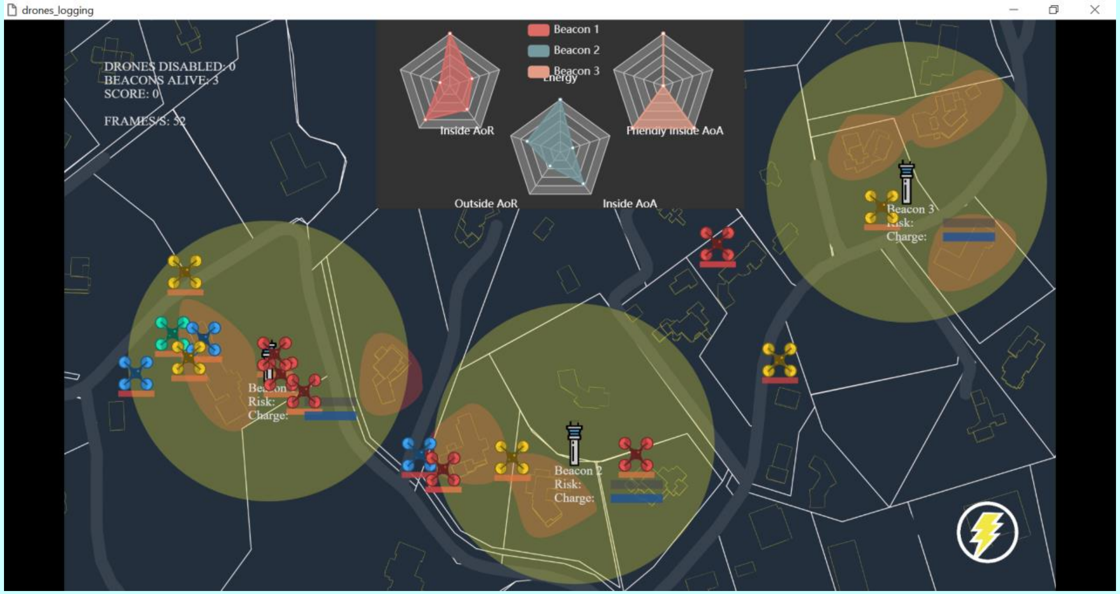
UNIVERSITY OF BIRMINGHAM

School of Computer Science

EVALUATION METHODS AND STATISTICS

Prof. Chris Baber
Chair of Pervasive and Ubiquitous Computing

The Drones Game



- The initial experimental design:

Red Drones only			Red + Yellow Drones		
Auto	Self	Both	Auto	Self	Both

UNIVERSITY OF BIRMINGHAM

Participants

- Students on the MSc module ‘Evaluation Methods and Statistics
  - N = c.140 students registered on EMS
  - n = 93 games completed. But, 11 files which could not be used
  - n = 82. But, 13 participants with errors in config for at least one trial.
  - n = 69 participants completed all three trials with correct config.

UNIVERSITY OF
BIRMINGHAM

Dependent Variables

- Time per Target
  – Total time spent playing the game divided by the total ‘drone Neutralised’
- Beacon activation
  – Total ‘beaconOnOff’
- Sensitivity (d’)
  – Applied only to ‘drone Neutralised’

d’$= ln\left(\frac{(H*(1-FA))}{((1-H)*FA)}\right)$

UNIVERSITY OF BIRMINGHAM

Hypotheses

- H1: When participants receive decision support (in the form of the polygon display), their sensitivity will be higher than when they do not have such support.
- H2: when participants can see the drones moving, their sensitivity will be higher than when they cannot see the drones.

