use of colour in the area, use of bold drop quotes in the area, size, location on the spread, etc.). For each AOI the related visual behaviour - as recorded in the scan-paths - was described in terms of rank in temporal order and dwell time. These parameters allowed for a direct comparison of designers' predictions and readers' visual behaviour. The differences between predicted and observed values were exploratively analysed in multiple regression analyses in order to identify layout factors that are relevant for the quality of predictions. Significant factors were then analysed in more detail.

Data analysis shows that newspaper designers are reasonably good at predicting the visual behaviour of their readers. Asked for a short motivation of their predictions, however, the designers mainly referred to the content and topic presented in the AOIs, rather than the layout or design.

As for the ***temporal order of observation***, designers showed some difficulties in predicting the effects of colour and the AOI's position on the spread. Concerning colour they were overconfident that colour would lead to earlier attention of an area. As for the position on the spread, AOIs on the left page were seen earlier than

predicted, whilst AOIs to the right were attended later than predicted. In addition, areas with information graphics and maps were attended somewhat later than predicted by designers.

Considerable differences between the predicted and observed ***dwell time*** were noted for AOIs with information graphics: these were regarded considerably longer than predicted by designers. In contrast, photos and drawings were attended shorter than predicted. Designers especially overestimated the duration for which attention is paid to large pictures. Just as in temporal order predictions even the predictions concerning dwell time revealed an overestimation of the effect of colour – coloured AOIs were attended shorter than predicted by designers.

This case study provides one example of how designers' ideas and hypotheses on readers' visual behaviour can be assessed - one crucial challenge is to find a common denominator on which designers' predictions and readers' visual behaviour can be compared.

INTRODUCTION: DESIGNERS' PREDICTIONS OF THE READERS' VISUAL BEHAVIOUR

When working on the layout of a daily newspaper spread designers make assumptions as to how alternative layout options might influence the way the reader is going to perceive / read the spread. Such assumptions can e.g. be that (European) readers start looking/reading at the upper left corner of a spread; another common conviction is that colour attracts the reader's attention at an early stage (personal communication with teachers at Den Grafiske Højskole in Copenhagen). Assumptions can concern the effect of local layout factors as the colour and position examples named above. They may also be related to more complex design characteristics, as for instance the composition of the spread or the contrast between different areas on the spread. Such assumptions are crucial when choosing between layout alternatives and even in education of future newspaper designers.

The opportunities for designers to critically test and verify their hypotheses about readers' visual behaviour are comparatively rare. Feedback is mostly provided by other designers' comments, discussions in focus groups or similar information. Detailed studies of the actual visual behaviour of readers, however, are few. This is partly due to the fact that systematic studies of visual behaviour require expensive and technically complex eye-tracking equipment. Some previous eye-tracking studies of newspaper reading have been carried out with head-mounted eye-tracking equipment recording eye-movements on video-films (e.g. Garcia & Stark, 1991; Widman & Polansky, 1990). This method has the advantage that the subject is free to move during eye-movement recording, however, the method implies time-taking analysis of the filmed material. Other studies (see e.g. Holmqvist et al. 2003) have used remote eye-tracking systems. This way absolute co-ordinates of the point of gaze are recorded over time, providing so-called scan-paths (see e.g. figure 3 below) that can be analysed more efficiently. However, the remote recording method requires that subjects sit still – thus, only newspapers in tabloid format can be studied as reading of broadsheet newspapers implies considerable head-movements. Advanced eye-tracking devices equipped with a head-tracker allow for the recording of scan-paths whilst the subject is free to move – thus, combining the advantage of an ecologically valid recording situation with the advantage of efficient data analysis.

Even given these technical possibilities, however, there are further challenges when trying to test designers' expectations: Often it is tacit knowledge, experience and not readily assessable assumptions that rule designers' decisions. Thus, another difficulty is to describe designers' convictions in a way that allows for objective testing and comparison with the readers' actual visual behaviour.

The present case study provides an example of how one might assess designers' expectations. The study comprised two sub-studies: firstly, designers at 17 daily newspapers provided their predictions concerning the visual behaviour of readers. Secondly, the visual behaviour of 26 participants reading the selected spreads was recorded. Data were integrated in a common database - including a systematic description of the local layout of areas on the spreads. Based on these data three questions could be addressed:

1) To what extent do local layout factors influence the visual behaviour of readers?

2) To what extent are designers' predictions of the readers' visual behaviour influenced by local layout factors?

