Page loading time on Amazon.com with different settings

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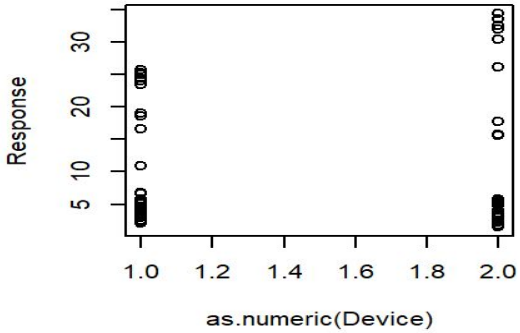
Data Collection & Research Question

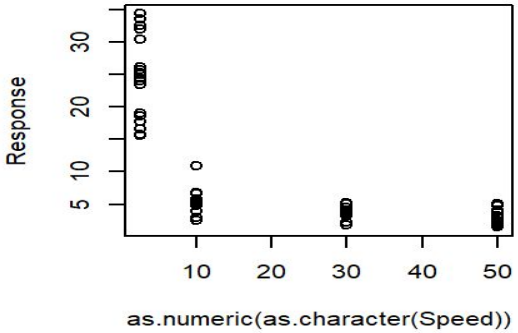
- **Designs: Full Factorial Design with three factors and three replications (4 x 3 x 2 x 3 = 72 runs)**
  1. Response :
     - Full loading time in seconds (shown on the inspect page of browser)
  2. Factors:
     a. Internet speed (Avg 2.5/10/30/50 mbps)
     b. Browsers - Opera, Chrome, Firefox
     c. Page Layout (Device) - Desktop, Mobile
  3. Blocking (Three Replications):
     - Three different researchers contributed

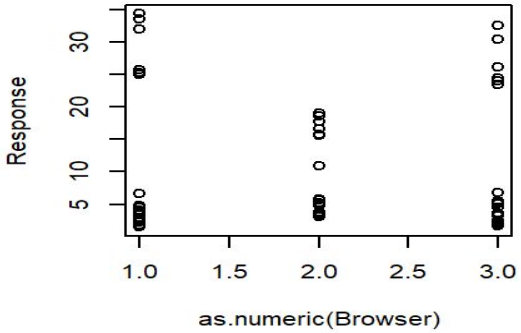
- **Research Question:**
  - Does loading time vary by different browsers, internet speeds, or types of page layout (desktop or mobile)?
  - Any interaction effects?

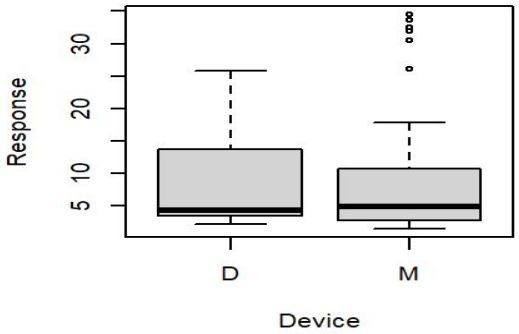
				seconds		
Run	Device	Speed	Browser	Replicate 1	Replicate 2	Replicate 3
1	D	1	C	2.95	4.09	2.92
2	D	1	F	3.75	3.08	3.25
3	D	1	O	2.25	2.15	2.52
4	D	2	C	4.46	3.51	3.86
5	D	2	F	3.35	3.61	3.52
6	D	2	O	3.68	3.38	4.57
7	D	3	C	6.7	3.87	3.91
8	D	3	F	10.86	5.69	5.82
9	D	3	O	5.12	5.41	6.74
10	D	4	C	25.35	24.97	25.77
11	D	4	F	18.55	16.67	18.98
12	D	4	O	23.44	24.07	24.43
13	M	1	C	2.45	1.67	1.45
14	M	1	F	5.13	4.84	4.78
15	M	1	O	1.61	1.75	1.72
16	M	2	C	1.8	4.12	2.3
17	M	2	F	5.27	5.13	5.16
18	M	2	O	3.42	3.63	3.28
19	M	3	C	2.99	4.76	2.5
20	M	3	F	5.75	4.84	4.73
21	M	3	O	5.31	5.52	5.17
22	M	4	C	31.93	33.58	34.42
23	M	4	F	15.83	17.80	15.63
24	M	4	O	26.10	30.45	32.54