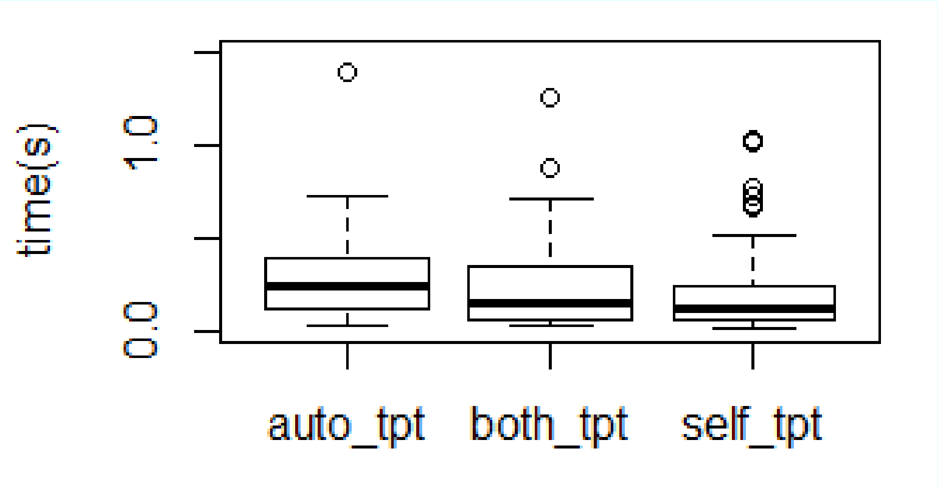
UNIVERSITY OF BIRMINGHAM

Data Preparation

- Data for dependent variable were tested for normality (using Shapiro Wilk test in R)
- If data were not shown to be normally distributed, a Box-Cox transformation was applied
- If data (following transformation) were not normally distributed, a non-parametric analysis was applied

UNIVERSITY OF BIRMINGHAM

Time per Target



- Shapiro-Wilk: w= 0.251, p<2.2e-16. Box-Cox transformation did not normalise data, so non-parametric tests applied.
- Friedman Analysis of Variance indicated a main effect of condition [$x^2(2) = 8.85293$, $p<0.05$].
- Post-hoc, pairwise comparison showed significant difference between the ‘auto’ and ‘self’ conditions [$z = 2.95$, $p<0.005$, power (d) = 0.358].

UNIVERSITY OF BIRMINGHAM

Friedman Analysis of Variance

- Non-parametric tests make no assumption about the underlying distribution of data
- Developed by Milton Friedman (economics Nobel laureate)
- Ranks the set of data and then asks whether the ranks are more likely to be binned in the independent variable categories

Simple Example…

Participant	Task 1	Rank	Task 2	Rank	Task 3	Rank
1	18		18.5		19	
2	17.9		18		18.5	
3	16.5		16		17	
4	21		19		20	
5	21		22		22.5	
6	17.5		17.5		19	
7	18		19		20	
8	15		14		15.5	
9	16		17		17.5	
10	18		19.5		20	
11	19		18		19.5	
12	17		18		19	

Simple Example…

Participant	Task 1	Rank	Task 2	Rank	Task 3	Rank
1	18	1	18.5	2	19	3
2	17.9	1	18	2	18.5	3
3	16.5	2	16	1	17	3
4	21	3	19	1	20	2
5	21	1	22	2	22.5	3
6	17.5	1.5	17.5	1.5	19	3
7	18	1	19	2	20	3
8	15	2	14	1	15.5	3
9	16	1	17	2	17.5	3
10	18	1	19.5	2	20	3
11	19	2	18	1	19.5	3
12	17	1	18	2	19	3
Sum of ranks		17.5		19.5		35

Friedman Statistic

$$Q = \frac{12}{mk(k+1)} \sum_{j=1}^{k} R_j^2 - 3m(k+1)$$

- k = levels of independent variable (columns)
- m = discrete measures (rows)
- R = rank across each row

Simple Example…

k = 3 (one for each task)
m = 12 (one for each participant)
$\sum_{j=1}^{k} R_j^2$ = (17.5^2 + 18.5^2 + 35^2)

