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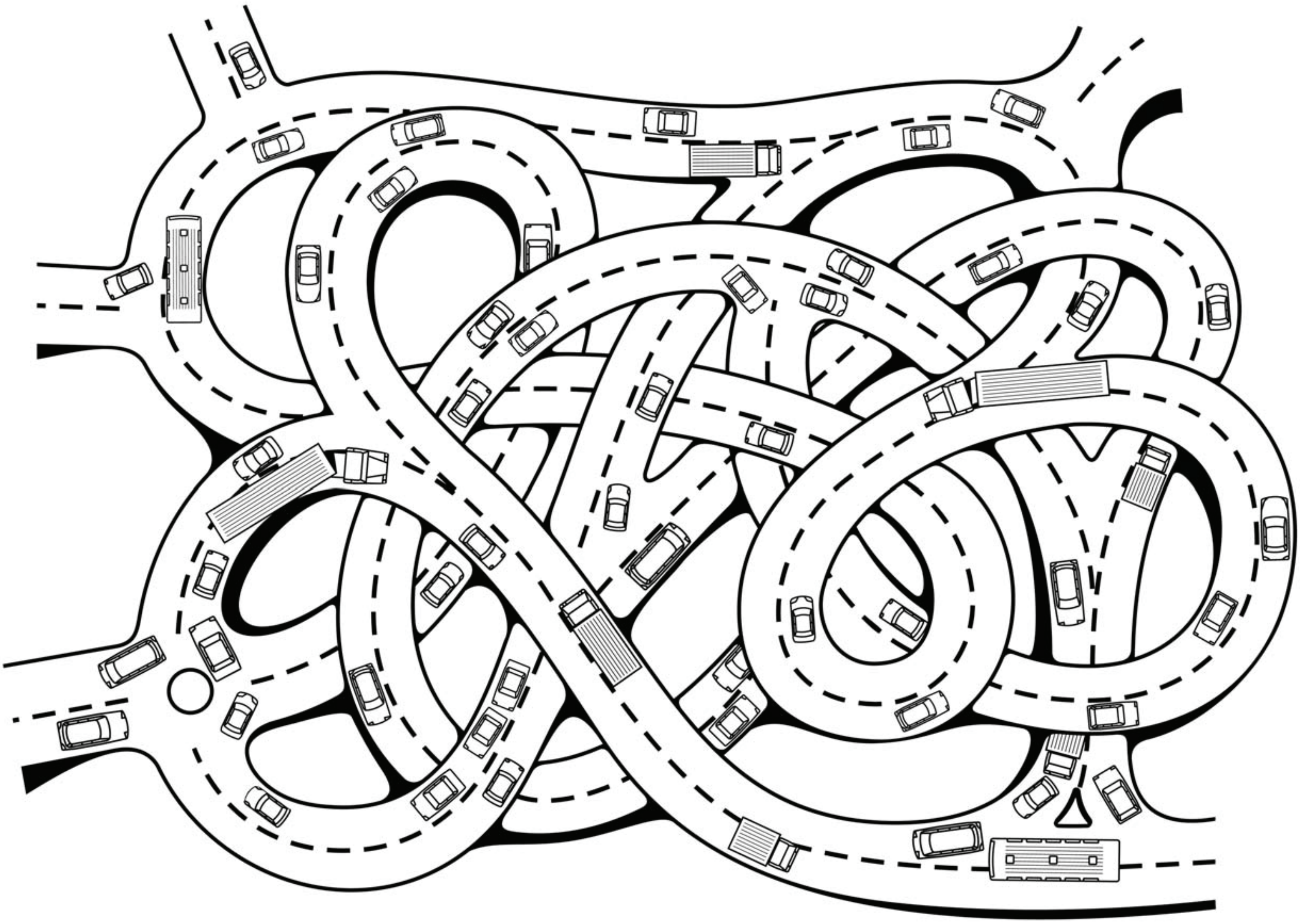
Making sense of complex environments



HUMAN FACTORS IN CITIZEN SCIENCE

DEFINING THE FUTURE OF VIRTUAL REALITY

THE SATNAV MADE ME DO IT!

Making sense of complex environments

Sandra Starke, Chris Baber, Neil Cooke, Andrew Howes & Natan Morar

Many aspects of our everyday lives depend on people, somewhere, making the right decisions based on available information. For example, there would be no functioning air traffic without air traffic control or no reliable medical diagnosis without systematic clinical investigation. We often take the outcome of these decision problems for granted and do not recognise the complexity involved in them. Consequently, it comes as a surprise when things go wrong, and this matters if just once an airplane is overlooked on the radar or one small tumour is overlooked on an x-ray.

At the University of Birmingham, we are interested in how humans combine visual information in complex environments to make decisions. This frequently relies almost exclusively on vision: people have to use their eyes to spot abnormalities and other events in various forms of data presentation. Information often has to be gathered and combined from a variety of displays and other sources in order to understand what is happening and to decide on the most appropriate next steps. We find this scenario for example in control rooms, where staff operate in an environment that consists of various displays, each with content that is frequently updating and/or changing, often in real time. It is therefore necessary to stay on top of this changing information, which is constrained by the need to sequentially look at the different display units.

