Reconstructing Events Across Fragmented Information:

An Eye-Tracking Study of Comic Panels

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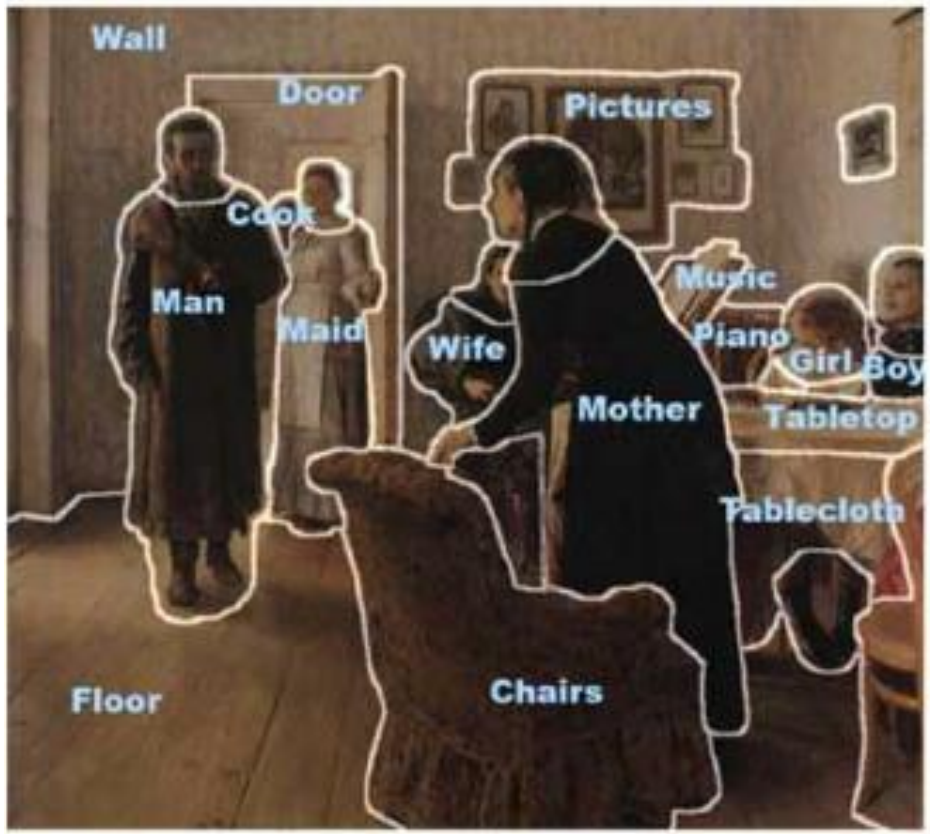
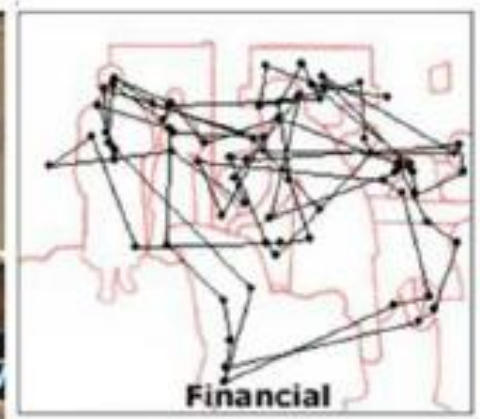
Background & Motivation

- Yarbus, 1960 study, translated in 1967 [1].
- Rayner, 1998. Attentional selection- serialization of events [2].
- Goal oriented- top down approach.

[1] Yarbus, A. L. (1967). *Eye movements and vision*. New York: Plenum Press.
[2] Rayner, K. (1998). *Eye movements in reading and information processing: 20 years of research*. **Psychological Bulletin, 124**(3), 372–422.

This painting, They Did Not Expect Him, was used in Yabus's study. Ilya Repin/Wikimedia


Wall
Door
Pictures
Cook
Man
Maid
Wife
Music
Piano
Girl
Boy
Mother
Tabletop
Tablecloth
Floor
Chairs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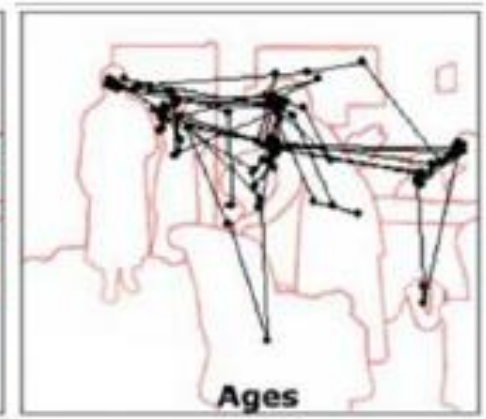
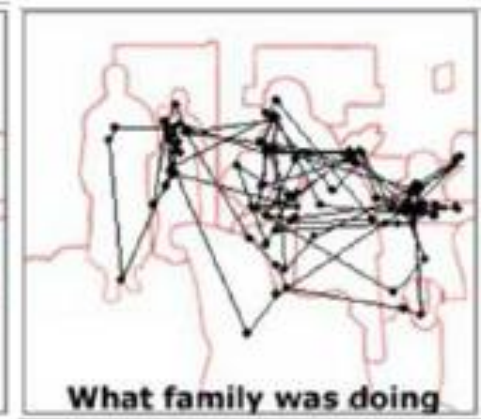
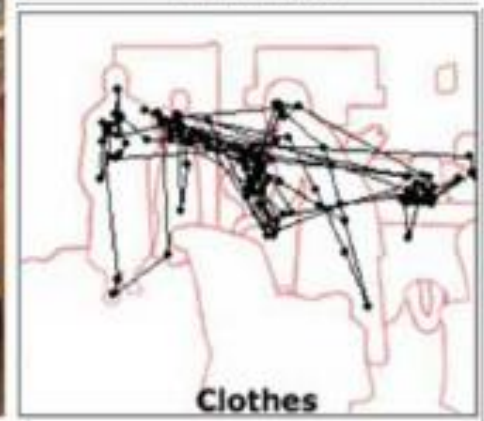
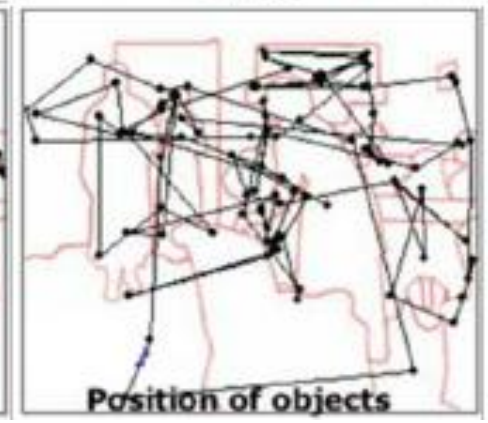
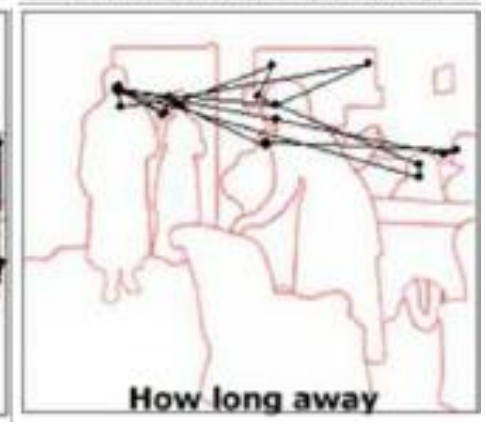

Ages

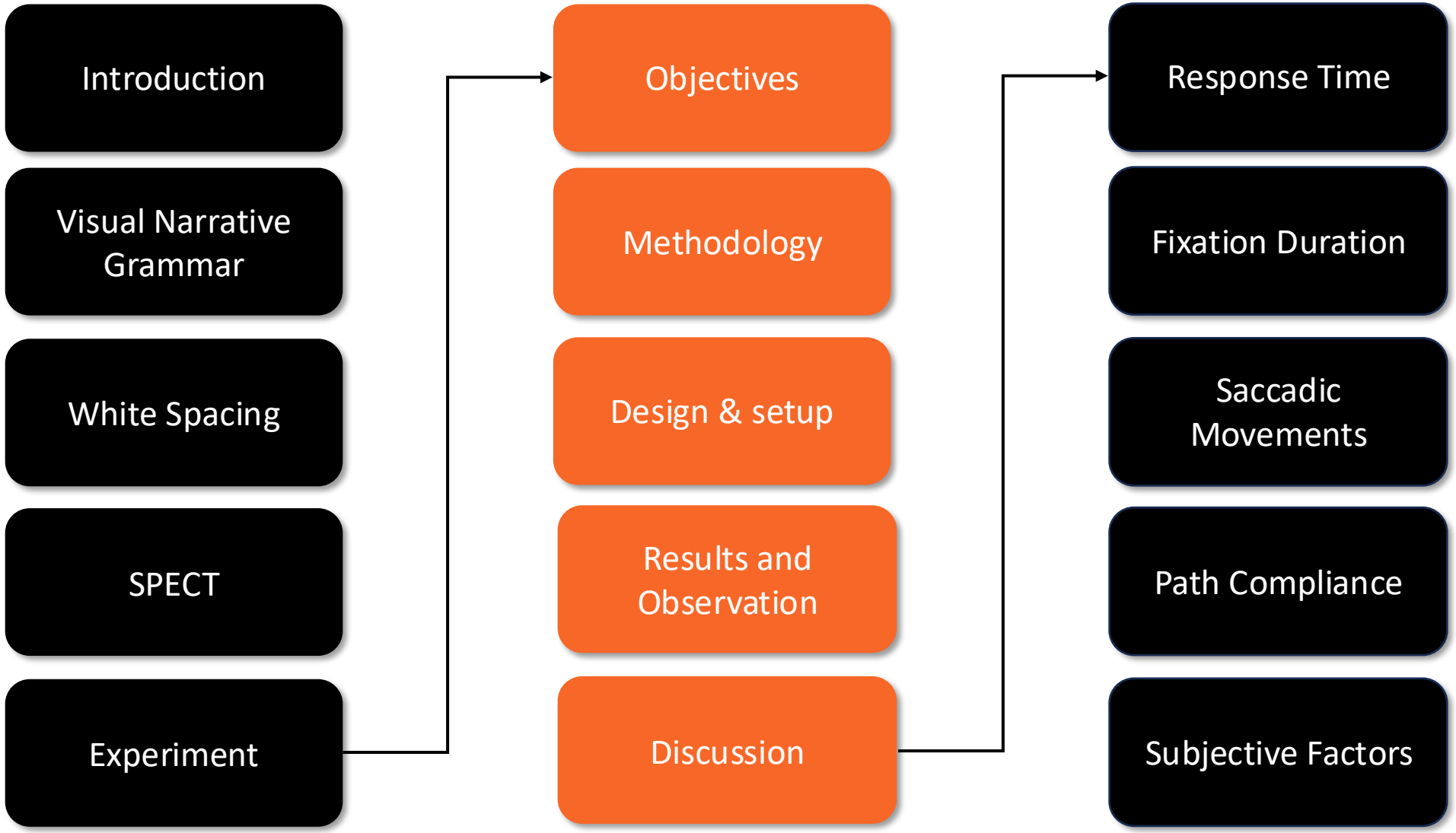

What family was doing


Clothes


Position of objects


How long away

Overview


Introduction
Visual Narrative Grammar
White Spacing
SPECT
Experiment
Objectives
Methodology
Design & setup
Results and Observation
Discussion
Response Time
Fixation Duration
Saccadic Movements
Path Compliance
Subjective Factors

What are Comics?