Q = 15.29

UNIVERSITY OF BIRMINGHAM

Table of critical values

$$M = \frac{12}{nk(k+1)}\sum R_j^2 - 3n(k+1)$$

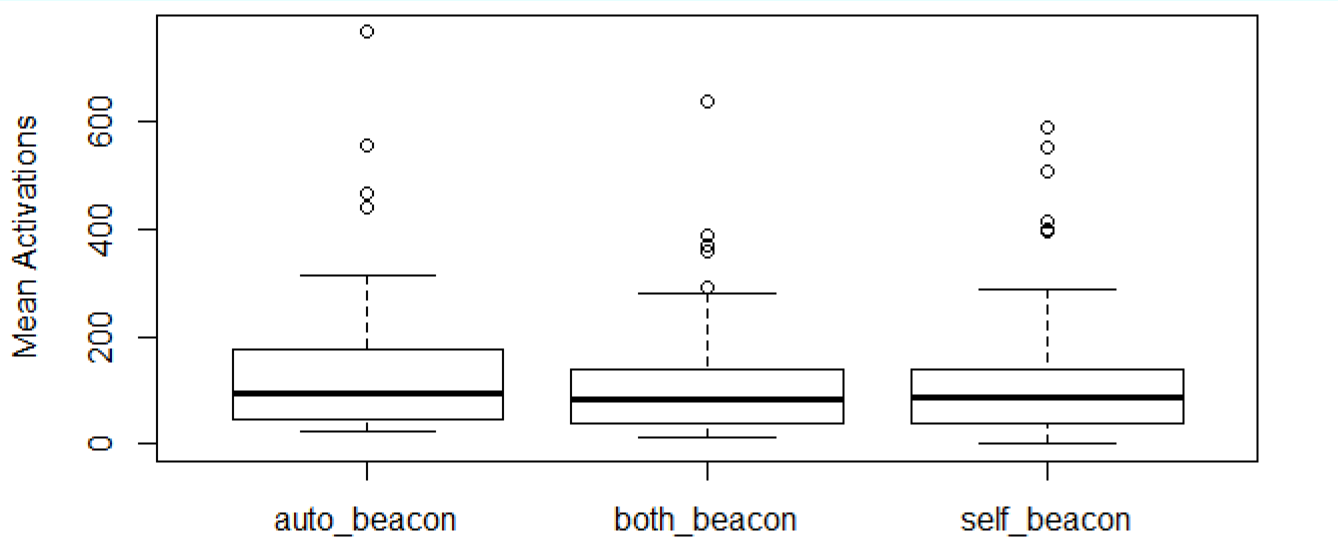
n	k=3		k=4		k=5		k=6	
	α=5%	α=1%	α=5%	α=1%	α=5%	α=1%	α=5%	α=1%
2	—	—	6.000	—	7.600	8.000	9.143	9.714
3	6.000	—	7.400	9.000	8.533	10.130	9.857	11.760
4	6.500	8.000	7.800	9.600	8.800	11.200	10.290	12.710
5	6.400	8.400	7.800	9.960	8.960	11.680	10.490	13.230
6	7.000	9.000	7.600	10.200	9.067	11.870	10.570	13.620
7	7.143	8.857	7.800	10.540	9.143	12.110	10.670	13.860
8	6.250	9.000	7.650	10.500	9.200	13.200	10.710	14.000
9	6.222	9.556	7.667	10.730	9.244	12.440	10.780	14.140
10	6.200	9.600	7.680	10.680	9.280	12.480	10.800	14.230
11	6.545	9.455	7.691	10.750	9.309	12.580	10.840	14.320
12	6.500	9.500	7.700	10.800	9.333	12.600	10.860	14.380
13	6.615	9.385	7.800	10.850	9.354	12.680	10.890	14.450
14	6.143	9.143	7.714	10.890	9.371	12.740	10.900	14.490
15	6.400	8.933	7.720	10.920	9.387	12.800	10.920	14.540
16	6.500	9.375	7.800	10.950	9.400	12.800	10.960	14.570
17	6.118	9.294	7.800	10.050	9.412	12.850	10.950	14.610
18	6.333	9.000	7.733	10.930	9.422	12.890	10.950	14.630
19	6.421	9.579	7.863	11.020	9.432	12.880	11.000	14.670
20	6.300	9.300	7.800	11.100	9.400	12.920	11.000	14.660
∞	5.991	9.210	7.815	11.340	9.488	13.280	11.070	15.090

