

Working with eye-tracking data

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ECCEM Conference, Eye-tracking workshop

20 June 2019

Workshop materials are available on:

■ <https://github.com/dliuxi/ECCEM>

Basic terminology of gaze

- Fixations
- Saccades
- Area of Interest
- Transitions
- Scan path

Fixations: where did we look?

What we want:

List of screen coordinates for each fixation (i.e., point where eye looked at)

A	B	C	D	E	F	G	H
Participant_ID	Trial_Number	Fixation_Duration	Fixation_Index	Fixation_X	Fixation_Y	Fixation_Total	
6	61	264	1	885.3	552.4	65	
6	61	187	2	829.3	628.8	65	
6	61	150	3	769.8	999	65	
6	61	144	4	887.9	978.1	65	
6	61	189	5	905.5	631.6	65	
6	61	135	6	950.6	639.4	65	
6	61	116	7	914.9	401.7	65	
6	61	172	8	916.9	350.1	65	
6	61	61	9	802.2	802.7	65	
6	61	137	10	805.1	679.4	65	
6	61	85	11	795.6	620.6	65	
6	61	230	12	775.1	641.4	65	
6	61	108	13	889.3	959.4	65	
6	61	110	14	829.1	988.2	65	
6	61	175	15	718.7	986.8	65	
6	61	307	16	1072.5	1010.9	65	
6	61	140	17	920.4	630.7	65	
6	61	175	18	814.7	620.4	65	
6	61	220	19	910.4	356.3	65	
6	61	112	20	970.8	595.8	65	
6	61	131	21	899.3	624.4	65	
6	61	106	22	835.8	625.4	65	
6	61	33	23	854.4	645.7	65	
6	61	255	24	941.9	639.8	65	
6	61	392	25	964	643.1	65	
6	61	303	26	803.1	650.4	65	
6	61	230	27	889.9	660.7	65	
6	61	210	28	948.6	662.1	65	
6	61	202	29	985.7	662.2	65	
6	61	82	30	945.3	396.2	65	
6	61	188	31	922.2	448.9	65	
6	61	277	32	911.8	350	65	
6	61	84	33	901	590.4	65	
6	61	189	34	891	596.1	65	
6	61	321	35	1099.7	1003.6	65	
6	61	179	36	1113.9	1050	65	
6	61	129	37	1086.3	1039.5	65	
6	61	213	38	1094.1	981.6	65	
6	61	133	39	1134.2	980.6	65	
6	61	206	40	880.4	991.6	65	
6	61	157	41	884.1	613.5	65	
6	61	144	42	781.6	1016.8	65	
6	61	204	43	785.3	981.5	65	
6	61	180	44	669.3	969.5	65	
6	61	208	45	808.4	971	65	

What we want:

List of screen coordinates for each fixation (i.e., point where eye looked at)

Also:

Duration—how long did they look?

A	B	C	D	E	F	G	H
Participant_ID	Trial_Number	Fixation_Duration	Fixation_Index	Fixation_X	Fixation_Y	Fixation_Total	
6	61	264	1	885.3	552.4	65	
6	61	187	2	829.3	628.8	65	
6	61	150	3	769.8	999	65	
6	61	144	4	887.9	978.1	65	
6	61	189	5	905.5	631.6	65	
6	61	135	6	950.6	639.4	65	
6	61	116	7	914.9	401.7	65	
6	61	172	8	916.9	350.1	65	
6	61	61	9	802.2	802.7	65	
6	61	137	10	805.1	679.4	65	
6	61	85	11	795.6	620.6	65	
6	61	230	12	775.1	641.4	65	
6	61	108	13	889.3	959.4	65	
6	61	110	14	829.1	988.2	65	
6	61	175	15	718.7	986.8	65	
6	61	307	16	1072.5	1010.9	65	
6	61	140	17	920.4	630.7	65	
6	61	175	18	814.7	620.4	65	
6	61	220	19	910.4	356.3	65	
6	61	112	20	970.8	595.8	65	
6	61	131	21	899.3	624.4	65	
6	61	106	22	835.8	625.4	65	
6	61	33	23	854.4	645.7	65	
6	61	255	24	941.9	639.8	65	
6	61	392	25	964	643.1	65	
6	61	303	26	803.1	650.4	65	
6	61	230	27	889.9	660.7	65	
6	61	210	28	948.6	662.1	65	
6	61	202	29	985.7	662.2	65	
6	61	82	30	945.3	396.2	65	
6	61	188	31	922.2	448.9	65	
6	61	277	32	911.8	350	65	
6	61	84	33	901	590.4	65	
6	61	189	34	891	596.1	65	
6	61	321	35	1099.7	1003.6	65	
6	61	179	36	1113.9	1050	65	
6	61	129	37	1086.3	1039.5	65	
6	61	213	38	1094.1	981.6	65	
6	61	133	39	1134.2	980.6	65	
6	61	206	40	880.4	991.6	65	
6	61	157	41	894.1	613.5	65	
6	61	144	42	781.6	1016.8	65	
6	61	204	43	785.3	981.5	65	
6	61	180	44	669.3	969.5	65	
6	61	208	45	808.4	971	65	