3) How well do designers' predictions fit the readers' actual visual behaviour? The present paper focuses on the third question whilst the remaining topics are addressed in Holmqvist & Wartenberg (2004).

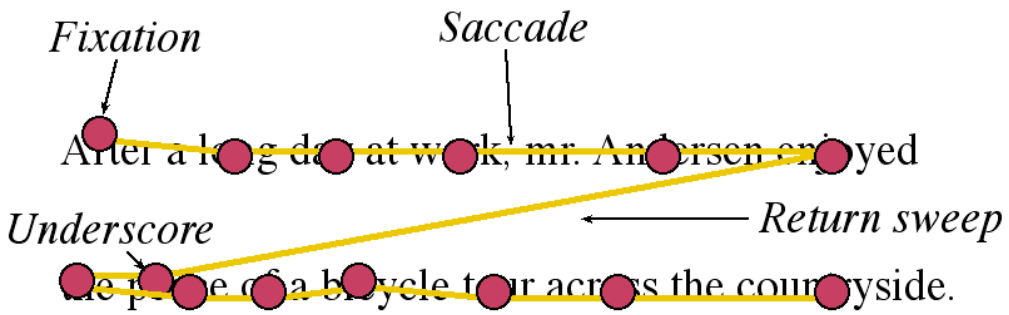


Figure 1: Eye movements during reading of a text.

CHARACTERISTIC EYE MOVEMENTS DURING NEWSPAPER READING

Visual behaviour when reading a newspaper can be described as a process of reading and scanning. *Reading* is a well-defined motion of the eye from left to right, with approximately one fixation at each word and small jumps, called saccades, between fixations (see figure 1 for an example). *Scanning* is characterized by a different behaviour of the eye: during scanning the saccades are much longer and can go in practically any direction. The point of gaze often moves to pictures, headlines and drop quotes during scanning. Only single or few words can be processed at each fixation. The purpose of scanning behaviour appears to be to find interesting entry points; points at which the more time-taking reading can take over.

Based on this distinction between reading and scanning, important parameters to describe the visual behaviour of a newspaper reader are amongst others:

1. The temporal order in which the reader looks at different areas of a spread – that is the sequence in which different areas catch the readers' attention.
2. The dwell time during which the reader looks at the different areas of a spread – reflecting the degree to which an area catches and keeps the reader's attention and interest.
3. Other characteristic parameters as e.g. reading depth, time per spread, dwell time per cm^2 etc. are not treated in this paper.

METHOD

The following section provides separate descriptions of both sub-studies - the study of designers' predictions, and the study of participants' eye movements.

Usually there are several fixations within a text line followed by a return sweep to the beginning of the next line. At times reading may include so called regressions – right-to-left eye movements returning to previously read parts of the text. It is assumed that readers *process* the text when they show eye-movements of this kind. (For a detailed description of eye movements in reading see Rayner, 1978.

SUB-STUDY I: DESIGNERS' PREDICTIONS

17 Scandinavian daily newspapers participated in the present study. Participation implied that a designer of the respective newspaper selected two spreads to be tested in the study and made predictions concerning the visual behaviour of readers regarding these spreads.

Designers were requested to provide spreads in time for testing on the day of publication (Danish and Swedish newspapers) or shortly after publication (Norwegian and Finnish newspapers).

The designer partitioned each spread into up to 16 AOIs (e.g. articles, fact-boxes or adverts) of his own choice and provided predictions for each AOI. Predictions comprised two parameters:

Temporal rank: This parameter describes at which rank in the temporal order an AOI is attended - that is - which AOI on the spread is regarded first, second etc.. Here, only the first observation of an area is decisive – subsequent returns to the same area are not considered in the parameter.

Dwell time: This parameter describes the percentage of time for which an AOI is attended in relation to the total observation time of the spread (defined as 100%).

Figure 2: Example of designer's prediction. The spread is partitioned into ten areas of interest (AOI) – indicated by ten red boxes. For each AOI the predicted temporal rank (Roman number) and dwell time (Arabic number) are given.

Figure 2 presents an example of a prediction. Boxes indicate the partitioning of the spread into ten AOIs, Roman numbers indicate the predicted temporal rank of observation and Arabic numbers indicate the predicted percentage of dwell time allocated to each AOI. In addition to predicting these parameters, designers wrote a short motivation of their prediction.