"Juxtaposed pictorial and other images in a deliberate sequence, intended to convey information, and/or to produce an aesthetic response in the viewer" [1]

1. McCloud, 1993

Visual Narrative Grammar

Establisher Initial peak release

Establisher initial

initial

Establisher | initial | peak | release

Arc

initial

Establisher

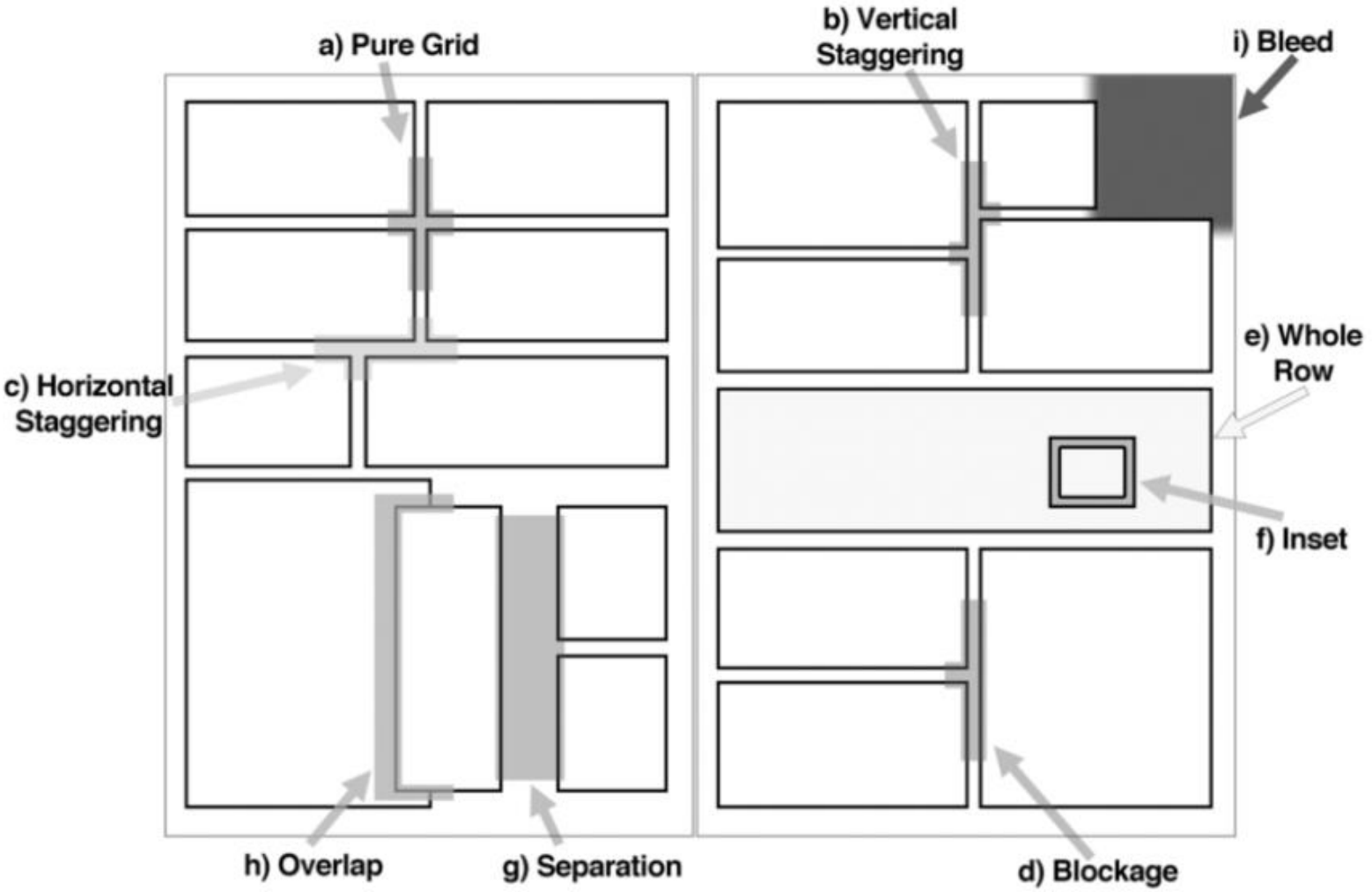
initial

peak

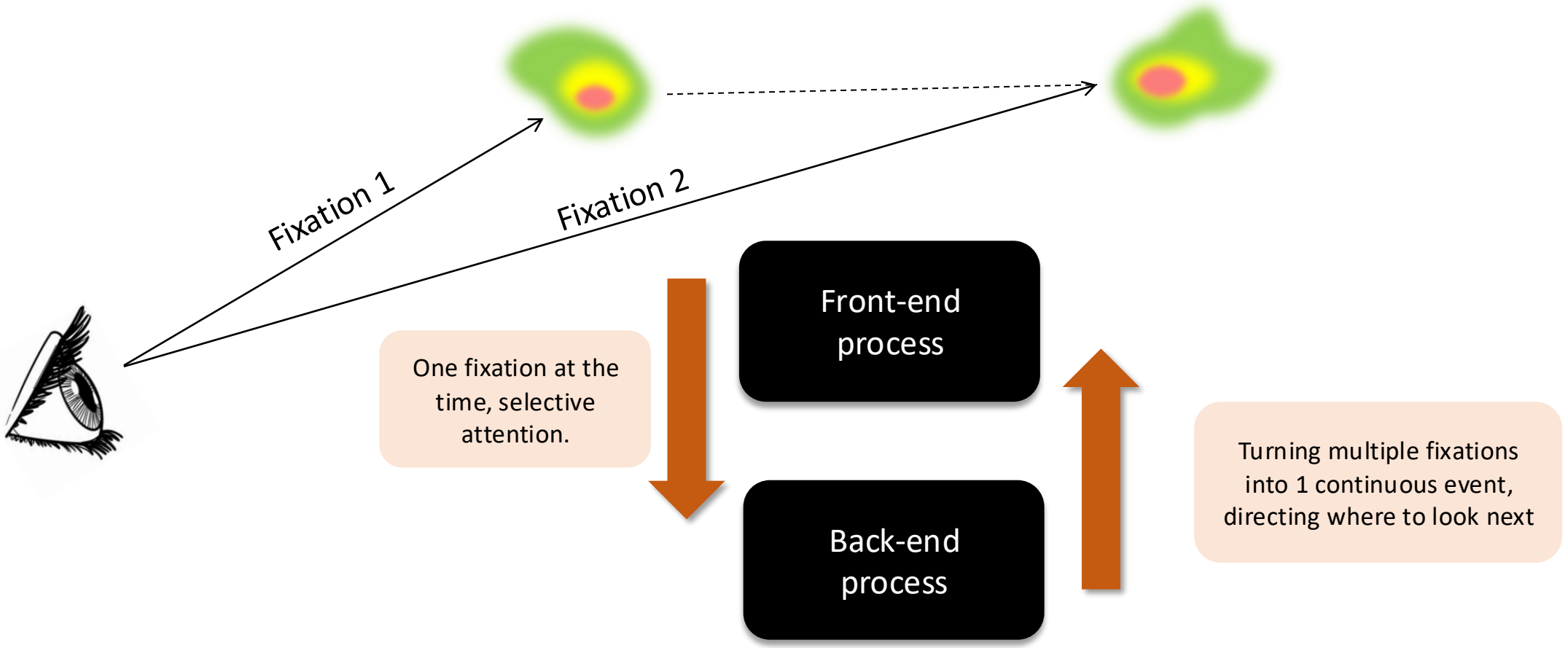
release

White Spacing/ “Gutter”

External Composition Structure



Scene Perception and Event Comprehension Theory



Objectives

- Panel Layout's effects on Navigation & Inference Generation: spatial order providing temporal information.
- Understanding how navigational rerouting will affect processing cost.
- To check whether higher processing cost creates inefficiency.

Hypothesis:

H1: states that the visual sequences that has an intuitive external composition structure will be processed more efficiently.

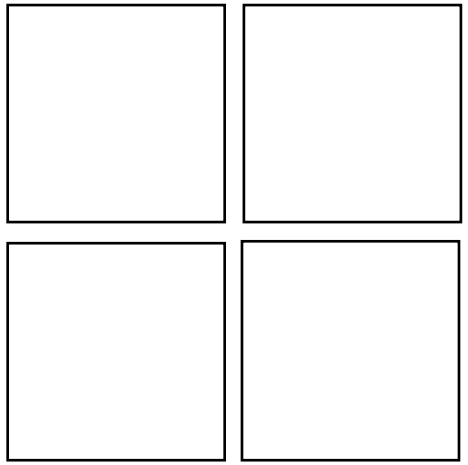
H2: states that panels which are more difficult to navigate will yield more prediction errors and will disrupt event reconstruction, increasing processing cost.

H3: states that the semantic coherences will stabilize any navigational rerouting or structural ambiguities, hence will allow successful event reconstruction even with an increased processing cost.

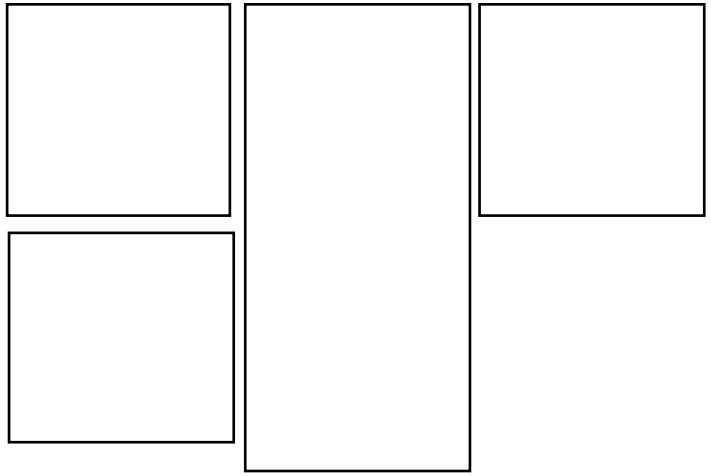
Methodology

Stimuli

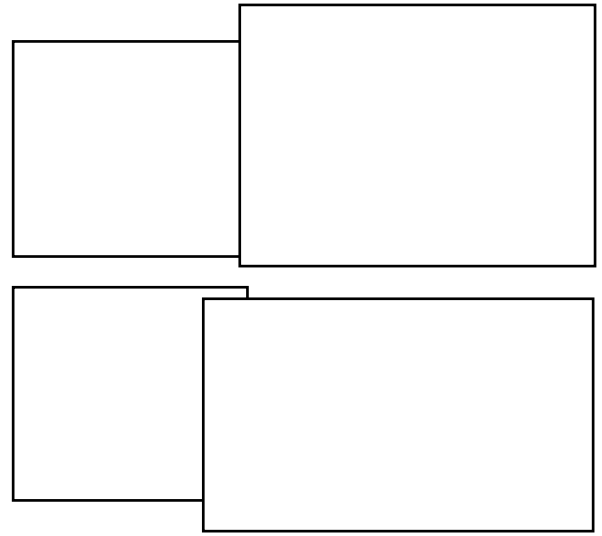
- 9 Comic Strips were selected from *Peanuts* and *Calvin & Hobbes* Comics.
- 3 of them were worded comics, 3 wordless, and 3 containing emotive expressions and onomatopoeic words.
- Each were arranged into 6 different layout structures.
- Giving us a total 9 X 6 = 54 comic strips as stimuli.