What we want:

List of screen coordinates for each fixation (i.e., point where eye looked at)

Also:

Duration—how long did they look?

Index—what order did they look?

A	B	C	D	E	F	G	H
Participant_ID	Trial_Number	Fixation_Duration	Fixation_Index	Fixation_X	Fixation_Y	Fixation_Total	
6	61	264	1	885.3	552.4	65	
6	61	187	2	829.3	628.8	65	
6	61	150	3	769.8	999	65	
6	61	144	4	887.9	978.1	65	
6	61	189	5	905.5	631.6	65	
6	61	135	6	950.6	639.4	65	
6	61	116	7	914.9	401.7	65	
6	61	172	8	916.9	350.1	65	
6	61	61	9	802.2	802.7	65	
6	61	137	10	805.1	679.4	65	
6	61	85	11	795.6	620.6	65	
6	61	230	12	775.1	641.4	65	
6	61	108	13	889.3	959.4	65	
6	61	110	14	829.1	988.2	65	
6	61	175	15	718.7	986.8	65	
6	61	307	16	1072.5	1010.9	65	
6	61	140	17	920.4	630.7	65	
6	61	175	18	814.7	620.4	65	
6	61	220	19	910.4	356.3	65	
6	61	112	20	970.8	595.8	65	
6	61	131	21	899.3	624.4	65	
6	61	106	22	835.8	625.4	65	
6	61	33	23	854.4	645.7	65	
6	61	255	24	941.9	639.8	65	
6	61	392	25	964	643.1	65	
6	61	303	26	803.1	650.4	65	
6	61	230	27	889.9	660.7	65	
6	61	210	28	948.6	662.1	65	
6	61	202	29	985.7	662.2	65	
6	61	82	30	945.3	396.2	65	
6	61	188	31	922.2	448.9	65	
6	61	277	32	911.8	350	65	
6	61	84	33	901	590.4	65	
6	61	189	34	891	596.1	65	
6	61	321	35	1099.7	1003.6	65	
6	61	179	36	1113.9	1050	65	
6	61	129	37	1086.3	1039.5	65	
6	61	213	38	1094.1	981.6	65	
6	61	133	39	1134.2	980.6	65	
6	61	206	40	880.4	991.6	65	
6	61	157	41	894.1	613.5	65	
6	61	144	42	781.6	1016.8	65	
6	61	204	43	785.3	981.5	65	
6	61	180	44	669.3	969.5	65	
6	61	208	45	808.4	971	65	

Extracting the data

- The 'shortcut': DataViewer—generate fixation report
 - But software is not free
- Typically we will need to convert to .asc files
 - .DOS prompt (in Windows)
 - <https://rdr.io/github/davebraze/FDBeye/man/edf2asc.html>
- Fortunately, very smart and very generous people post free workarounds on the Internet!
 - <https://rdr.io/cran/eyelinker/man/read.asc.html>