SUB-STUDY II: PARTICIPANTS' VISUAL BEHAVIOUR WHEN READING THE SPREADS

The selected spreads were mounted on cardboard and joined into a kind of "newspaper" - consisting of 4 to 12 spreads from up to 6 different daily newspapers. The order of spreads in the "newspaper" was varied between participants.

Subjects were comfortably seated in front of a slightly tilted table onto which the "newspaper" was fastened. Participants were instructed to read the newspaper as they would do in an everyday context. They were free to turn pages and to go back and forth among spreads. Eye-movements were recorded using a light-weight head-mounted device including a head-tracker (SMI Iview X Headset with Polhemus headtracking). With this equipment it is possible to record the point of gaze on a spread whilst allowing the participant to move freely.

Participants

26 readers participated in the study. Each subject read an average of 9.5 (4 up to 12) spreads. All in all a total 246 scan paths were recorded. Figure 3 provides an example of a scan path - that is the eye movements of one participant on one spread.

Figure 3: Example of a scan path of one participant looking at one spread.

The group of participants was heterogeneous - there was a wide variation in respect to the participants' education, profession, reading interests, and age (22 up to 55 years, mean: 32 years). For each language included in the study (Danish, Finnish, Norwegian and Swedish) 6 - 7 native speakers were included.

Data analysis

Eye tracking data were analysed using the SMI iView analysis tool. For each participant by AOI combination - the two parameters of visual behaviour – observed temporal rank and observed dwell time – were identified. Parameters were determined on the basis of fixation data only.

Data collected in both sub-studies were integrated into a common database with 2722 cases, each case representing data for one combination of a participant and a specific AOI. Each case included information about the designer's prediction for the respective AOI (predicted temporal rank and predicted dwell time) and the participant's visual behaviour (observed temporal rank and observed dwell time). Furthermore, the differences between predicted and observed values were calculated.

The database was extended to even describe local layout characteristics of each AOI. Table 1 presents a list of the local layout factors included in this description.

Table 1: Factors used for describing the local layout of AOIs. (Statistically significant is marked by asterisk * in the fourth / fifth column)

Factor	**Values**	**Statistical relevance for difference between predicted / observed temporal rank**	**Statistical relevance for difference between predicted / observed dwell time**
Vertical size of AOI	Size in cm		
Horizontal size of AOI	Size in cm		
Position on spread in horizontal direction	Upper / middle / lower third of the spread	*	
Position on spread in vertical direction	Left /middle left/ middle right / right quarter of the spread		
Occurence of bold drop quotes or bold introductions	Bold texts within AOI/ no bold texts within AOI		
Number of columns	Number		
Use of colour	AOI with colour/ AOI in greyscale	*	*
Use of picture	Picture within AOI/ picture related to AOI/ no picture		
Type of picture	Photograph, information graphics, drawing, map	*	*
Size of picture	Large/ middle/Small		*

Based on this database, differences between designers' predictions and the observed eye movement data could be analysed in terms of the given local layout factors.

In two explorative multiple regression analyses (one for the temporal rank parameter and one for the dwell time parameter) differences were analysed in order to identify layout factors that are relevant for the deviation between predicted and observed data. The ten layout factors listed in table 1 were included as predictive variables in these multiple regression analyses.

Layout factors that showed to be relevant in the multiple regression analysis were then assessed in more detailed analyses - by data plots.

AOIs that were classified as advertisements or that did not contain any text were excluded from data analysis.

Results

The following section provides short information on results in each of the two sub-studies and focuses then on the results concerning the differences between designers' predictions and readers' visual behaviour.

Results of sub-study I: Designers' predictions

The selected spreads presented mostly editorial material (world news, local news, and sports).

Most designers partitioned their spreads into AOIs coinciding with whole articles. Short notes were often grouped into one AOI.

In general the designers' predictions showed reasonable correlation with the observed visual behaviour. Correlation between the observed and the predicted temporal rank reached r = .38 and correlation between predicted and observed dwell time was r = .35.

Although asked to motivate their predictions in terms of layout characteristics, designers often explained their expectations with the content presented in the AOI.

Results of sub-study II: Participants' eye movements

In the eye tracking study, the average time spent on a spread was 128 seconds - which is rather long in comparison to former studies on newspaper reading (e.g. Holmqvist et al. 2003 report a mean observation time of 36 seconds per spread). However, there is reason to assume that the study set up was a valid reading situation: the majority (73%) of participants reported that they did read the paper just as they would have done usually and 61% of participants did not feel disturbed at all by the eye-tracking equipment. Results of this sub-study are described in detail in Holmqvist & Wartenberg (2004).