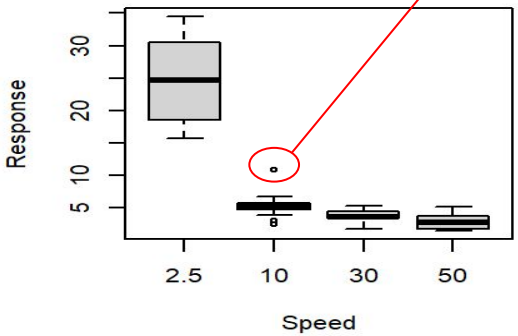
Exploratory Analysis



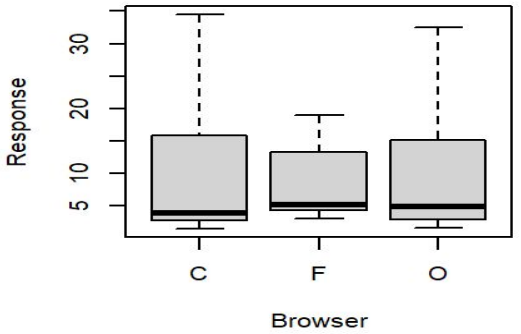








Run 8



Model1 - Linear Model (Summary and Anova)

Loading Time = Speed + Device + Browser + Device:Speed + Device:Browser + Speed:Browser + Replication

Model Summary

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	27.12306	0.90071	30.113	< 2e-16	***
DeviceM	4.35889	0.98668	4.418	5.08E-05	***
Speed10	-22.515	1.13932	-19.762	< 2e-16	***
Speed30	-24.00167	1.13932	-21.067	< 2e-16	***
Speed50	-24.65889	1.13932	-21.644	< 2e-16	***
BrowserF	-11.51625	1.10314	-10.44	2.30E-14	***
BrowserO	-2.54542	1.10314	-2.307	0.025044	*
replicate2	0.0225	0.49334	0.046	0.963798	
replicate3	0.08	0.49334	0.162	0.871808	
DeviceM:Speed10	-5.4	1.13932	-4.74	1.70E-05	***
DeviceM:Speed30	-3.98667	1.13932	-3.499	0.000966	***
DeviceM:Speed50	-4.17889	1.13932	-3.668	0.000576	***
DeviceM:BrowserF	-1.15417	0.98668	-1.17	0.247436	
DeviceM:BrowserO	0.09417	0.98668	0.095	0.924334	
Speed10:BrowserF	14.25333	1.39538	10.215	4.97E-14	***
Speed30:BrowserF	13.09167	1.39538	9.382	8.97E-13	***
Speed50:BrowserF	13.64333	1.39538	9.778	2.25E-13	***
Speed10:BrowserO	3.92167	1.39538	2.81	0.006958	**
Speed30:BrowserO	2.81667	1.39538	2.019	0.048703	*
Speed50:BrowserO	1.91	1.39538	1.369	0.176944	

Anova - M1

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Device	1	6.8	6.79	2.3247	0.1333922	
Speed	3	5710.8	1903.59	651.778	< 2.2e-16	***
Browser	2	46.4	23.21	7.946	0.0009745	***
replicate	2	0.1	0.04	0.014	0.9861143	
Device:Speed	3	74.3	24.77	8.4797	0.0001104	***
Device:Browser	2	5.8	2.9	0.9927	0.3774856	
Speed:Browser	6	474.9	79.15	27.102	2.19E-14	***
Residuals	52	151.9	2.92			