There are at least two caveats to sequential visual information extraction. Firstly, all the information has to be held in memory, which sets limits to human performance. Secondly, while people are often under the impression that they always see everything, what we actually 'see' in high resolution at any one point is no larger than the size of the thumb at an arm's length. Hence, we have to move our eyes around to build up an image of what we are looking at while the brain does its best to fill in the gaps. This is effective when dealing with everyday situations, but can be counter-productive when looking for abnormalities in familiar patterns. The need to move the eyes can lead to information sources or parts on a screen being forgotten about and not looked at, with the result that an observer is completely unaware of the content without realising it.

As part of the European Union funded project SPEEDD, we are investigating visual information sampling in road traffic control rooms. Road traffic management in such control rooms requires operators to, for example, monitor a multitude of information sources, assess the severity of incidents, interact with the road network via lane closures/speed limits to manage the situation, and record all actions in an incident log. We are working with operators from the DIR-CE facility in Grenoble, France, where a range of cutting-edge technology such as sensors embedded in stretches of road network is being tested. The control room at DIR-CE Grenoble contains CCTV feeds, some of which can be interacted with, as well as multiple PC monitors that display for example, an incident log, a schematic road network and CCTV controls. Operators have to attend to these information sources while dealing with incidents.

In our study, we used a wearable eye tracking device, Tobii glasses, to examine the viewing patterns of three operators while dealing with the simulated incident 'object in the road'. Eye tracking allows us to record the 'point of gaze' that corresponds to the point in an environment that a participant is looking at with central or foveal vision. It has been shown many times that people look at what they are interested in with respect to completing a task, which of course especially holds true for goal-directed tasks. Using the point of gaze to quantify what information sources people attend to and how they move attention between different regions of interest has, accordingly, a long tradition. Using eye tracking methodology as well as a hierarchical task analysis, we were able to determine whether different participants followed a comparable approach when performing a similar task. We could then ask questions about whether operators attend to the same information sources or follow comparable

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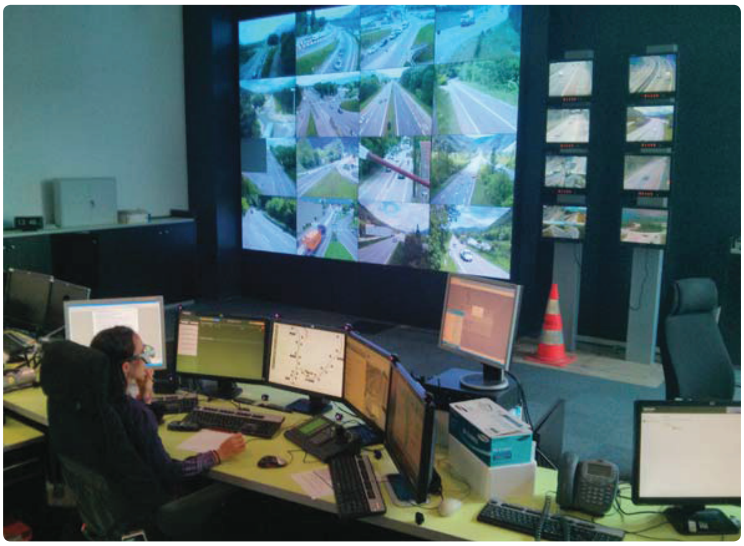
workflows when resolving incidents, given the multitude of sources they can use.

When analysing the eye tracking data, it turned out that the three operators had developed different preferences for the displays they attended to. While of course all operators attended to the screen showing the incident log, participant 1 spent most of the remaining time viewing a panel of CCTV screens that could be interacted with, participant 2 favoured looking at a screen displaying the schematic road network and participant 3 looked at a screen displaying a selected CCTV feed, which could have also been looked at on the panel that participant 1 attended to. In line with the finding that participants allocated attention to differing information sources, we also found that they took differing scan paths while engaging in the activity, although the switch frequency between regions of interest was similar, averaging between 0.1 and 0.2 Hz. These switches were not evenly distributed, often showing bursts. Interestingly, none of the participants allocated noteworthy time to looking at a large (several square metres) projection of 16 CCTV feeds. These corresponded to stationary cameras that could not be interacted with. Despite the prominence of this large display within the facility, the information seemed irrelevant in this particular scenario.

We were also interested in whether eye movements were accompanied by head movements. There is evidence that such paired gaze shifts indicate a goal-directed search and this allows us to make inferences of the, potentially subconscious, gaze shift. We found that most gaze shifts between the different regions of interest were accompanied by head movement. This may have in parts been necessitated by the widely spaced distribution of the computer monitors and displays, given that above 40 degrees visual angle, eye movement is typically accompanied by head movement as a physiological constraint. However, the consistency of paired eye and head movements also suggested that operators followed an internal agenda in attending to information sources they had already decided would hold the relevant information.

One of the main questions that arises from this work concerns optimal user interface design: should information presentation encourage predictable and repeatable scan patterns both for the same participant and across participants, or should it allow individuality? On one hand, to ensure that an operator always attends to all information sources in a systematic manner, it may be necessary to achieve repeatable and consistent scan patterns.



Work in the field of medicine has shown that such systematic scanning behaviour is very beneficial for performing a task correctly. On the other hand, in context of 'ideal observer' theory it is also possible that it is important to accommodate individual differences based on participant-specific constraints on factors such as working memory. In this case, it would be detrimental to pre-define a single scan path by design. Instead, it may be important to accommodate individual behaviour. Further, there may be several 'optimal' scan paths, and participants in such a scenario should not be constrained to a single solution, and equally may not exhibit a repetitive pattern. These are amongst the questions we are planning to address in the future. ❖