Results of the comparison between predicted and observed parameters

The objective of these analyses was to find out whether there are certain layout characteristics that coincide with a greater mismatch between designers' predictions of readers' visual behaviour. Explorative multiple regression analysis was used to identify local layout factors that correlate with the differences between predicted and observed values, indicating that designers systematically over- or underestimate the effect of the respective layout factor.

Analysis of the differences between predicted and observed temporal rank

Using the ten layout factors of table 1 as predictors for the difference between predicted and observed temporal rank revealed that three factors significantly contribute to prediction of the degree of mismatch between designers' predictions and observed eye movements:

- position of the AOI on the spread in horizontal direction,
- type of picture (photograph, map, drawing or information graphics)
- colour.

It has to be noted that the ten predictors explain only about 7% of the variation in differences between predicted and observed temporal rank. Thus, the explanatory power of the local layout factors is strongly limited. This indicates that other sources of variation as e.g. the content of the article, global layout factors, individual hypotheses of the designers, individual reading styles of the readers etc. - all cause variation that can not be explained by the local layout factors included in this analysis.

A closer analysis of the significant layout factors listed above, reveals that AOIs to the left are seen earlier than predicted by designers, AOIs to the right are seen later than predicted by designers (see figure 4).

Figure 4: Difference between predicted and observed temporal rank by horizontal position on the spread. (Circles indicate mean values and whiskers indicate the 95% confidence interval). (Perfect predictions would result in differences of 0 - indicated by a dotted line. Positive values indicate that AOIs are attended later than predicted, negative values that AOIs are attended earlier than predicted.)

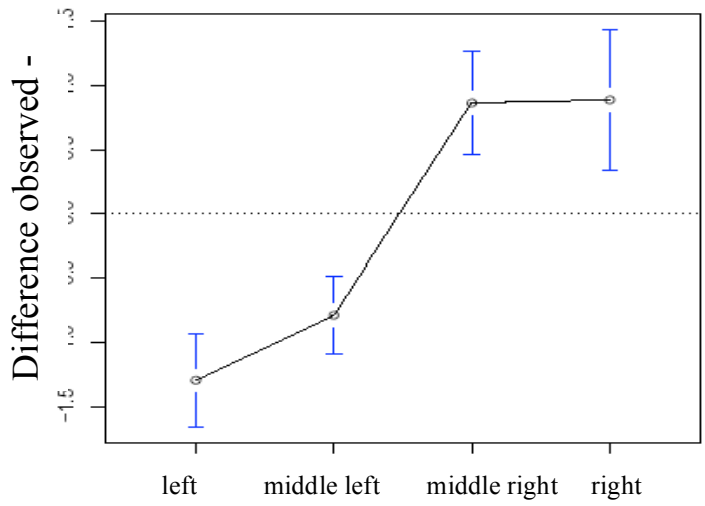
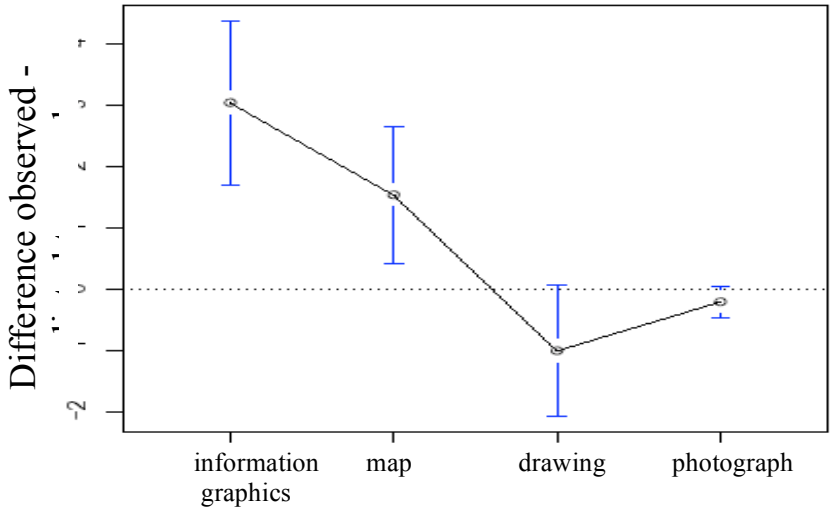