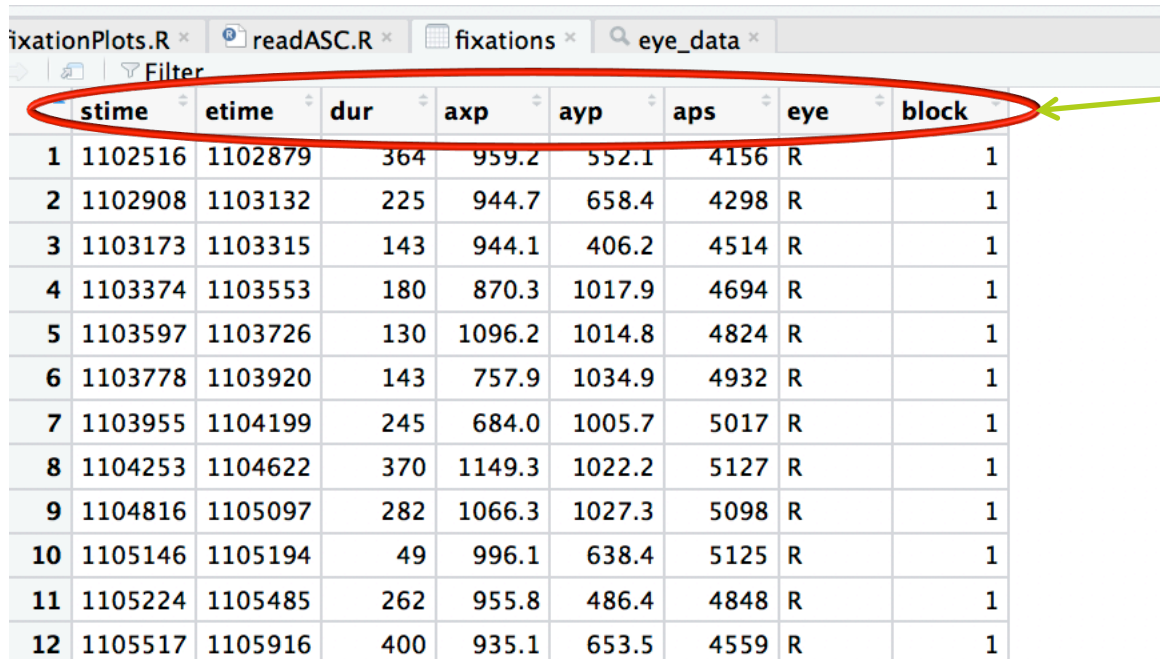
Extracting the data

- On the computers: ECEM_ET_Workshop.Rproj
- Run the code
 - (The key function is `read.asc`)
 - You get a load of data—but we want fixations now

name	type	value
• eye_data	list [6]	List of length 6
• raw	list [336042 x 6] (S3: d	A data.frame with 336042 rows and 6 columns
• msg	list [409 x 3] (S3: data.	A data.frame with 409 rows and 3 columns
• sacc	list [1194 x 11] (S3: da	A data.frame with 1194 rows and 11 columns
• fix	list [1304 x 8] (S3: dat	A data.frame with 1304 rows and 8 columns
• blinks	list [125 x 5] (S3: data.	A data.frame with 125 rows and 5 columns
• info	list [8]	List of length 8

Extracting the data

- Once we have our fixation dataset, we can rename the variables to give them sensible names



The screenshot shows an RStudio window with several tabs: 'fixationPlots.R', 'readASC.R', 'fixations', and 'eye_data'. The 'eye_data' tab is active, displaying a data table. The column names are circled in red: 'stime', 'etime', 'dur', 'axp', 'ayp', 'aps', 'eye', and 'block'. A green arrow points to the 'block' column with the text: 'This makes sense to the person who wrote this code, but I like more indicative names!'.

	stime	etime	dur	axp	ayp	aps	eye	block
1	1102516	1102879	364	959.2	552.1	4156	R	1
2	1102908	1103132	225	944.7	658.4	4298	R	1
3	1103173	1103315	143	944.1	406.2	4514	R	1
4	1103374	1103553	180	870.3	1017.9	4694	R	1
5	1103597	1103726	130	1096.2	1014.8	4824	R	1
6	1103778	1103920	143	757.9	1034.9	4932	R	1
7	1103955	1104199	245	684.0	1005.7	5017	R	1
8	1104253	1104622	370	1149.3	1022.2	5127	R	1
9	1104816	1105097	282	1066.3	1027.3	5098	R	1
10	1105146	1105194	49	996.1	638.4	5125	R	1
11	1105224	1105485	262	955.8	486.4	4848	R	1
12	1105517	1105916	400	935.1	653.5	4559	R	1

This makes sense to the person who wrote this code, but I like more indicative names!