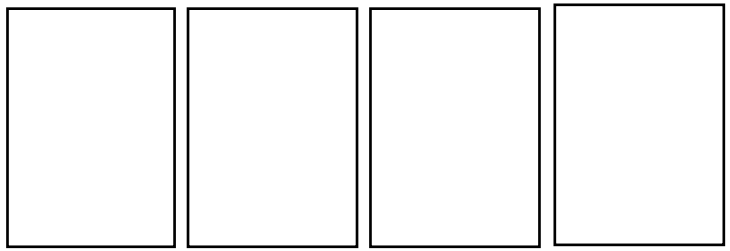
Grid Structure



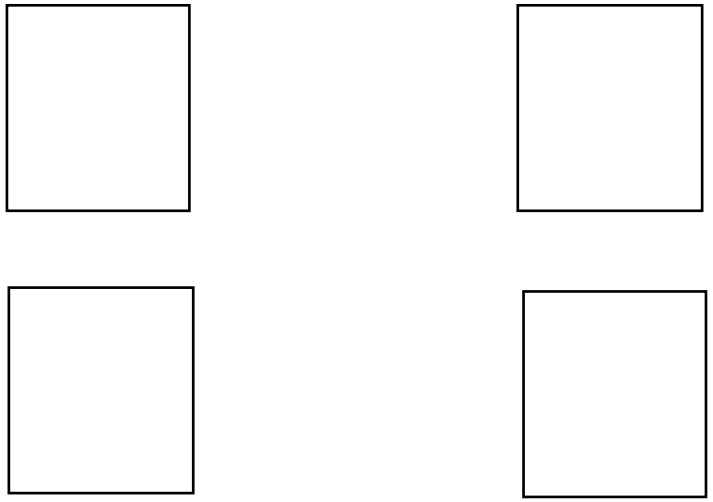
Blocked structure



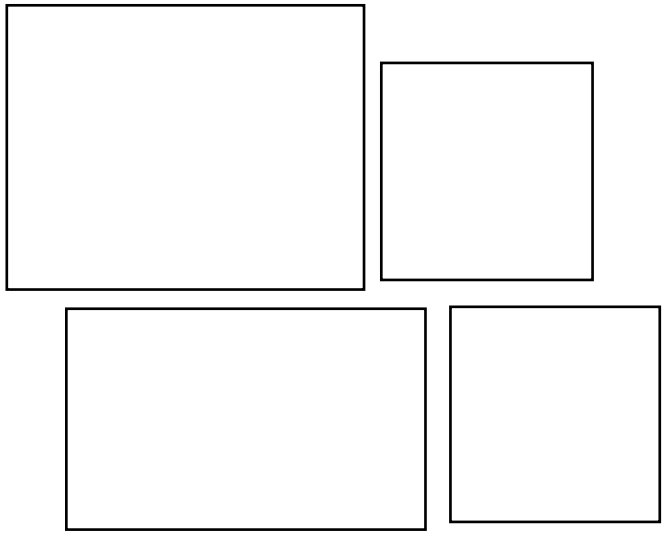
Overlap Structure



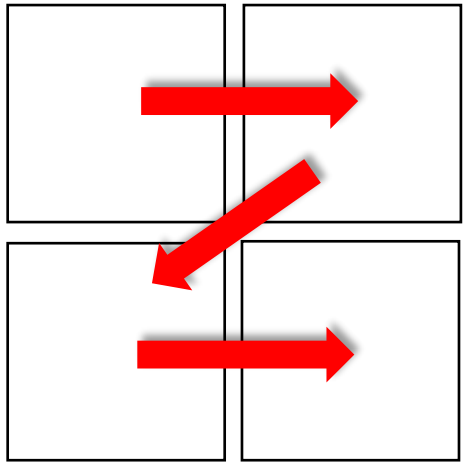
Horizontal Structure



Separated Structure



Staggered Structure



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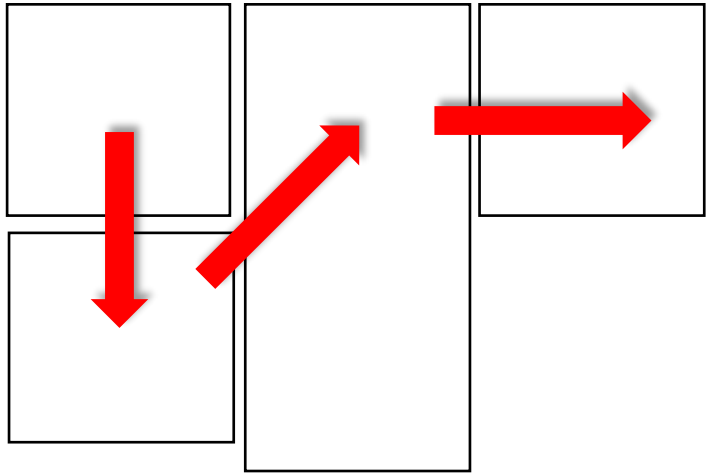

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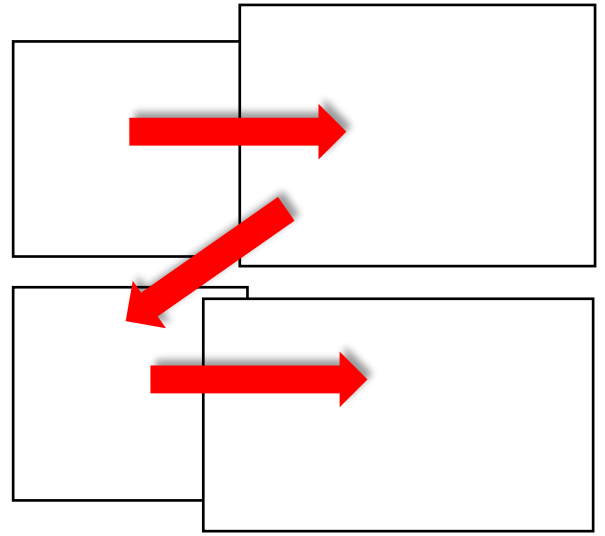

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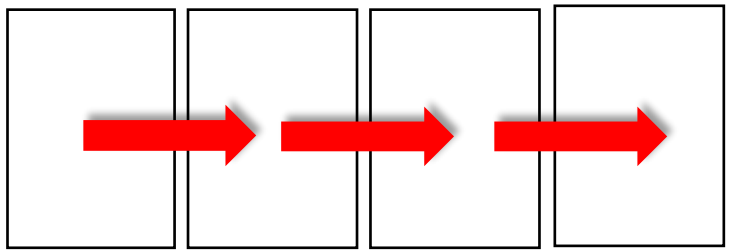
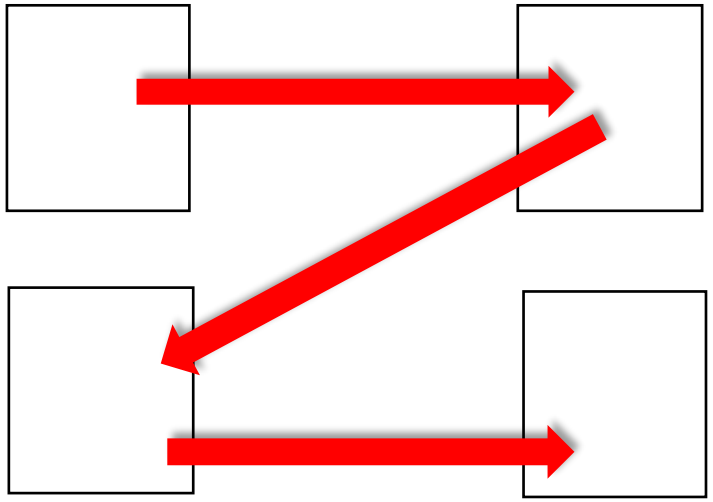


Horizontal Structure



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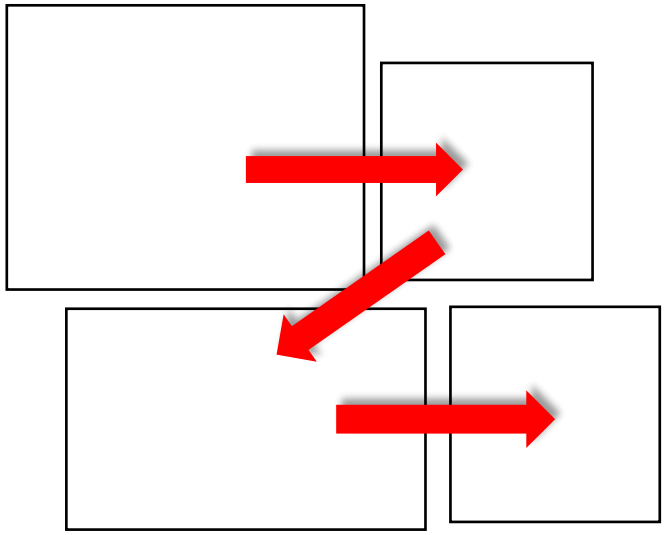

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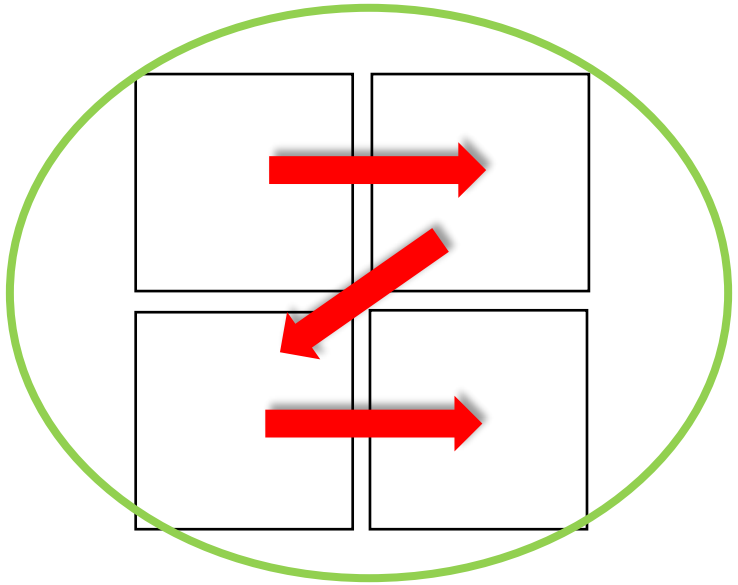