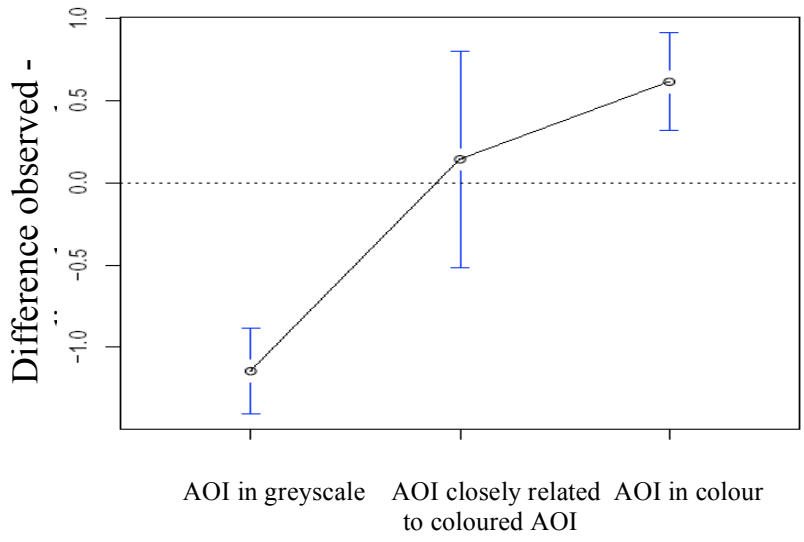
Figure 5: Difference between predicted and observed temporal rank by type of illustration/picture included in the AOI. (Circles indicate mean values and whiskers indicate the 95% confidence interval) (Perfect predictions would result in differences of 0 - indicated by a dotted line. Positive values indicate that AOIs are attended later than predicted, negative values that AOIs are attended earlier than predicted.)



Concerning the type of picture used in an AOI, predictions were better for photographs than for other types of pictures. Especially, information graphics and maps are attended later than predicted by designers (figure 5).

Concerning the factor colour - designers overestimate the effect of colour: AOIs in greyscale are seen earlier than predicted by designers whilst coloured AOIs are seen later than predicted. Thus, designers' expectation concerning the colour's attraction of early attention - could not be confirmed in this study (see figure 6).

Figure 6: Difference between predicted and observed temporal rank by use of colour in the AOI. (Circles indicate mean values and whiskers indicate the 95% confidence interval). (Perfect predictions would result in differences of 0 - indicated by a dotted line. Positive values indicate that AOIs are attended later than predicted, negative values that AOIs are attended earlier than predicted.)



Analysis of the differences between predicted and observed dwell time

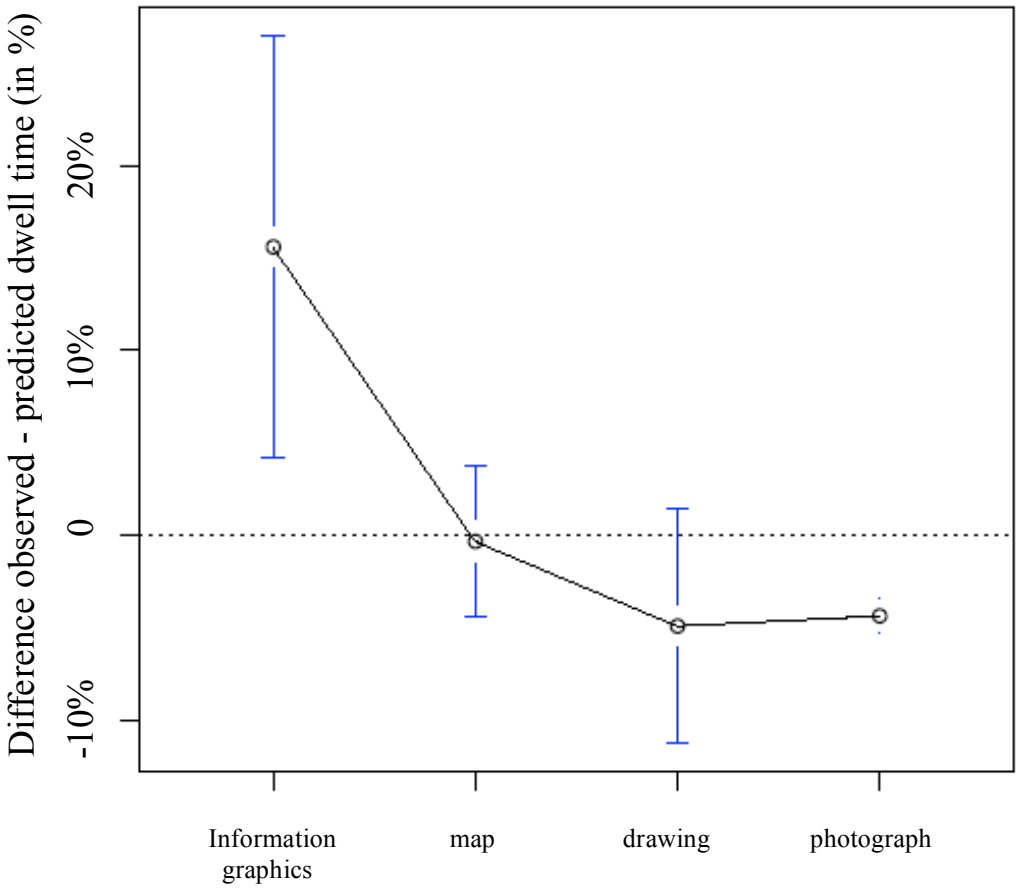
Just as in the previous parameter of temporal rank, the differences between predicted and observed dwell times were analysed in an explorative multiple regression analysis using the local layout factors of table 1 as predictors.