For values of *n* greater than 20 and/or values of *k* greater than 6, use χ^2 tables with ***k*-1** degrees of freedom

For n = 12, k = 3: m = 6.5
Calculated Q > m, so reject null hypothesis at $p<0.05$

UNIVERSITY OF BIRMINGHAM

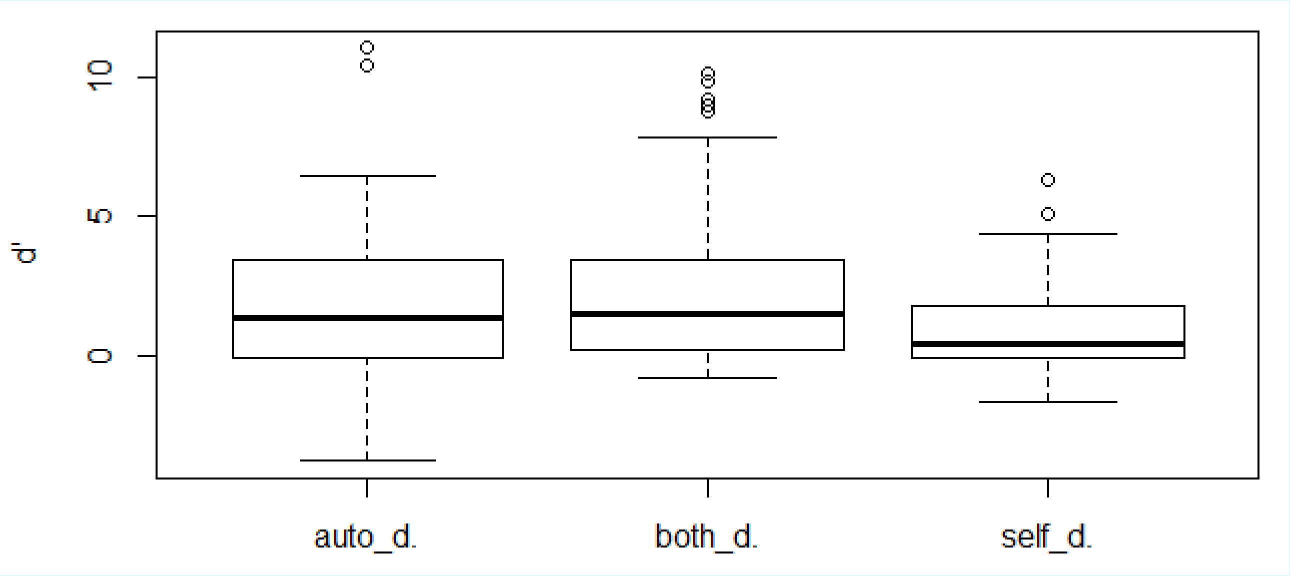
Beacon Activation



- Shapiro-Wilk: w = 0.776, p<2.2e-16. Box-Cox transformation did not normalise data, so non-parametric tests applied.
- Not significant effect of condition [$x^2(68) = 4.067$, p=0.131]

UNIVERSITY OF BIRMINGHAM

Sensitivity



- Shapiro-Wilk…
- A significant main effect of condition [x2(68) = 7.373, p<0.05].
- Post-hoc, pairwise comparison using Wilcoxon Signed Rank Test showed significant differences between ‘auto’ and ‘self’ (z= 2.188, p<0.05, power (d) = 0.27) and between ‘both’ and ‘self’ (z = 3.318, p<0.001, d=0.40)

UNIVERSITY OF BIRMINGHAM

Conclusions

- We can accept H1 and conclude that providing participants with decision support (in the form of polygon displays) improves sensitivity and can reduce time per target, relative to a display which does not provide this.
- We can reject H2 and conclude the seeing the drones does not improve sensitivity.