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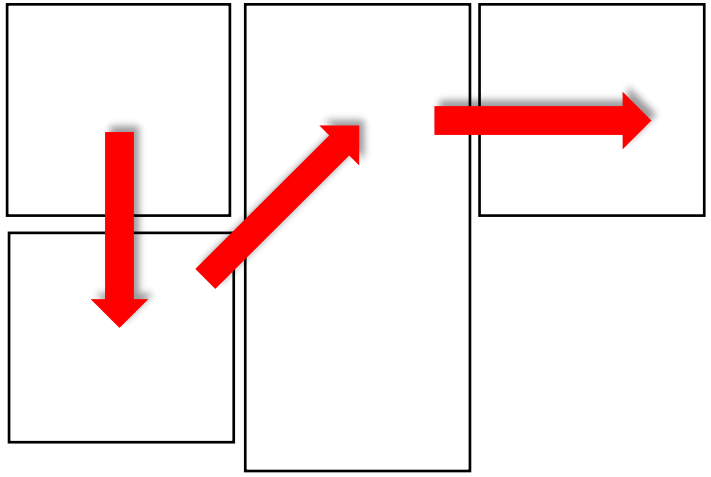

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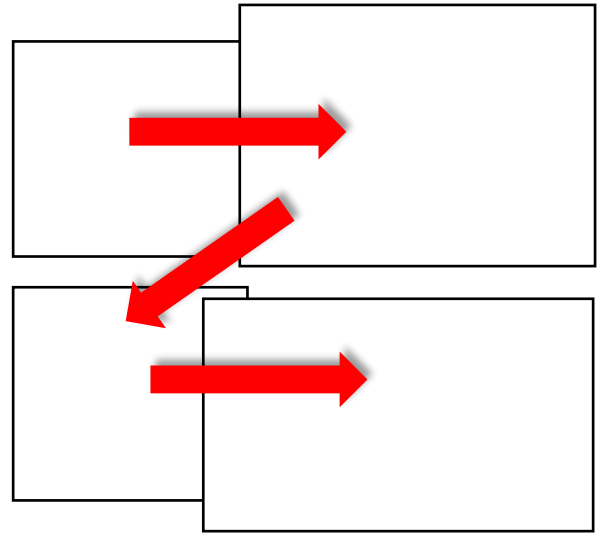
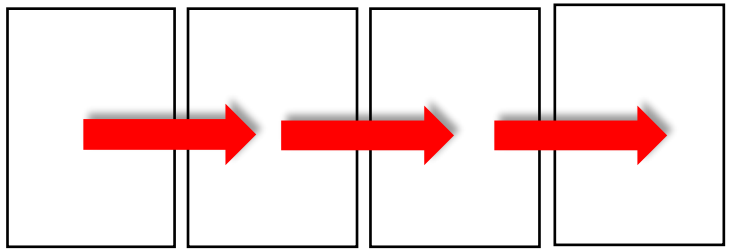


Overlap Structure



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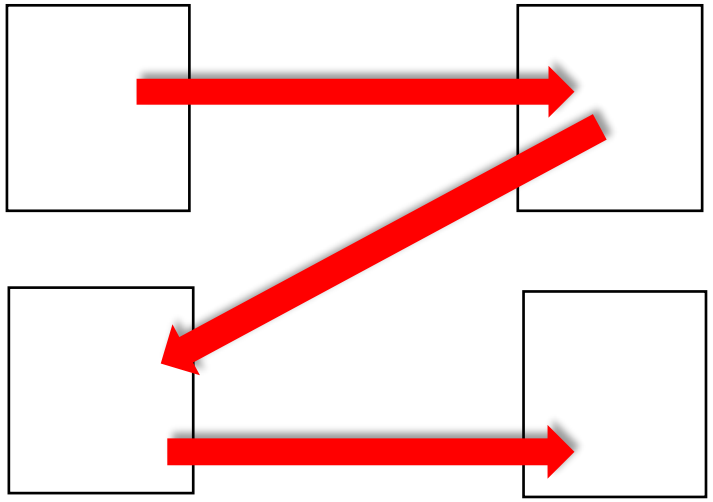

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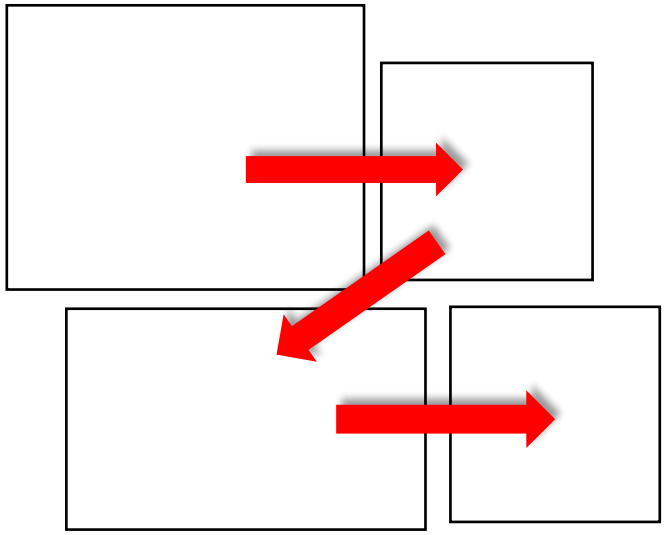

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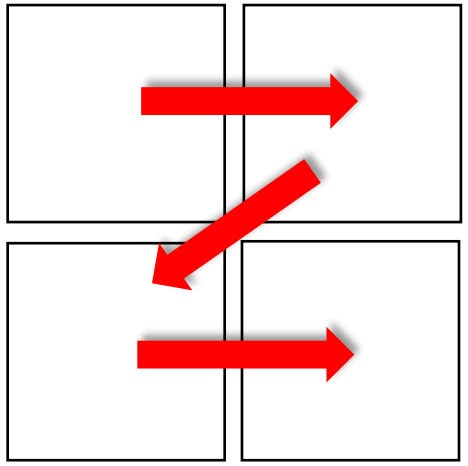

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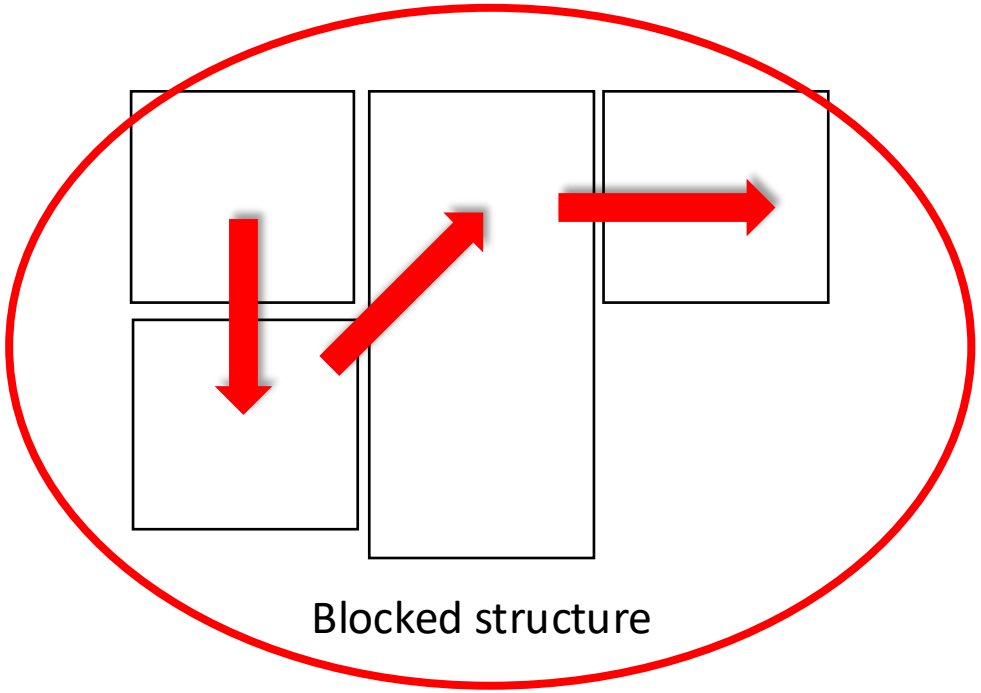

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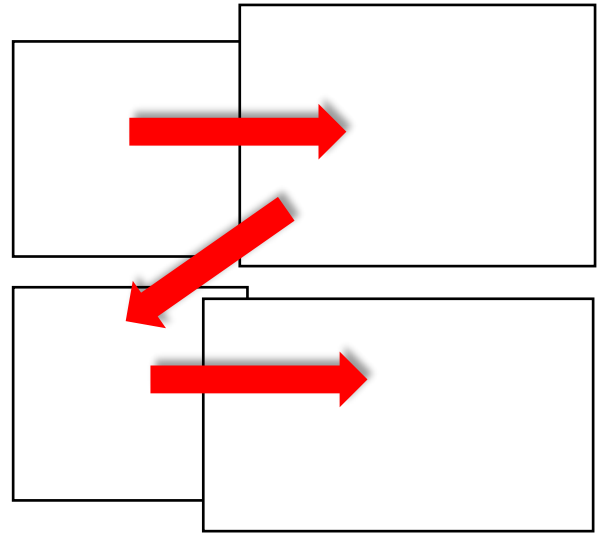

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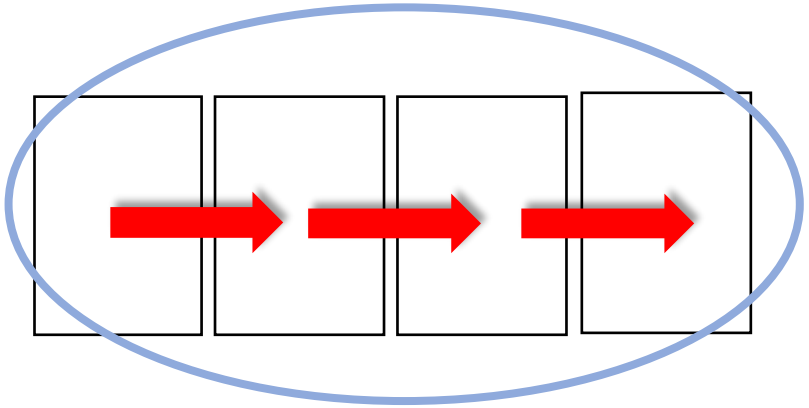
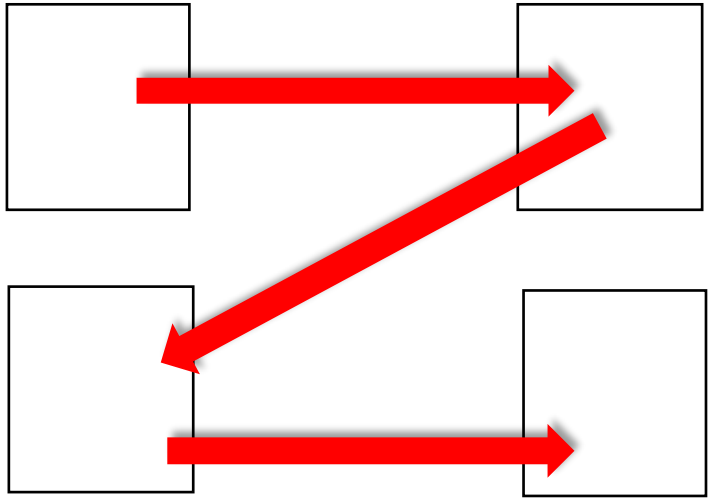