Even for this analysis it has to be noted that the ten predictors explain only about 7% of the variation of differences between predicted and observed values. The analysis revealed a significant influence of the following factors:

- type of picture (photograph, map, drawing or information graphics)
- size of the picture (small, medium, large)
- colour.

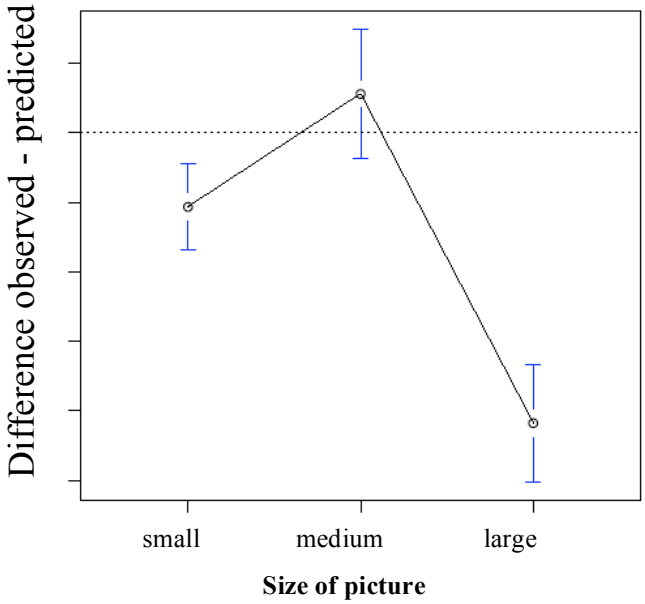
The time a reader spends looking at an AOI with information graphics, is underestimated systematically by designers. (Average underestimation is by about 15% of the total time spent on the spread). Whilst predictions concerning AOIs with maps are rather exact, designers overestimate the duration of attention to AOIs with drawings or photographs by on average ca. 5% (see figure 7).

Figure 7: Difference between predicted and observed dwell time (in% of total observation of spread) by type of picture presented in the AOI (Circles indicate Mean values and whiskers indicate the 95% confidence interval). (Perfect predictions would result in differences of 0 - indicated by a dotted line. Positive values indicate that AOIs are attended longer than predicted, negative values that AOIs are attended shorter than predicted.)