Extracting the data

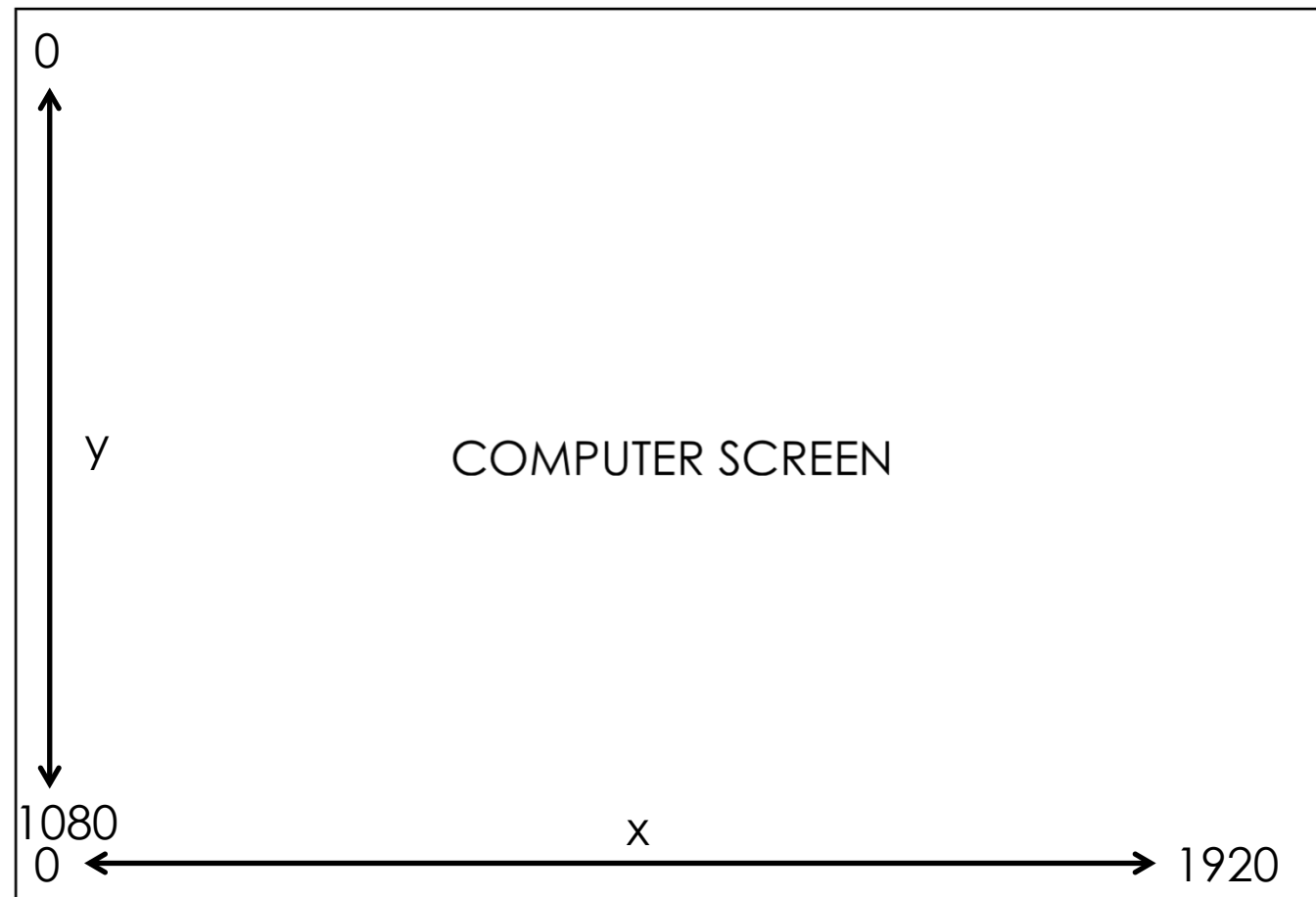
- Once we have our fixation dataset, we can rename the variables to give them sensible names

	stime	etime	Fixation_Duration	Fixation_X	Fixation_Y	aps	eye	Trial_No	Trial_Time
1	1102516	1102879	364	959.2	552.1	4156	R	1	363
2	1102908	1103132	225	944.7	658.4	4298	R	1	224
3	1103173	1103315	143	944.1	406.2	4514	R	1	142
4	1103374	1103553	180	870.3	1017.9	4694	R	1	179
5	1103597	1103726	130	1096.2	1014.8	4824	R	1	129
6	1103778	1103920	143	757.9	1034.9	4932	R	1	142
7	1103955	1104199	245	684.0	1005.7	5017	R	1	244
8	1104253	1104622	370	1149.3	1022.2	5127	R	1	369
9	1104816	1105097	282	1066.3	1027.3	5098	R	1	281
0	1105146	1105194	49	996.1	638.4	5125	R	1	48
1	1105224	1105485	262	955.8	486.4	4848	R	1	261
2	1105517	1105916	400	column 0: rownames		4559	R	1	399
3	1105972	1106012	41	1084.8	1071.1	4611	R	1	40
4	1106047	1106621	575	1064.5	1039.5	4676	R	1	574

So I changed them to stuff that makes sense to me (and hopefully you!)