Horizontal Structure



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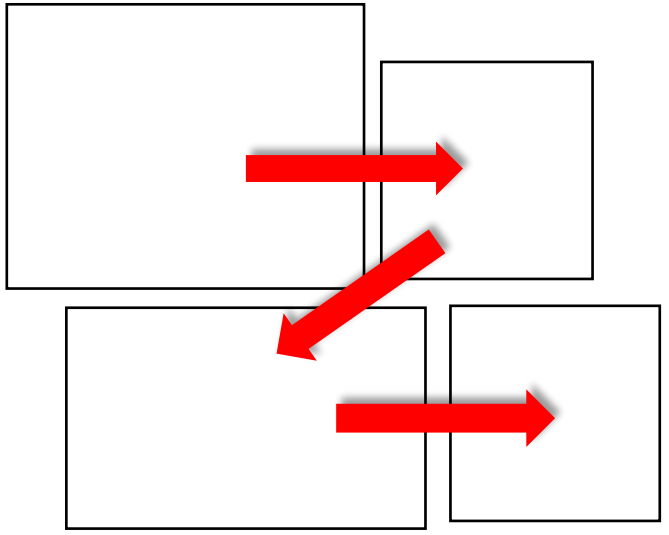
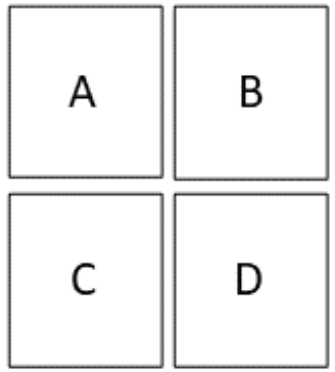
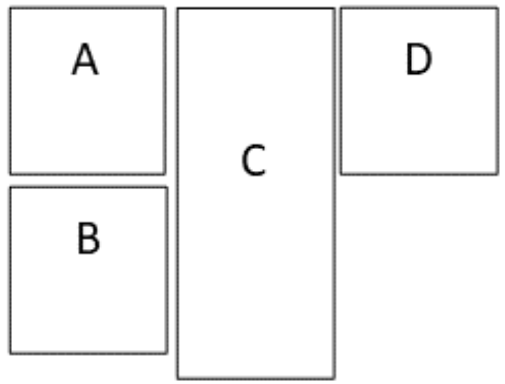


Staggered Structure



Grid Structure



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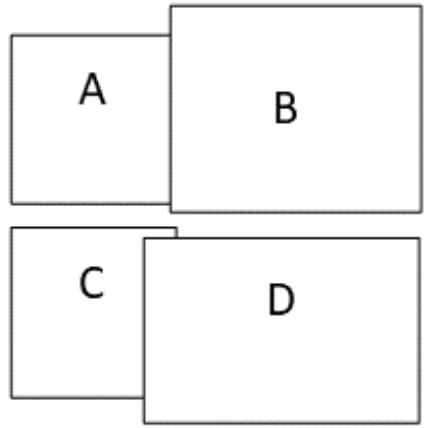
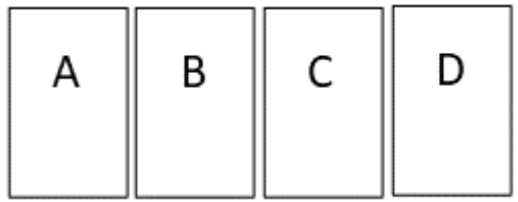
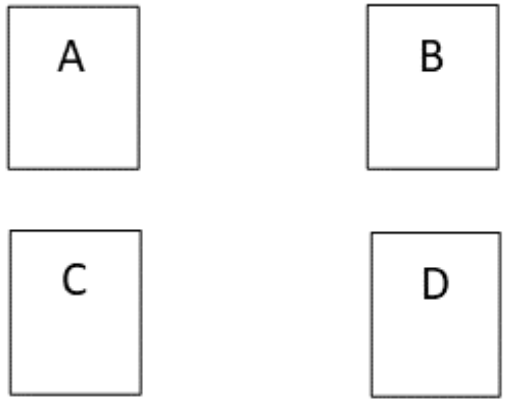


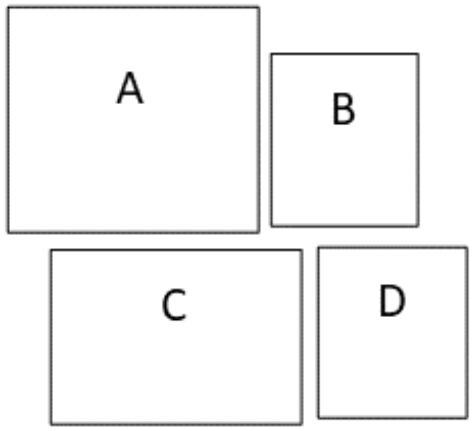
Overlap Structure



Horizontal Structure



Separated Structure



Staggered Structure

Methodology

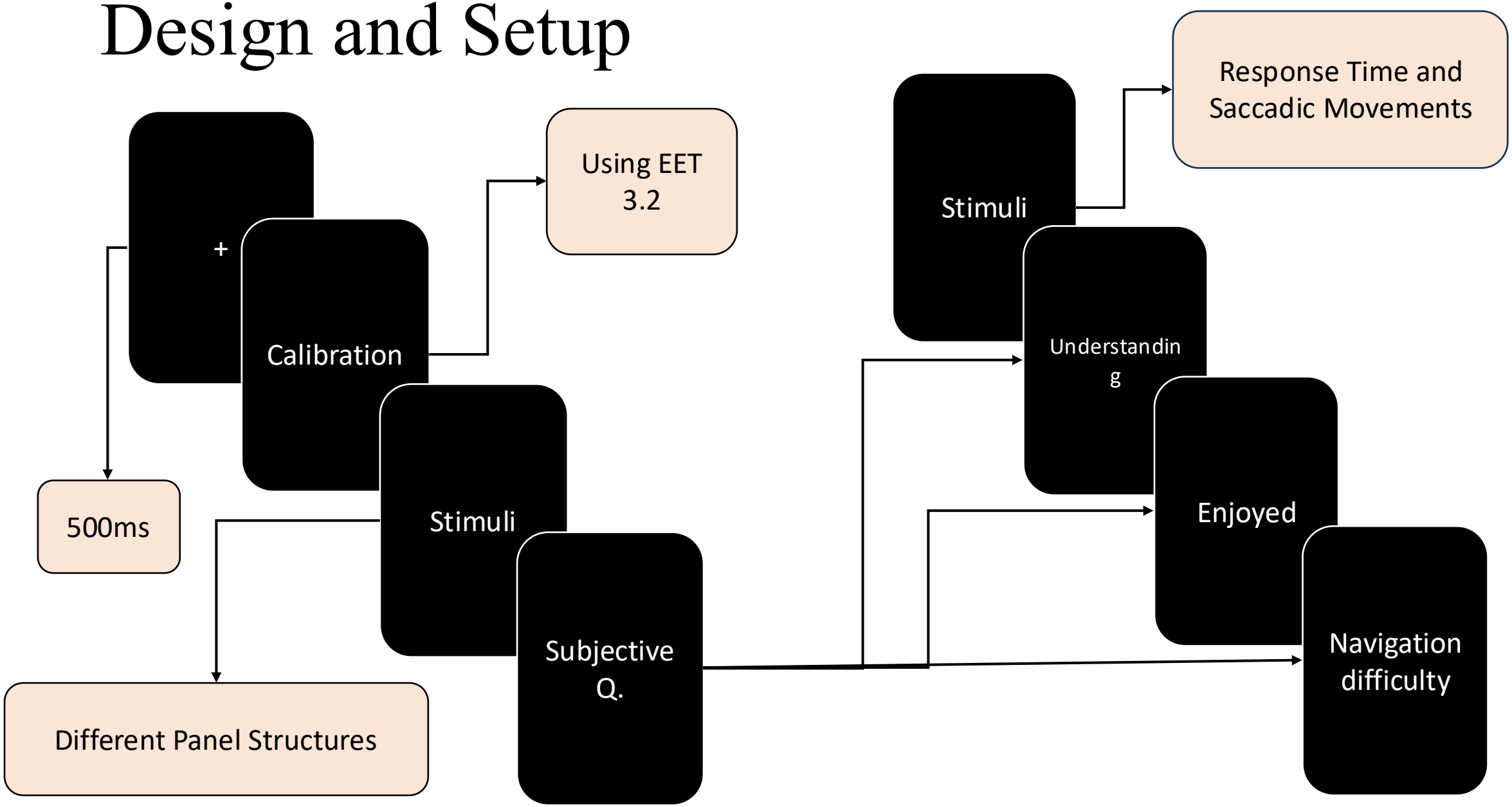
Participants

- 100 (77 male, 23 female) participants from IITG participated in the experiment.
- Age group: 18-35 (M=22, SD=2.4).
- All of them could read English, and were LTR readers.

Tools

- E-Prime 3.0
- Tobii Pro Fusion 250 Hz
- Tobii Pro Lab
- E-prime Extension for Tobii Pro 3.2
- MATLAB

Design and Setup



Response Times

Statistical Analysis

We fitted a Gamma Generalized Linear Mixed Model with the panel categories as fixed factors, the response times as dependent variables, and the participants as random variables. We used the 'Grid' structure as the intercept. We used the following model:

$$Yij \mid bi \sim Gamma(\mu ij, \phi)$$

Where, Yij is the response time for subject i on trial j.

$\mu ij = E[Yij \mid bi] > 0$ *and* ϕ = *dispersion/ shape parameterization.*

We modelled the linear predictor with fixed effects and random intercept:

$\log(\mu ij) = \beta 0 + \beta H1Horizontalij + \beta O1Overlapij + \beta B1Blockedij + \beta Sep1Separatedij + \beta St1Staggeredij + bi, bi \sim N(0, \sigma b2)$ = random effects.

Since we used a log link, we exponentiated coefficient to get multiplicative effects on the mean. We computed Incidence Rate Ratio (IRR) to determine effect size of our results:

$IRRk = \exp(\beta k)$, multiplicative change in μ for category k vs Grid.