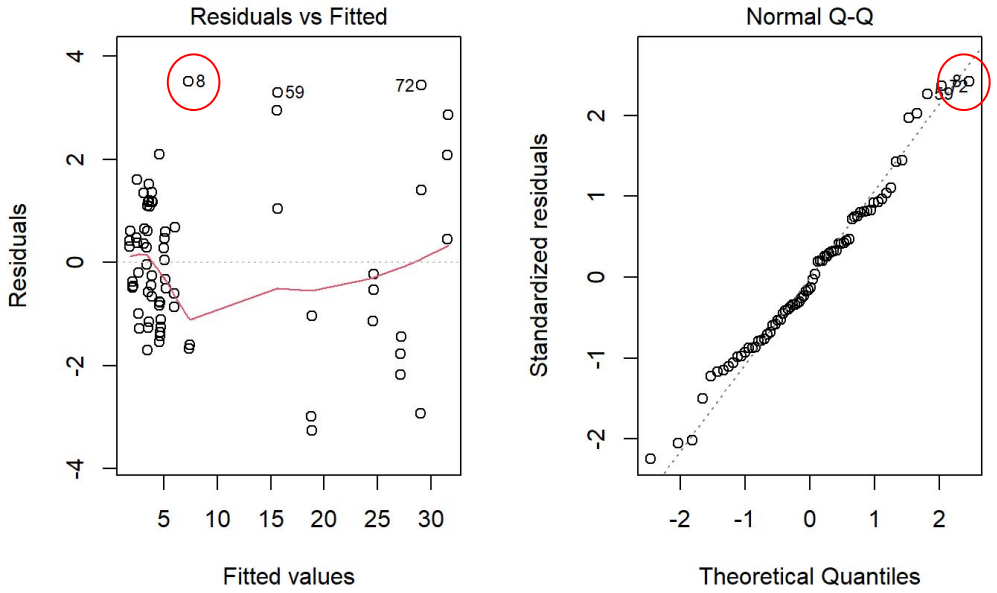
R^2 = 0.968

Model1 - Tukey and Model Assumptions

Tukey

Factors	Levels	Difference	P-Values
Device	M-D	0.6141667	0.1333922
Speed	10-2.5	-19.1566667	0
Speed	30-2.5	-20.6922222	0
Speed	50-2.5	-21.5638889	0
Speed	30-10	-1.5355556	0.0452395
Speed	50-10	-2.4072222	0.0005442
Speed	50-30	-0.8716667	0.4272319
Browser	F-C	-1.84625	0.0013069
Browser	O-C	-0.33625	0.7752172
Browser	O-F	1.51	0.0096095
Replications	2-1	0.0225	0.9988539
Replications	3-1	0.08	0.9856117
Replications	3-2	0.0575	0.9925397

Model Validation



Model2 - Linear Model using Boxcox (Summary and Anova)

Lambda : -0.74...

Loading Time_Transformed = Speed + Device + Browser + Device:Speed + Device:Browser + Speed:Browser + Replication

Model Summary

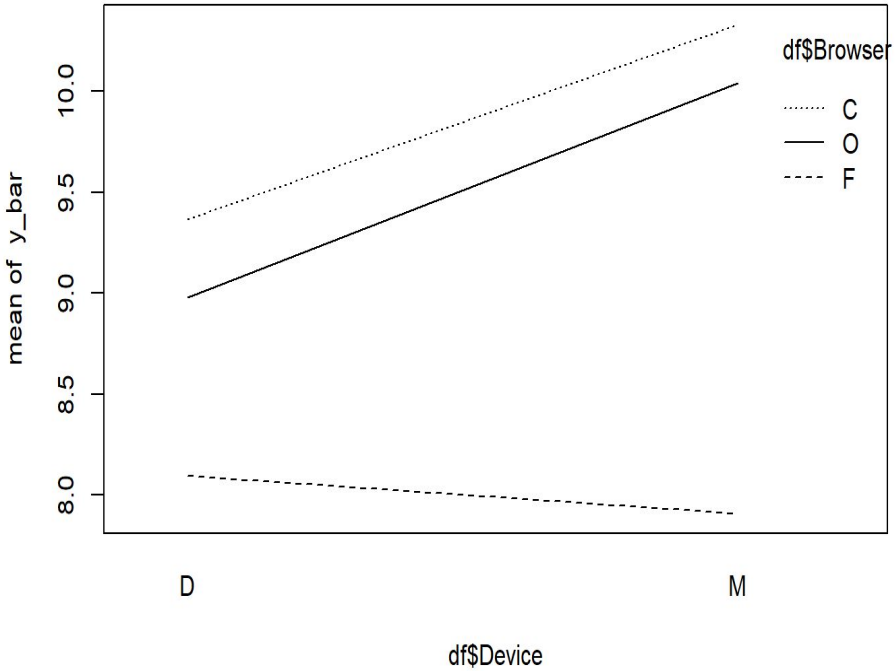
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	1.163929	0.054261	21.451	< 2e-16	***
DeviceM	-0.107313	0.0612	-1.753	0.08471	.
Speed	-0.009493	0.001549	-6.129	7.88E-08	***
BrowserF	-0.109835	0.067992	-1.615	0.11155	
BrowserO	0.033175	0.066145	0.502	0.61785	
replicate2	0.005485	0.035455	0.155	0.87759	
replicate3	-0.015627	0.035455	-0.441	0.66101	
DeviceM:Speed	-0.002083	0.001554	-1.341	0.1851	
DeviceM:BrowserF	0.208715	0.070911	2.943	0.00464	**
DeviceM:BrowserO	0.099099	0.070068	1.414	0.16253	
Speed:BrowserF	0.004895	0.001907	2.567	0.0128	*
Speed:BrowserO	-0.00264	0.001895	-1.393	0.16874	