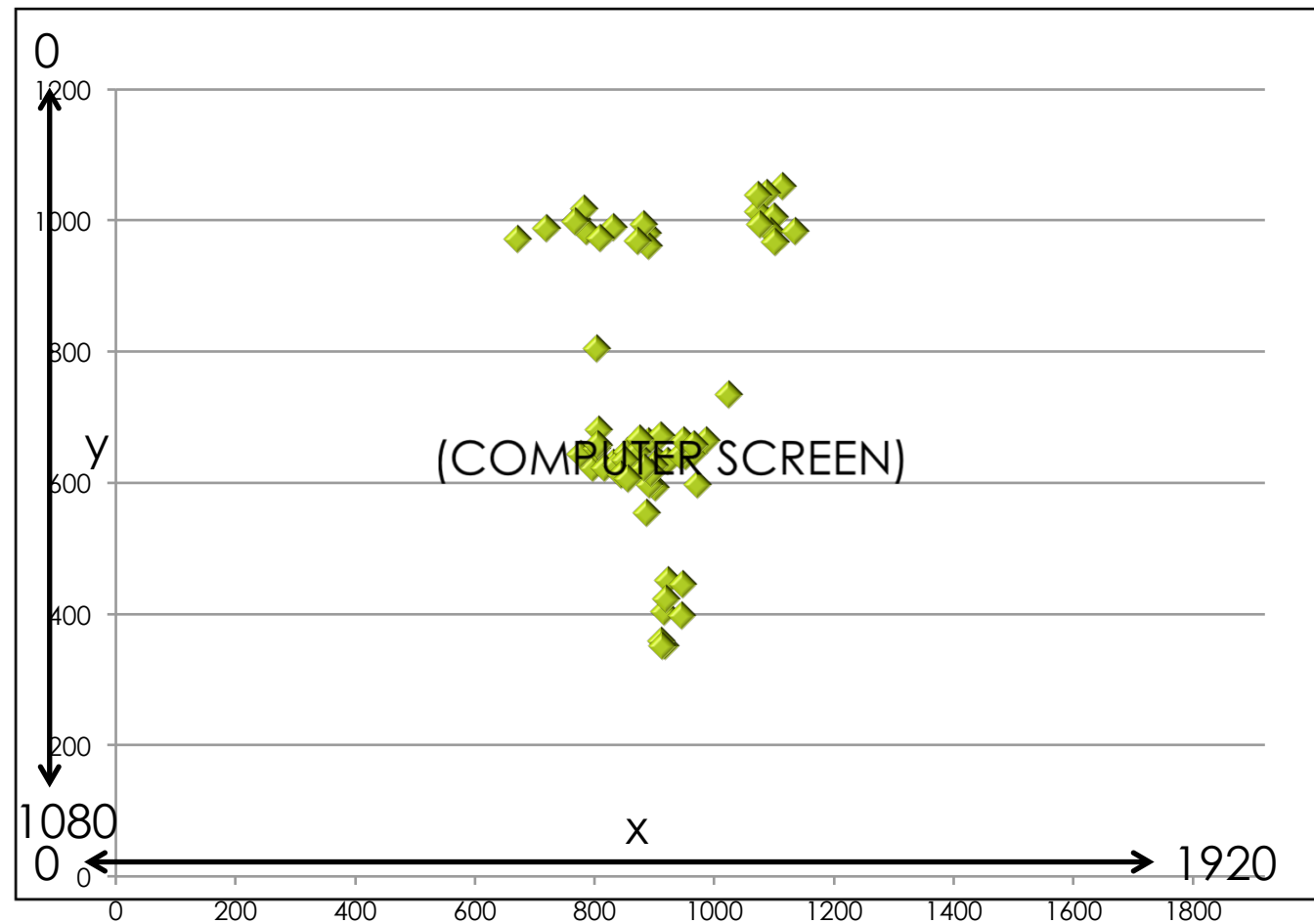
So we have our data. Now what?

