Some Approaches to the Analysis of Replicated Bivariate Spatial Point Patterns: Drosophila Retina

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ABSTRACT

With advances in technology and microscopy, many biologists are finding that their data take the form of replicated spatial point patterns. These are patterns in which the locations of points are the main interest. Scientific questions regarding the locations of cells, such as cell fate and communication, indicate a need for rigorous statistical approaches to the analysis of these types of data. Currently there are only a handful of papers addressing replicated spatial point patterns for the univariate case. When there are two types of points the data are bivariate point patterns, and there is very little statistical methodology for these type of data. Our data consisted of 28 bivariate patterns of fly retina, with two types of R7 cells, R7p (referred to as "green") and R7y (referred to as "red"). We considered several analytical approaches, including the bivariate K-function, generalised (binomial) linear mixed models on the outcome of proportion of red neighbours about green, and permutation tests. Complicating factors somewhat is the need to take account of the physical space taken up by each of the cells, and what the best method for this might be given the measurement method, which has some unavoidable bias. Individual K-functions showed evidence of small scale regularity and larger scale clustering between the two types of points, but when combined there was no evidence of a departure from independence of the two types of points. The generalised linear mixed models showed a borderline statistically significant result ($p = 0.06$) for the proportion of red neighbours about green (0.590, 95%CI: 0.572, 0.608), when tested against the overall proportion of red in the patterns (0.605). Comparing each pattern's estimated proportion against its overall proportion yielded 6 patterns that had a significantly lower proportion. One pattern showed a significantly higher value, and 22 patterns were not statistically significant. The permutation test consisted of generating 999 patterns for each of the 28 actual patterns with the same proportion of red and green points. The locations remained the same but color was randomly shuffled, and the proportion of red about green was recorded. Using a Monte Carlo technique, all but two of the 28 patterns were not statistically significantly different than their null (actual) values. The results from each of the approaches were mostly consistent, but were at some levels, contradictory, underscoring the need for more research into statistical methods for these type of data.

Keywords and phrases**:** replicated bivariate spatial point patterns, generalised linear mixed models, K-functions, permutation, randomisation, cell fate determination