

## Eye tracking and Eyewitness Memory

Jamal K. Mansour & Heather D. Flowe

For more than a century psychologists have utilized eye tracking as a window into how we think and how we feel, and to test theories of the mind and its mental processes. A range of forensic topics has been investigated with eye tracking, such as the effect of weapon exposure (e.g., Hope & Wright, 2008), visual attention in anti-social personality disorder (e.g., Ceballos & Bauer, 2004), and the role of expertise in deception detection (Bond, 2008). Recently, researchers have begun to use eye tracking to study eyewitness decision processes in criminal lineup identification (e.g., Mansour, Lindsay, Brewer, & Munhall, 2009). This paper reviews the application of eye tracking technology in criminal identification lineup research and discusses issues that arise in translating eye movements to reveal eyewitness decision processes.

### What is eye tracking?

Eye tracking refers simply to recording eye movements whilst a participant examines a visual stimulus (Collewyn, 1991). Accurate eye tracking must account for both the position of the head and the position of the eyes relative to the head. The earliest eye trackers were mechanical devices that must have caused participants great discomfort due to their size and invasiveness (see Collewyn, 1991 and Hayoe, & Ballard, 2005 for descriptions of various techniques). The technology has progressed significantly since then, such that systems are now available that do not require headgear or any physical attachments to be worn by the participant (E.g., Tobii, [www.tobii.com](http://www.tobii.com)).

Two important aspects of eye tracking are calibrating the system to specific participants and managing eye drift, via drift correction. Calibration normally involves participants looking at an image (e.g., a dot or a fixation cross) in a known location. The eye tracking system compares

the true location of the image to where it detects the participant's gaze on the screen, and applies a suitable correction for future fixations. Drift correction measures how much the difference between a participant's gaze and a central point "drifts" over a short time period. Drift can occur because of factors such as fatigue and changes in body (head) position. Moreover, the longer a viewing session, the more drift that occurs, and thus the less precise the gaze recording.

Fixation duration, frequency, location and sequencing are the primary measures of visual behaviour used to study face processing. Fixation duration provides an index of the speed with which information is processed. Increasing fixation duration is associated with tasks that require more detailed visual analysis (e.g., Xiaohua, C., & Liren, 2007). Frequency of fixations often serves as a measure of sampling quantity. Fixation location and sequencing provide information regarding the regions of the face to which participants are attending and information about the order in which stimulus properties are sampled.

## What has eye tracking revealed about lineup identifications?

In forensic paradigms, participants view a video of staged crime and then are tested with a lineup. Participants indicate which lineup member, if any, is the "criminal" from the video. The lineup features a suspect (who may be guilty or innocent) and a number of "foil" faces (i.e., distractors). Eye tracking may provide real time information about lineup decision processes because gaze can be continually monitored as participants view lineups.

In the United States and Canada, criminal identification tasks have been traditionally conducted using a simultaneous procedure, whereby a photograph of the suspect's face is placed among a set of foils and the eyewitness views all of the photos simultaneously. Recently, some jurisdictions have begun using sequential lineups. In a sequential lineup, suspect and foil photos are displayed one at a time. In the United Kingdom, eyewitnesses view lineup faces one at a

time, but a film clip of each lineup member (i.e., the member looks at the camera, and then moves his or her head to the right and left) is presented rather than a static photograph.

The accuracy of eyewitness lineup decisions has long been associated with the type of strategy used to make the decision. A relative decision strategy, involving comparisons among lineup members, is considered undesirable because it is associated with errors. An absolute strategy, where the witness compares the test face with their memory for a criminal, is considered optimal and is associated with fewer errors. In a simultaneous lineup, participants can make direct visual comparisons of the members, whereas in a sequential lineup, they cannot. Research indicates that the rate of identifying innocent suspects is reduced with a sequential compared to a simultaneous procedure (Steblay, Dysart, Fulero, & Lindsay, 2001). The rate of identifying the guilty suspect is also reduced in a sequential lineup, but to a smaller extent compared to the reduction in incorrect identifications. Additionally, participants who self-report using an absolute decision strategy tend to be more accurate than those reporting a relative decision strategy. Until recently, however, it was unclear whether decision strategy was associated with the manner in which information is visually extracted from faces.