Recall: Fixations are Screen Co-ordinates



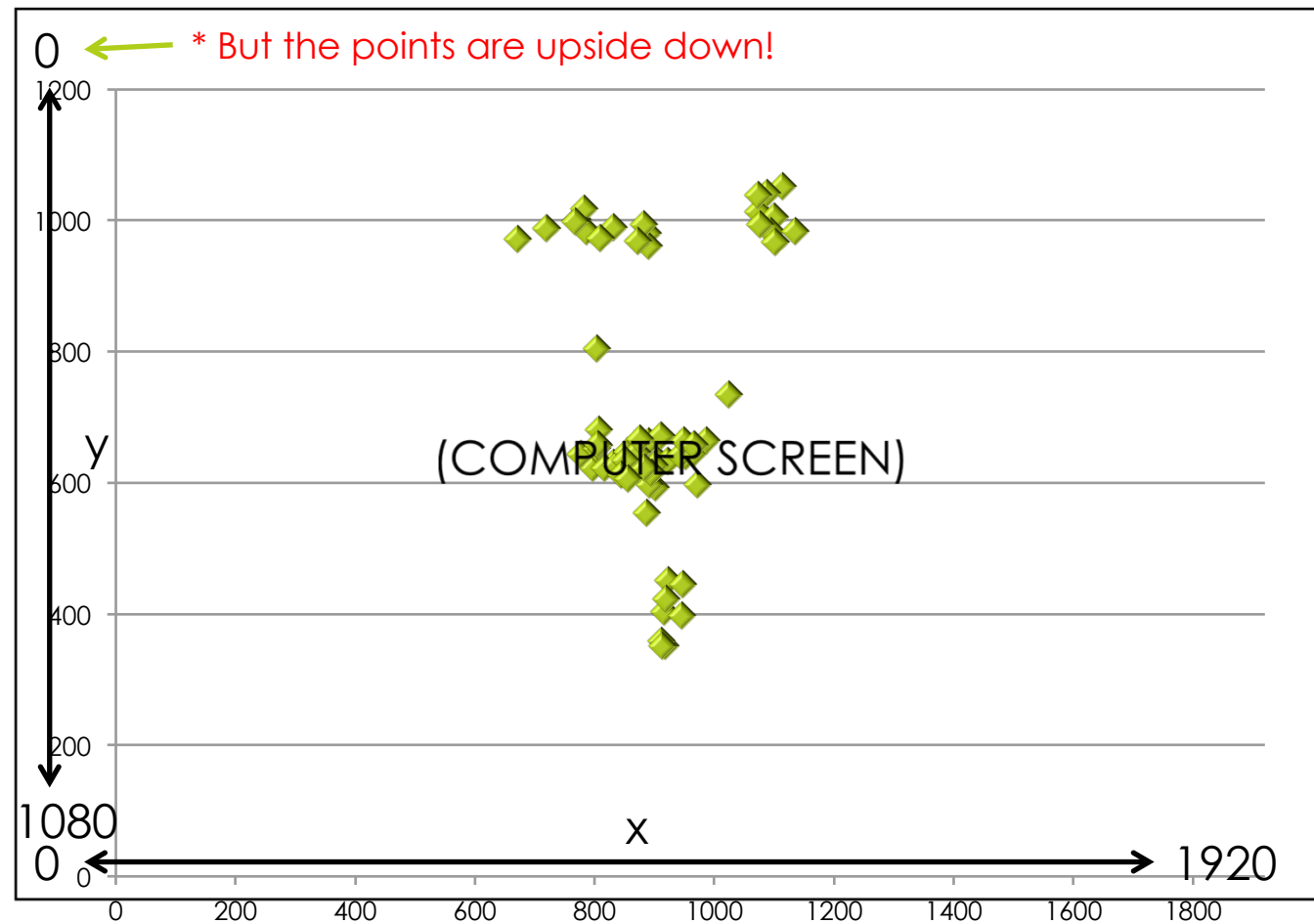
D	F	F	G
Index	Fixation_X	Fixation_Y	Fixation_Total
1	885.3	552.4	6
2	829.3	628.8	6
3	769.8	999	6
4	887.9	978.1	6
5	905.5	631.6	6
6	950.6	639.4	6
7	914.9	401.7	6
8	916.9	350.1	6
9	802.2	802.7	6
10	805.1	679.4	6
11	795.6	620.6	6
12	775.1	641.4	6
13	889.3	959.4	6
14	829.1	988.2	6
15	718.7	986.8	6
16	1072.5	1010.9	6
17	920.4	630.7	6
18	814.7	620.4	6
19	910.4	356.3	6
20	970.8	595.8	6
21	899.3	624.4	6
22	835.8	625.4	6
23	854.4	645.7	6
24	941.9	639.8	6
25	964	643.1	6
26	803.1	650.4	6
27	889.9	660.7	6
28	948.6	662.1	6
29	985.7	662.2	6
30	945.3	396.2	6
31	922.2	448.9	6
32	911.8	350	6
33	901	590.4	6
34	891	596.1	6
35	1099.7	1003.6	6
36	1113.9	1050	6
37	1086.3	1039.5	6
38	1094.1	981.6	6
39	1134.2	980.6	6
40	880.4	991.6	6
41	894.1	613.5	6
42	781.6	1016.8	6
43	785.3	981.5	6