Results: Response Times

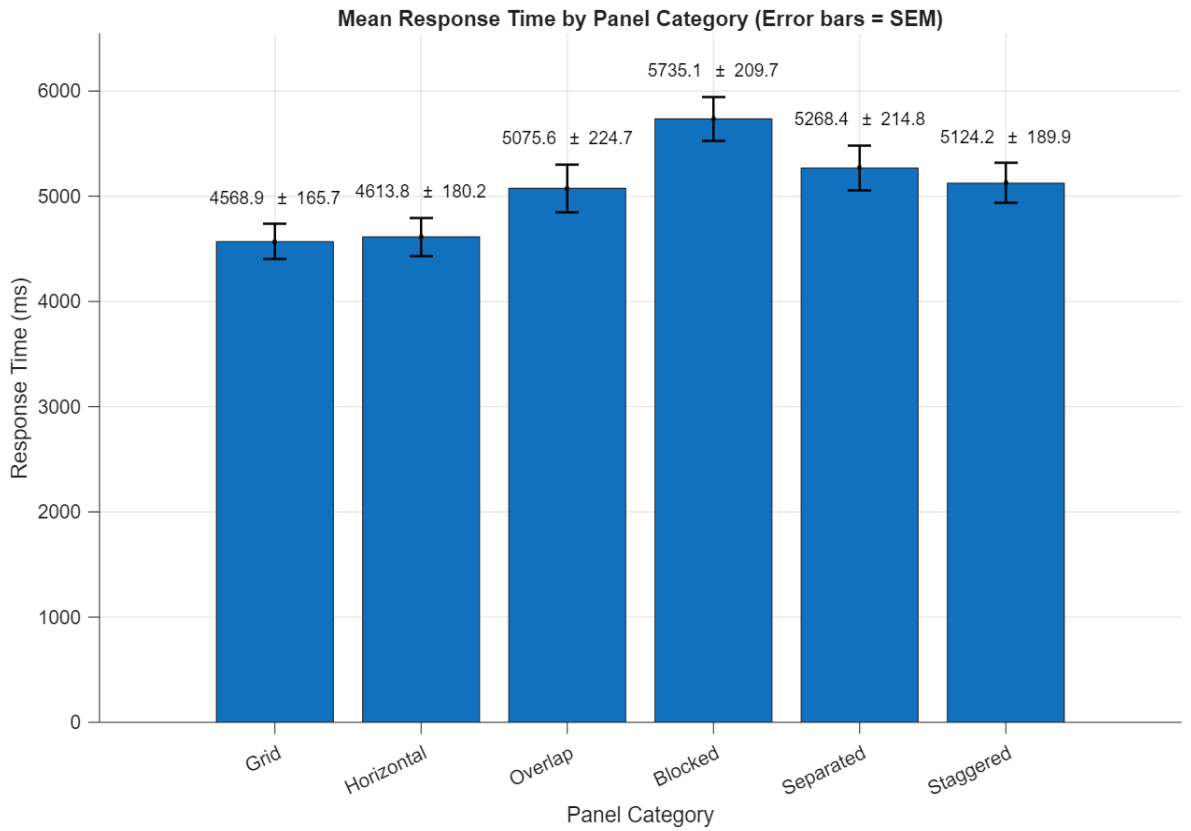
Term	Estimate (β)	SE	t	df	p	95% CI for β	IRR = exp(β)	95% CI for IRR
(Intercept) = Grid	2.0891	0.0064	327.01	3522	<0.001	[2.0766, 2.1017]	8.0776	[7.9773, 8.1801]
Horizontal vs Grid	0.0012	0.0058	0.20	3522	0.840	[-0.0102, 0.0125]	1.0012	[0.9899, 1.0126]
Overlap vs Grid	0.0041	0.0058	0.72	3522	0.473	[-0.0072, 0.0155]	1.0041	[0.9928, 1.0156]
Blocked vs Grid	0.0243	0.0058	4.21	3522	**<0.001**	[0.0130, 0.0356]	1.0246	[1.0131, 1.0363]
Separated vs Grid	0.0151	0.0058	2.62	3522	**0.008**	[0.0038, 0.0265]	1.0153	[1.0038, 1.0268]
Staggered vs Grid	0.0125	0.0058	2.16	3522	**0.03**	[0.0011, 0.0238]	1.0125	[1.0011, 1.0241]

Term (vs Grid)	IRR = exp(β)	% change vs Grid
Horizontal	1.0012	+0.12%
Overlap	1.0041	+0.41%
Blocked	1.0246	+2.46%
Separated	1.0153	+1.53%
Staggered	1.0125	+1.25%

Post-hoc

Group1	Group2	Diff_eta	SE	t	p_raw	p_Holm	Ratio	95% CI (Ratio)
Grid	Horizontal	-0.0011633	0.0057757	-0.2014	0.840	1.000	0.99884	[0.98759, 1.0102]
Grid	Overlap	-0.0041406	0.0057757	-0.7169	0.473	1.000	0.99587	[0.98466, 1.0072]
Grid	Blocked	-0.0242990	0.0057757	-4.2071	<0.001	<0.001	0.97599	[0.96501, 0.98711]
Grid	Separated	-0.0151460	0.0057757	-2.6224	0.008	0.105	0.98497	[0.97388, 0.99618]
Grid	Staggered	-0.0124690	0.0057757	-2.1588	0.030	0.309	0.98761	[0.97649, 0.99885]
Horizontal	Overlap	-0.0029773	0.0057757	-0.5155	0.606	1.000	0.99703	[0.98580, 1.0084]
Horizontal	Blocked	-0.0231360	0.0057757	-4.0057	<0.001	<0.001	0.97713	[0.96613, 0.98825]
Horizontal	Separated	-0.0139830	0.0057757	-2.4210	0.015	0.170	0.98611	[0.97501, 0.99734]
Horizontal	Staggered	-0.0113050	0.0057757	-1.9574	0.050	0.403	0.98876	[0.97763, 1.0000]
Overlap	Blocked	-0.0201580	0.0057757	-3.4902	<0.001	0.006	0.98004	[0.96901, 0.99120]
Overlap	Separated	-0.0110060	0.0057757	-1.9055	0.056	0.403	0.98905	[0.97792, 1.0003]
Overlap	Staggered	-0.0083280	0.0057757	-1.4419	0.149	0.747	0.99171	[0.98054, 1.0030]
Blocked	Separated	0.0091526	0.0057757	1.5847	0.113	0.678	1.00920	[0.99783, 1.0207]
Blocked	Staggered	0.0118300	0.0057757	2.0483	0.040	0.365	1.01190	[1.00050, 1.0234]
Separated	Staggered	0.0026779	0.0057757	0.4636	0.642	1.000	1.00270	[0.99139, 1.0141]

PanelCategory	N	Mean_RT	SD_RT	SEM_RT
Grid	588	4568.9	4018.6	165.72
Horizontal	588	4613.8	4369.3	180.19
Overlap	588	5075.6	5449.0	224.71
Blocked	588	5735.1	5084.6	209.68
Separated	588	5268.4	5207.7	214.76
Staggered	588	5124.2	4605.4	189.92



Viewing Times

We modelled the linear predictor as:

$$\eta i = \beta 0 + \sum_{l=1}^{5} \beta \ell x i \ell$$

Where, $\beta 0$ refers to the intercept or the Grid layout structure in this case, $xi\ell \in 0,1$ refers to indicator variables (non-Grid), and every $\beta\ell$ is the effect of each layout relative to the intercept.

The distribution can be mathematically stated as:

$$Yi \sim Gamma(\mu i, \phi), g(\mu i) = \log(\mu i) = \eta i$$

$$\mu i = \exp(\eta i)$$

We further computed IRR through:

$$\frac{\mu(L = Grid)}{\mu(L = \ell)} = \exp(\beta \ell)$$

$\exp(\beta\ell)$ refers to the multiplicative change in the mean duration Vs Grid.

We further computed the percentage changes from Grid using:

$(\exp(\beta\ell) - 1) \times 100$

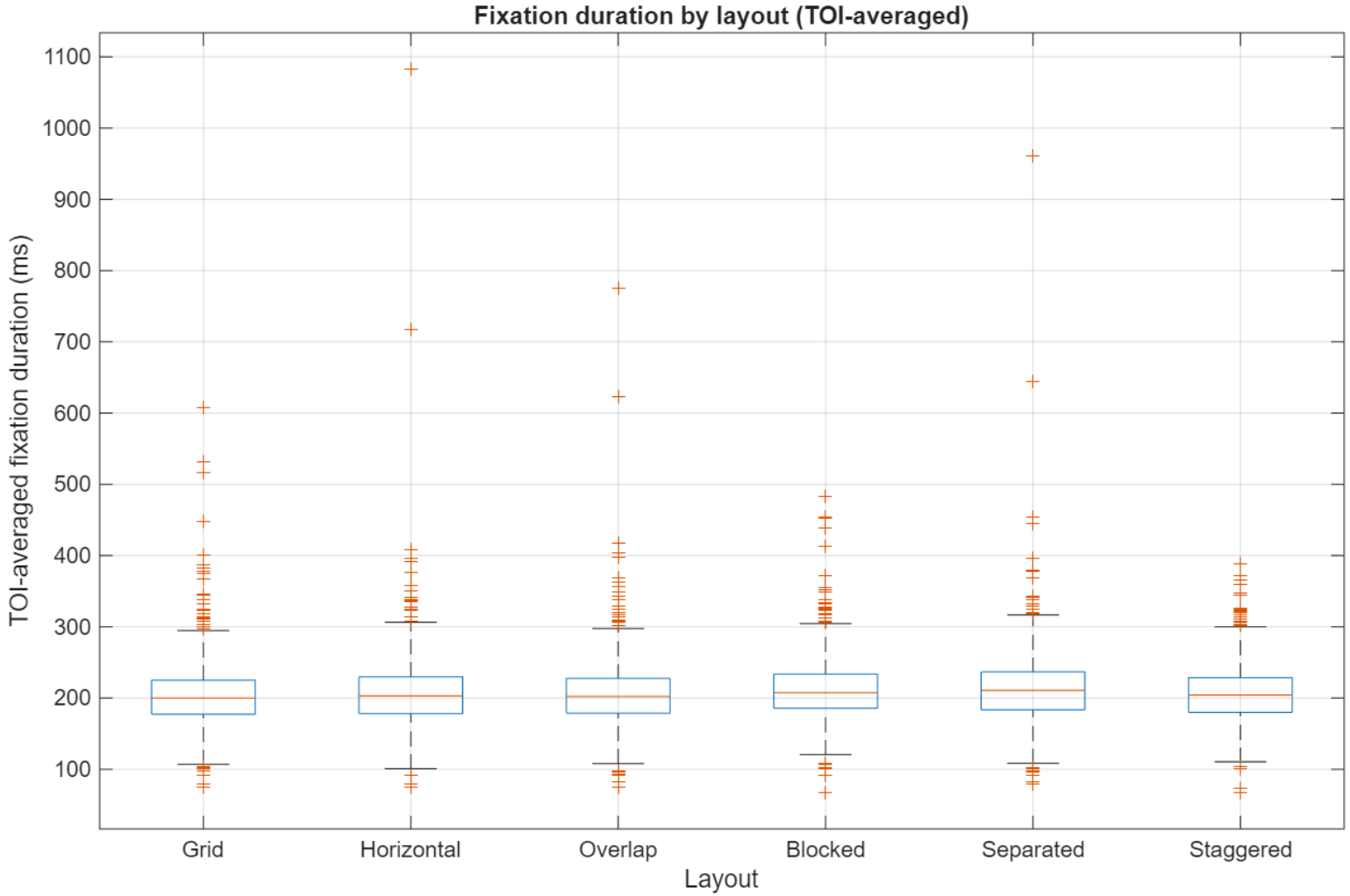
Results: Viewing Times

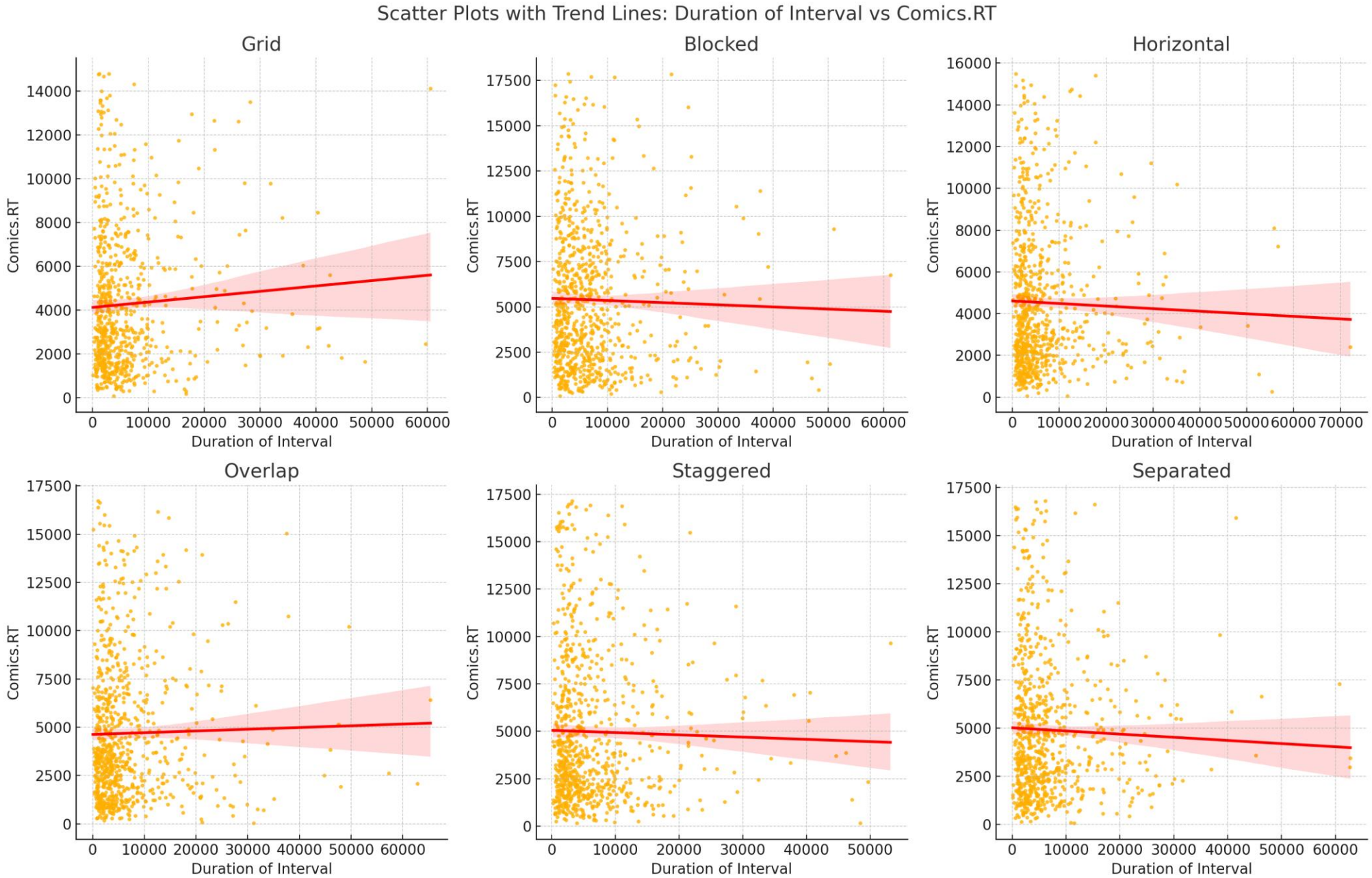
Term	β (log)	SE	z	p	IRR (ratio)	95% CI	% change (vs Grid)
Horizontal vs Grid	0.01553	0.01446	1.074	0.282	1.0156	[0.9873, 1.0448]	+1.56%
Overlap vs Grid	0.00902	0.01067	0.846	0.397	1.0091	[0.9882, 1.0304]	+0.9%
Blocked vs Grid	0.03636	0.00880	4.131	<0.001	1.0370	[1.0193, 1.0551]	+3.7%
Separated vs Grid	0.04509	0.01034	4.362	<0.001	1.0461	[1.0251, 1.0675]	+4.6%
Staggered vs Grid	0.00938	0.00944	0.993	0.320	1.0094	[0.9909, 1.0283]	+0.94%

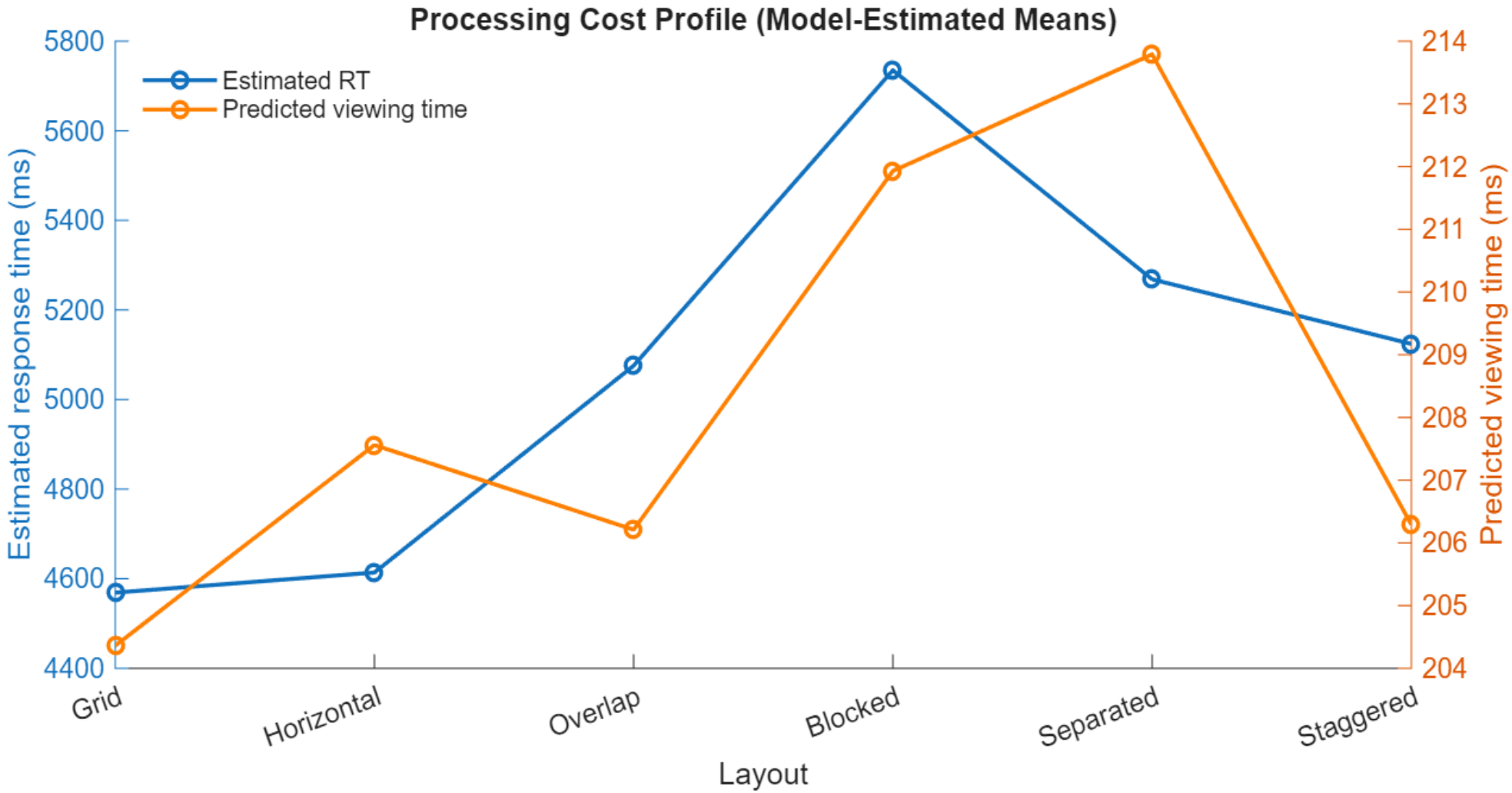
Layout	Predicted mean (ms)	95% CI
Grid	204.36	[198.29, 210.62]
Horizontal	207.56	[201.13, 214.20]
Overlap	206.21	[199.70, 212.95]
Blocked	211.93	[205.88, 218.16]
Separated	213.79	[207.33, 220.45]
Staggered	206.29	[200.81, 211.92]

Post-hoc

Contrast	Ratio	95% CI	p (raw)	p (Holm)
Grid vs Separated	0.955	[0.93, 0.97]	<0.001	<0.001
Grid vs Blocked	0.964	[0.94, 0.98]	<0.001	<0.001
Separated vs Staggered	1.036	[1.01, 1.05]	<0.001	0.001
Overlap vs Separated	0.964	[0.94, 0.98]	0.0005	0.006
Blocked vs Staggered	1.027	[1.01, 1.04]	0.001	0.011
Overlap vs Blocked	0.973	[0.95, 0.99]	0.014	0.146
Horizontal vs Separated	0.970	[0.94, 0.99]	0.020	0.183
Grid vs Horizontal	0.984	[0.95, 1.01]	0.282	1
Grid vs Overlap	0.991	[0.97, 1.01]	0.397	1
Grid vs Staggered	0.990	[0.97, 1.00]	0.320	1
Horizontal vs Overlap	1.006	[0.97, 1.03]	0.640	1
Horizontal vs Blocked	0.979	[0.95, 1.00]	0.132	1
Horizontal vs Staggered	1.006	[0.98, 1.02]	0.588	1
Overlap vs Staggered	0.999	[0.98, 1.01]	0.969	1
Blocked vs Separated	0.991	[0.97, 1.01]	0.417	1


Fixation duration by layout (TOI-averaged)
TOI-averaged fixation duration (ms)
1100
1000
900
800
700
600
500
400
300
200
100
Grid
Horizontal
Overlap
Blocked
Separated
Staggered
Layout


Scatter Plots with Trend Lines: Duration of Interval vs Comics.RT
Grid
Blocked
Horizontal
Overlap
Staggered
Separated
Comics.RT
Duration of Interval


Processing Cost Profile (Model-Estimated Means)
Estimated RT
Predicted viewing time
Estimated response time (ms)
Predicted viewing time (ms)
5800
5600
5400
5200
5000
4800
4600
4400
214
213
212
211
210
209
208
207
206
205
204
Grid
Horizontal
Overlap
Blocked
Separated
Staggered
Layout

Saccade Counts

Saccades were calculated as the gaze trail between two complete fixation points. For our analysis, we cleaned our dataset by taking only whole saccades. We recorded a total of 25,355 whole saccades.