In the seminal study examining the relationship between eye movements and decision accuracy in simultaneous lineups, Mansour and colleagues (2009) operationalized a relative versus absolute judgement strategies in two ways: via comparisons (relative judgements included some comparisons, absolute judgements included no comparisons) and via search exhaustiveness (relative judgements involved fixating all lineup members, absolute judgements involved viewing only some lineup members). Both operationalizations suggested that the majority of witnesses utilize a relative strategy with lineups, even when participants self-reported that they had used an absolute strategy. However, these operationalizations were only partially consistent

with predictions. An absolute strategy was associated with fewer incorrect identifications than a relative strategy as measured by search exhaustiveness, but this was not found for comparisons. However, absolute versus relative judgement strategies should elicit similar rates of correct identifications and this was found.

Eye tracking would be forensically most useful if gaze behaviour could differentiate guilty and innocent suspects. Flowe and Cottrell (2009) presented participants with target-present and target-absent lineups such that for target-present lineups a previously studied face was presented in the lineup with foil faces. In the target-absent condition, a previously studied face was removed from the lineup and replaced by a look-alike that differed from the study face on one feature, as previous research has found that greater visual attention is directed to features that have been changed (Ryan & Cohen. 2004a, b). No significant differences, however, were found in gaze behaviour across the target-present and -absent conditions. Mansour et al. (2009) found that gaze behaviour easily distinguished between when participants made a selection from a simultaneous lineup versus when they did not, however, gaze did not clearly differentiate correct and incorrect simultaneous lineup decisions. Both Flowe and Cottrell, and Mansour and colleagues (unreported data) found that accurate positive identifications could be differentiated from incorrect positive identifications on the basis of visual behaviour. These results have also been replicated in sequential lineups (Flowe, 2009). Thus, gaze behaviour clearly varies with decision, which is theoretically useful, but gaze behaviour does not differentiate accurate from inaccurate decisions, which would be forensically useful.

## Challenges in translating gaze behaviour to eyewitness decisions

In sum, relative decisions can be indexed by visual behaviour. Faces perceived as the most familiar are examined for longer than less familiar faces. Duration of fixations can also

distinguish correct from incorrect positive identifications from target-present lineups. Does this mean that the police can use it? We have found that there are vast individual differences in eye movement behaviour and eye movements have been shown to vary in relation to task demands (e.g., Everdell, Marsh, Yurick, Munhall, & Paré, 2007; Mertens, Siegmund, & Grusser, 1993). Therefore, we do not think eye tracking is suitable for assessing the accuracy of an actual eyewitness' identification decision given our knowledge at this time.

Eye tracking is promising for elucidating decision processes and theory testing, but there are caveats. First, not all differences in visual behaviour across lineup procedures can be attributed to differences in an underlying decision process; therefore, we must be judicious about making causal attributions to eye movements. What is more, underlying processes can vary and not be accompanied by attendant changes in visual behaviour (e.g., de Heering, Rossion, Turati, & Simion, 2008; Williams & Henderson, 2007).

Second, aspects of the eye tracking machinery itself are a concern for the ecological validity of eye tracking data when applied to the eyewitness paradigm. It is unclear how knowing one's eyes are being recorded affects attentional processes. Perhaps people in eye tracking studies pay a great deal of attention or change their eye movements simply because their eye movements are being monitored. Wearing headgear may impact eyewitness behaviour. Eye movement data collection procedures can affect visual data in a lineup experiment. A central fixation point may change the order and manner in which faces are expected. One potential solution to the problem would be to arrange the photos in a circle around a central starting fixation point, but this arrangement of the photos is different from that used in practice, and the results, therefore, may not generalize to actual criminal identifications.

Third, as experimental control is tightened to reduce the variability in eye movement data caused by individual differences in attention and memory, and extraneous features of stimuli, real world validity is reduced. We used multiple lineup test trials in our studies so as to increase the reliability of the eye movement data. In the real world, however, eyewitnesses are given a single lineup test. Learning effects across multiple identification tasks did not appear in Flowe and colleagues' studies, but there was a trend towards more accurate decisions as more trials were completed in the Mansour et al. (2009) study. Additionally, the studies conducted by the second author of this paper had more in common with basic face identification research compared to forensic research. For instance, the faces were generated by a composite drawing program as a means of studying how specific facial features affect recognition, holding constant as possible the configural properties of the faces. Head hair and facial hair were not included on the face as previous research has shown that these factors alone can affect identification accuracy. Additionally, to increase the odds that the faces would be encoded, the faces were presented alone at test, and were not part of a criminal event. These procedures reduce variability in visual behaviour that is caused by extraneous variation and allow one to test basic cognitive processes; whether these processes occur under increasingly complex circumstances needs to be addressed in future studies.