So we could plot a graph ...



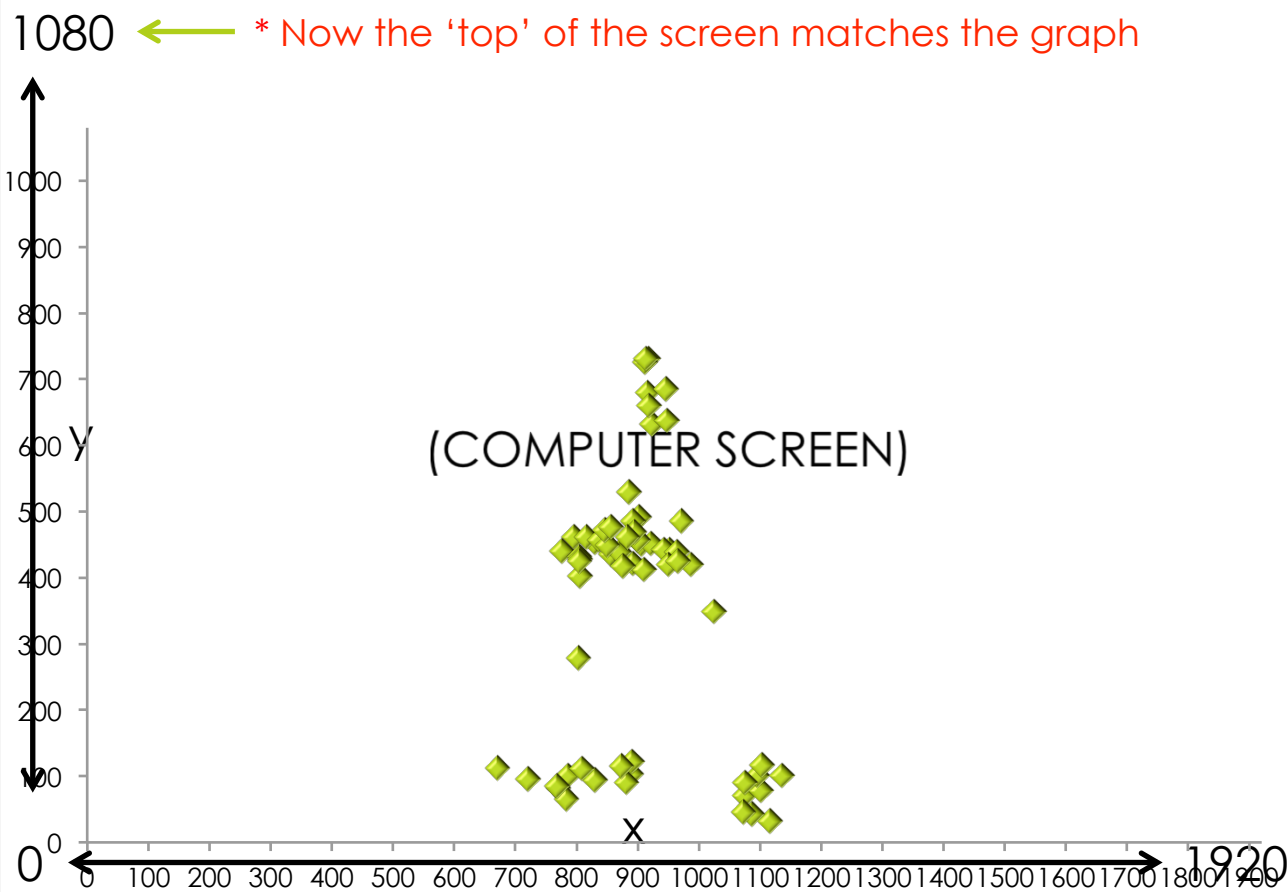
D	E	F	G
Index	Fixation_X	Fixation_Y	Fixation_Total
1	885.3	552.4	6
2	829.3	628.8	6
3	769.8	999	6
4	887.9	978.1	6
5	905.5	631.6	6
6	950.6	639.4	6
7	914.9	401.7	6
8	916.9	350.1	6
9	802.2	802.7	6
10	805.1	679.4	6
11	795.6	620.6	6
12	775.1	641.4	6
13	889.3	959.4	6
14	829.1	988.2	6
15	718.7	986.8	6
16	1072.5	1010.9	6
17	920.4	630.7	6
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19	910.4	356.3	6
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22	835.8	625.4	6
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24	941.9	639.8	6
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31	922.2	448.9	6
32	911.8	350	6
33	901	590.4	6
34	891	596.1	6
35	1099.7	1003.6	6
36	1113.9	1050	6
37	1086.3	1039.5	6
38	1094.1	981.6	6
39	1134.2	980.6	6
40	880.4	991.6	6
41	894.1	613.5	6
42	781.6	1016.8	6
43	785.3	981.5	6