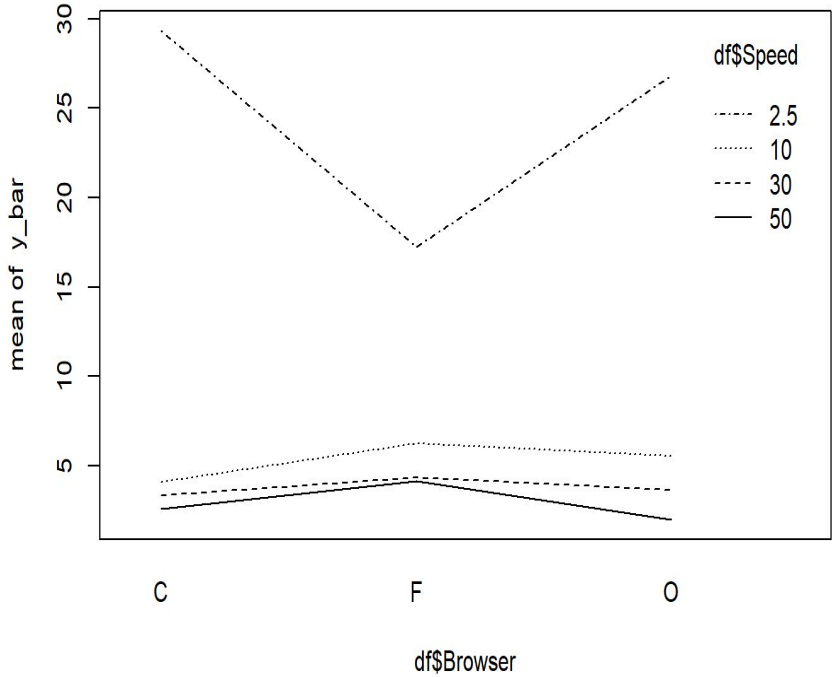
Anova - M2

Response: Response_t						
	Df	Sum Sq	Mean Sq	F Values	Pr(>F)	
Device	1	0.04567	0.04567	3.1008	0.0834358	.
Speed	1	2.35264	2.35264	159.732	< 2.2e-16	***
Browser	2	0.16768	0.08384	5.6921	0.0054904	**
replicate	2	0.0071	0.00355	0.241	0.7866234	
Device:Speed	1	0.02336	0.02336	1.5861	0.2128442	
Device:Browser	2	0.12139	0.06069	4.1209	0.0211246	*
Speed:Browser	2	0.23646	0.11823	8.0271	0.0008252	***
Residuals	59	0.86899	0.01473			