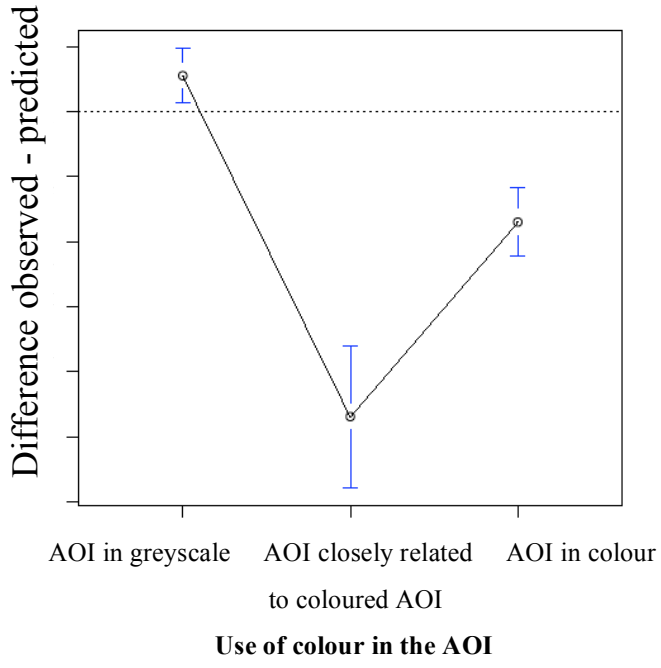
Concerning the size of pictures - especially AOIs with large pictures are attended considerably shorter than predicted by designers - on average 9% shorter (see figure 8).

Figure 8: Difference between predicted and observed dwell time (in% of total observation of spread) by size of picture presented in the AOI (Circles indicate Mean values and whiskers indicate the 95% confidence interval). (Perfect predictions would result in differences of 0 - indicated by a dotted line. Positive values indicate that AOIs are attended longer than predicted, negative values that AOIs are attended shorter than predicted.)



As for colour, again the results show an overestimation of the attraction exerted by colour. AOIs that are in colour are on average regarded about 3% shorter than predicted by designers, for AOIs closely relating to coloured areas, the average observed dwell time is even about 9% shorter than predicted (see figure 9).

Figure 9: Difference between predicted and observed dwell time (in% of total observation of spread) by use of colour in the AOI (Circles indicate Mean values and whiskers indicate the 95% confidence interval). (Perfect predictions would result in differences of 0 - indicated by a dotted line. Positive values indicate that AOIs are attended longer than predicted, negative values that AOIs are attended shorter than predicted.)



DISCUSSION

This case study provides one example of how designers' conceptions on readers' visual behaviour can be assessed. A detailed assessment calls for recording of actual visual behaviour of readers in a valid newspaper-reading situation. Such recordings require unobtrusive methods of eye-tracking and a careful set up of the study situation. A further crucial challenge is to find a common denominator on which designers' predictions and readers' visual behaviour can be compared. The collection of designers' predictions of clearly defined parameters, which can be compared to the actual visual behaviour of readers, proved to be a powerful method for assessment of designers' hypotheses and assumptions.

As for the local layout factors analysed in the present study – these factors showed to have a limited role both for the designers' predictions, the readers' visual behaviour, and the fit between both. Other aspects as e.g. the overall composition of the spread, the degree of "empty space" on a spread, etc. may be worth studying in a similar way.

It has to be noted that the results presented in this paper were observed in a case-study. That is, the local layout factors were not varied systematically but resulted from the selection of spreads and partition into AOIs determined by the newspaper designers. Thus, conclusions from this study have to be drawn with caution. The observed overestimation of colour effects for example may have been due to a missing effect of colour, but may even be related to the specific content of articles that happened to be presented in colour. The same holds for the effect of position - assuming that readers start reading on the left upper side of a spread may lead designers to position especially relevant and interesting articles in that part of the spread. This in turn would reinforce the visual behaviour of readers to start scanning / reading on the upper left part of the spread. In the context of the present study this means that the effect of position on the spread may partly be due to the layout factor, but partly even be due to the specific contents presented in different parts of the selected spread.

In order to learn more about the effect of layout factors both on the predictions of designers and on the actual visual behaviour of the readers - experimental studies are needed.

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REFERENCES:

Garcia, M.R. and Stark, P. (1991). *Eyes on the News*. St. Petersburg, Florida: The Poynter Institute.

Holmqvist, K, Holsanova, J, Barthelson, M. and Lundqvist, D. (2003): "Reading or Scanning? A Study of Newspaper and Net Paper Reading", in Hyönä, J, Radach, R and Deubel, H: *The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research*, Elsevier.

Holmqvist, K. and Wartenberg, C. (2004) "The role of local design factors for newspaper reading behaviour – an eye-tracking perspective" LUCS 127.

Rayner, K. (1978) Eye movements in reading and information processing. Psychological Bulletin, 85(3), 618-660.

Widman, L. & Polansky, S. H. (1990). "Annonsläsning: En ögonrörelseundersökning av DN-läsare." Unpublished report. Stockholm: Dagens Nyheter.