So we could plot a graph ...



D	F	F	G
Index	Fixation_X	Fixation_Y	Fixation_Total
1	885.3	552.4	6
2	829.3	628.8	6
3	769.8	999	6
4	887.9	978.1	6
5	905.5	631.6	6
6	950.6	639.4	6
7	914.9	401.7	6
8	916.9	350.1	6
9	802.2	802.7	6
10	805.1	679.4	6
11	795.6	620.6	6
12	775.1	641.4	6
13	889.3	959.4	6
14	829.1	988.2	6
15	718.7	986.8	6
16	1072.5	1010.9	6
17	920.4	630.7	6
18	814.7	620.4	6
19	910.4	356.3	6
20	970.8	595.8	6
21	899.3	624.4	6
22	835.8	625.4	6
23	854.4	645.7	6
24	941.9	639.8	6
25	964	643.1	6
26	803.1	650.4	6
27	889.9	660.7	6
28	948.6	662.1	6
29	985.7	662.2	6
30	945.3	396.2	6
31	922.2	448.9	6
32	911.8	350	6
33	901	590.4	6
34	891	596.1	6
35	1099.7	1003.6	6
36	1113.9	1050	6
37	1086.3	1039.5	6
38	1094.1	981.6	6
39	1134.2	980.6	6
40	880.4	991.6	6
41	894.1	613.5	6
42	781.6	1016.8	6
43	785.3	981.5	6

Just flip all the y-values so that they are upside-down (screen size - y)



Fixation_X	Fixation_Y	Flipped_Fixation_Y
885.3	552.4	527.6
829.3	628.8	451.2
769.8	999	81
887.9	978.1	101.9
905.5	631.6	448.4
950.6	639.4	440.6
914.9	401.7	678.3
916.9	350.1	729.9
802.2	802.7	277.3
805.1	679.4	400.6
795.6	620.6	459.4
775.1	641.4	438.6
889.3	959.4	120.6
829.1	988.2	91.8
718.7	986.8	93.2
1072.5	1010.9	69.1
920.4	630.7	449.3
814.7	620.4	459.6
910.4	356.3	723.7
970.8	595.8	484.2
899.3	624.4	455.6
835.8	625.4	454.6
854.4	645.7	434.3
941.9	639.8	440.2
964	643.1	436.9
803.1	650.4	429.6
889.9	660.7	419.3
948.6	662.1	417.9
985.7	662.2	417.8
945.3	396.2	683.8
922.2	448.9	631.1
911.8	350	730
901	590.4	489.6
891	596.1	483.9
1099.7	1003.6	76.4
1113.9	1050	30
1086.3	1039.5	40.5
1094.1	981.6	98.4
1134.2	980.6	99.4

Exercises: Try it in Excel!

<https://github.com/dliuxi/ECCEM>

FOLDER: WeatherFixations, file: single_participant.xlsx

Advanced practice: using R

ECCEM_ET_Workshop.Rproj