A similar issue arises when we consider that the method of administering sequential lineups differs significantly from that of simultaneous lineups: simultaneous lineups involve a single presentation while sequential require numerous presentations. For example, prior to presenting a simultaneous lineup, a drift correction is conducted, thus participants all begin their eye movements from the same location. With a sequential lineup, initial fixation point must either be uncontrolled (following presentation of the first face) or each face presentation must be

preceded by a drift correction. It is unknown which of these processes would be less disruptive of the eyewitness decision process. Another concern is the extent to which visual behaviour unrelated to the lineup task occurs as witnesses prepare their decision, indicate their decision, and prepare to view a subsequent face (sequential lineups). When comparing within a lineup type, the eye movements of all participants would be affected or random selection would circumvent the impact of individual differences; however there may be systematic differences between simultaneous and sequential lineups that confound eye movement results. These lineup procedures have been the classically used and compared methods, though many other types exist, and are the basis for much consideration of the basis for lineup errors and strategies. Future research will need to explore how best to compare the visual behaviour that occurs via each method.

## Conclusions

Eye tracking has a great deal of potential for informing us about how eyewitnesses make decisions but much work is required to determine the best ways to interpret the wealth of information gaze data affords. Future research should focus on operationalizing strategies and identifying gaze patterns and what they signify. Methods of comparing gaze behaviour for different types of lineups would also be beneficial for understanding the pros and cons of using different types of lineups. Most recent research has shown that there are differences in gaze behaviour when people come to different decisions, however, these are not yet precise enough that they could be used in an applied setting. Given the steady improvement in accessibility of eye tracking hardware, we can expect future work to provide much more practically useful information.

## References

- Bond, G. (2008). Deception detection expertise. *Law and Human Behaviour*, 32(4), 339-351.
- Ceballos, N., & Bauer, L. (2004). Effects of Antisocial Personality, Cocaine and Opioid Dependence, and Gender on Eye Movement Control. *Psychological Reports*, 95(2), 551-563.
- Collewijn, H. (1999). Eye movement recording. In RHS Carpenter & JG Robson (Eds.), *Vision research: A practical guide to laboratory methods* (pp. 245-285). Oxford: Oxford University Press.
- de Heering, A., Rossion, B., Turati, C., & Simion, F. (2008). Holistic face processing can be independent of gaze behaviour: Evidence from the composite face illusion. *Journal of Neuropsychology*, 2(1), 183-195.
- Everdell, I.T., Marsh, H., Yurick, M. D., Munhall, K. G., & Paré, M. (2007). Gaze behaviour in audiovisual speech: Asymmetrical distribution of face-directed fixations. *Perception*, 36, 1355-1545.
- Flowe, H. D. (2009). An exploration of visual behaviour in eyewitness identification tests. Manuscript submitted for publication.
- Flowe, H. D., & Cottrell, G. W. (2009). An examination of simultaneous lineup identification decision processes using eye tracking. Manuscript submitted for publication.
- Hayoe, M., & Ballard, D. (2005). Eye movements in natural behaviour. *Trends in Cognitive Science*, 9, 188 - 194.
- Hope, L. & Wright, D. (2008). Beyond unusual? Examining the role of attention in the weapon focus effect. *Applied Cognitive Psychology*, 21, 957- 961.
- Mansour, J. K., Lindsay, R. C. L, Brewer, N., & Munhall, K. G. (2009). Characterizing visual



- behaviour on a lineup task. *Applied Cognitive Psychology*, 23, 1012-1026.
- Mertens, I., Siegmund, H., & Grusser, O.-J. (1993). Gaze motor asymmetries in the perception of faces during a memory task. *Neuropsychologia*, 31, 989-998.
- Ryan, J. D., & Cohen, N. J. (2004a). Processing and short-term retention of relational information in amnesia. *Neuropsychologia*, 42, 497-511.
- Ryan, J. D., & Cohen, N. J. (2004b). The nature of change detection and on-line representations of scenes. *Journal of Experimental Psychology: Human Perception and Performance*, 30(5), 988-1015.
- Stebly, N. M., Dysart, J., Fulero, S., & Lindsay, R. C. L. (2001). Eyewitness accuracy rates in sequential and simultaneous lineup presentations: A meta-analytic comparison. *Law and Human Behaviour*, 25, 459-473.
- Williams, C., & Henderson, J. (2007). The face inversion effect is not a consequence of aberrant eye movements. *Memory & Cognition*, 35(8), 1977-1985.
- Xiaohua, C., & Liren, C. (2007). Eye movements in the sampling process for face recognition. *Psychological Science (China)*, 30(2), 316-319.