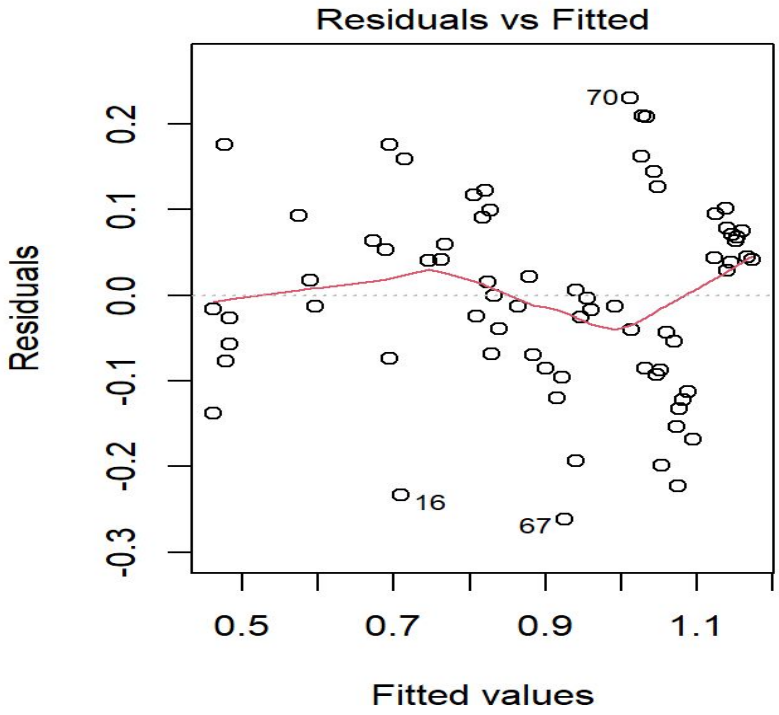
R^2 = 0.7303

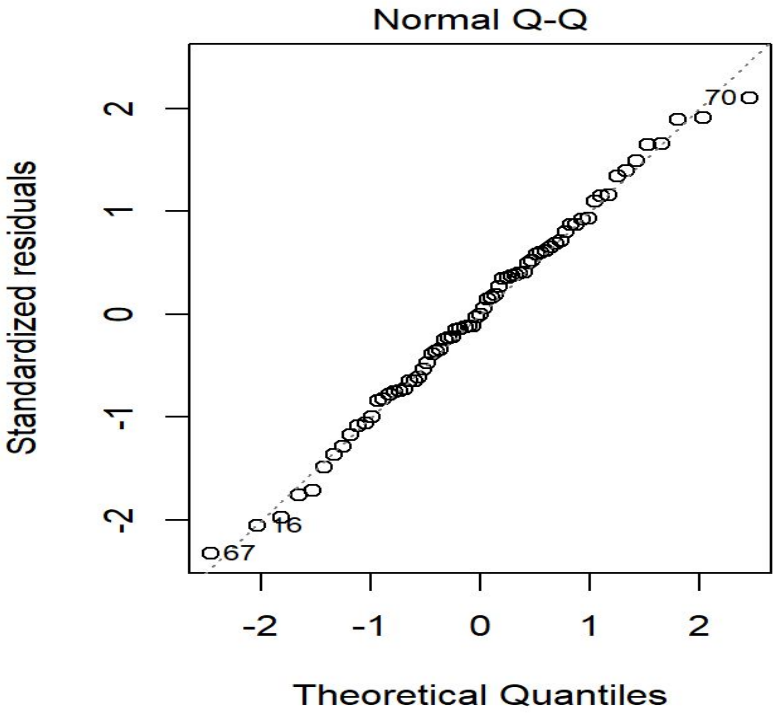
Model2 - Interaction Plots





Model2 - Model Assumptions





Conclusion

- At 10% level, main factors : Device, Speed, and Browser are statistically different.
  - Using mobile layout can shorten the loading time over desktop
  - Model Summary shows that Browser is not statistically significant, but anova does.
  - Higher speed provides faster loading time
- Interactions : Device vs. Browser and Speed vs. Browser statistically different.
  - Device vs. Browser : Firefox is the fastest at speed of 2.5, but slowest at other speeds. Chrome and Opera almost similar.
  - Speed vs. Browser : Firefox became faster when moving from desktop to mobile, but chrome and opera became slower.

Possible Confounding / Further Experiment

- Internet Latency is a confounding variable that can affect the loading time.
- Rather than mobile layout, test on mobile (Similar hardware settings needed, too)
- Fluctuating Traffic on Amazon.com cannot be controlled.
- Device environment : Ram Usage, CPU Usage should be considered

Thank you!