Quantitative Characterization of Eye Movements During 'Deep Learning' of Diagnostic Features in Mammograms

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Rationale

We have previously shown that implicit statistical learning of abstract patterns, or 'deep learning', can be used to train naïve, non-professional subjects to reliably detect anomalies in mammograms [1]. In the present study, we tested the hypothesis that eye movement patterns change in a learning-dependent fashion during the learning.

Method

We used our previously described deep learning methodology [1-3] to train naïve adult subjects (N = 9) with no previous radiological training to detect anomalies in actual screening mammograms. Another 5 subjects were similarly trained using digitally synthesized, perceptually metameric counterparts of the actual mammograms [1,3]. Subjects were trained to a criterion of d' >= 1.5 (p < 0.05). Eye movements were monitored throughout the training using a high-resolution (2000 Hz) video eye tracker.

Results

Eye movement patterns elicited by actual *vs*. synthetic mammograms were statistically indistinguishable (principal components analysis (PCA), test for linear separability, p > 0.05). Lengths of eye movement trajectory as well as the number of microsaccades roughly followed an inverted 'V' pattern over the course of training, whereby they rapidly rose at the outset of the training, peaked during the steepest part of the learning curve, and fell steadily to asymptotically low levels as the subjects reached asymptotic performance. Trials in which subjects reported finding no anomaly elicited trajectory lengths twice as long and microsaccades twice as frequent as the trials in which subjects reported finding an anomaly. PCA of eye movement trajectories showed that the eigenvalues of the microsaccadic components were inversely correlated with performance during the given block (r = -0.53, df = 1347, p << 0.05).

Conclusions

Taken together, our results indicate that eye movements during the acquisition of diagnostic expertise using mammograms follow a common statistical pattern across subjects. Detailed scrutiny of the images, mediated by microsaccades, is prevalent during the learning phase, but not during the asymptotic phase. Thus, after training, the "gist" of the image may be evident to the expert viewer without the necessity for detailed scrutiny of the image.

References

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