We used a Poisson Model:

$$Yij \sim Poisson(\mu ij)$$

Where Yij is the number of whole saccades for each participant j on every trial or TOI i.

We used the following log link:

$$\log(\mu ij) = \eta ij$$

$$\eta ij = \beta 0 + \beta H1[Layoutij = Horizontal] + \beta O1[Layoutij = Overlap] + \beta B1[Layoutij = Blocked] + \beta S1[Layoutij = Separated] + \beta T1[Layoutij = Staggered$$

We modelled the intercept as:

$$\log(\mu ij \mid Grid) = \beta 0 + uj$$

And the random variables as:

$$uj \sim N(0, \sigma u2)$$

We further calculated Incidence Ratio rates to interpret real world significance by:

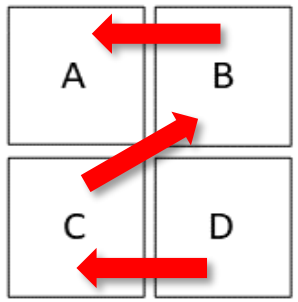
$$IRRk = \exp(\beta k)$$

Results: Saccade Counts

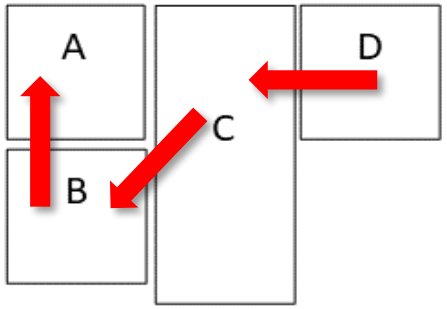
Term	β (log)	Robust SE	t	p	IRR	95% CI
Intercept (Grid)	2.912	0.049	58.355	<.001	18.403*	[16.688, 20.294]
Horizontal vs Grid	0.055	0.048	1.146	0.251	1.0569	[0.9615, 1.1618]
Overlap vs Grid	0.105	0.061	1.705	0.088	1.1110	[0.9844, 1.2538]
Blocked vs Grid	0.127	0.049	2.5896	0.009	1.1358	[1.0315, 1.2508]
Separated vs Grid	0.078	0.047	1.6635	0.096	1.0820	[0.9861, 1.1872]
Staggered vs Grid	0.032	0.056	0.5767	0.564	1.0328	[0.9254, 1.1527]

Layout	Predicted mean	95% CI	% change vs Grid
Grid	18.403	[16.688, 20.294]	0.00%
Horizontal	19.450	[17.761, 21.299]	+5.690%
Overlap	20.445	[18.254, 22.899]	+11.097%
Blocked	20.903	[19.198, 22.759]	+13.584%
Separated	19.911	[18.338, 21.619]	+8.196%
Staggered	19.007	[17.410, 20.751]	+3.283%

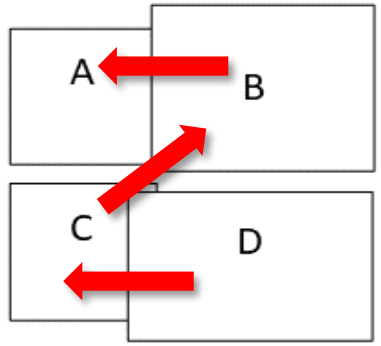
Saccadic Regressions



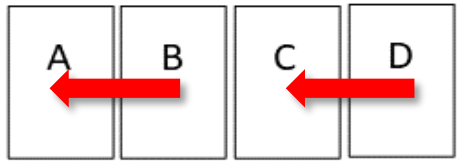
Grid Structure



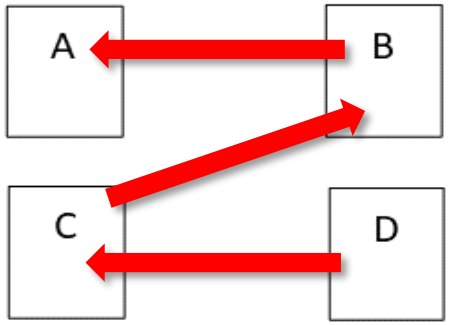
Blocked Structure



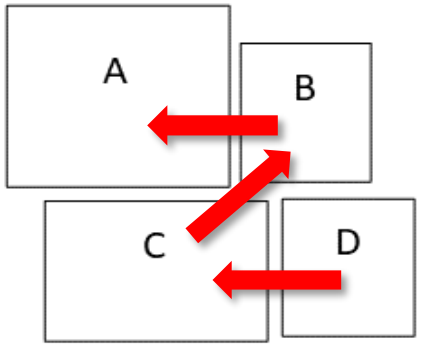
Overlap Structure



Horizontal Structure



Separated Structure



Staggered Structure

Results: Saccadic Regressions

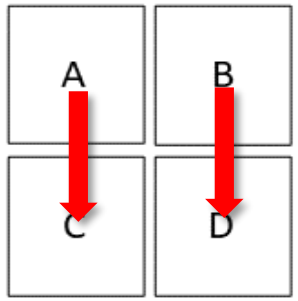
Term	β (logit)	Robust SE	t	p	OR	95% CI	% change in odds
Intercept (Grid)	-0.45386	0.03220	-14.10	<.001	0.6352*	[0.5963, 0.6765]	-36.48%*
Horizontal vs Grid	0.17389	0.03689	4.714	<0.001	1.1899	[1.1069, 1.2791]	+18.99%
Overlap vs Grid	0.16332	0.03329	4.905	<0.001	1.1774	[1.1030, 1.2568]	+17.74%
Blocked vs Grid	0.28305	0.03837	7.378	<0.001	1.3272	[1.2310, 1.4308]	+32.72%
Separated vs Grid	-0.01061	0.04287	-0.247	0.8046	0.9895	[0.9097, 1.0762]	-1.06%
Staggered vs Grid	-0.04179	0.03766	-1.110	0.2671	0.9591	[0.8908, 1.0325]	-4.09%

Layout	Predicted probability	95% CI
Grid	0.38844	[0.37356, 0.40353]
Horizontal	0.43046	[0.41882, 0.44218]
Overlap	0.42787	[0.41436, 0.44149]
Blocked	0.45740	[0.44815, 0.46668]
Separated	0.38593	[0.36995, 0.40215]
Staggered	0.37856	[0.36453, 0.39280]

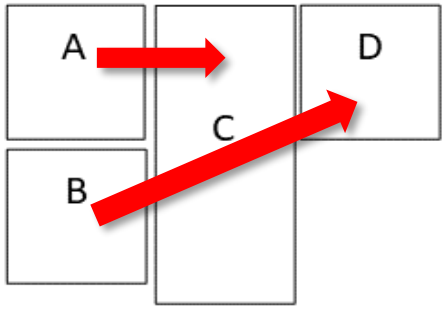
Post-hoc

Contrast	OR ratio	95% CI	p (raw)	p (Holm)
Blocked vs Staggered	1.3838	[1.2909, 1.4834]	<0.001	<0.001
Blocked vs Separated	1.3413	[1.2443, 1.4459]	<0.001	<0.001
Grid vs Blocked	0.75349	[0.69890, 0.81233]	<0.001	<0.001
Horizontal vs Staggered	1.2407	[1.1596, 1.3275]	<0.001	<0.001
Overlap vs Staggered	1.2277	[1.1484, 1.3124]	<0.001	<0.001
Grid vs Overlap	0.84932	[0.79566, 0.90659]	<0.001	<0.001
Overlap vs Separated	1.1900	[1.1100, 1.2757]	<0.001	<0.001
Grid vs Horizontal	0.84039	[0.78178, 0.90340]	<0.001	<0.001
Horizontal vs Separated	1.2026	[1.1079, 1.3055]	<0.001	<0.001
Overlap vs Blocked	0.88716	[0.83737, 0.93992]	<0.001	<0.001
Horizontal vs Blocked	0.89659	[0.84132, 0.95550]	<0.001	0.003
Grid vs Separated	1.0107	[0.92922, 1.0993]	0.8046	1
Grid vs Staggered	1.0427	[0.96849, 1.1225]	0.2671	1
Horizontal vs Overlap	1.0106	[0.94186, 1.0844]	0.7688	1
Separated vs Staggered	1.0317	[0.95033, 1.1200]	0.4568	1

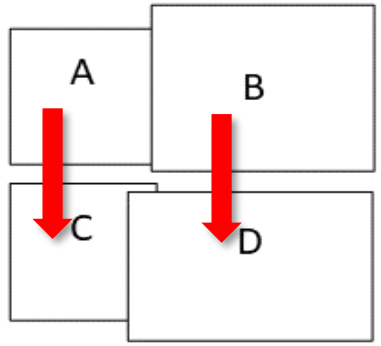
Panel Skips



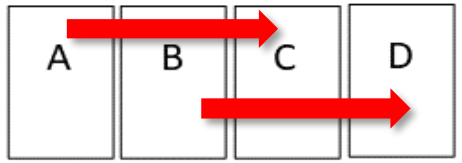
Grid Structure



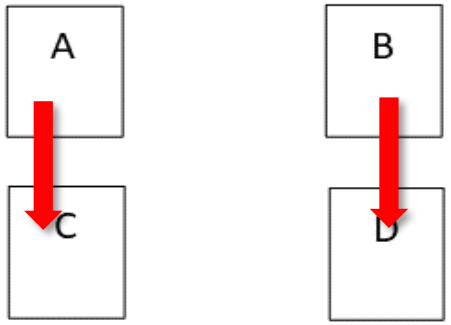
Blocked Structure



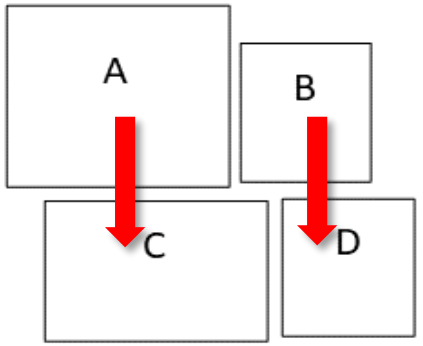
Overlap Structure



Horizontal Structure



Separated Structure



Staggered Structure

Rules of Skip Flagging

- We only considered it a skip if the panel next in the reading order was jumped and the reader went on to the next panel after that. We did not consider any other saccadic movements as a skip.

- In the prescribed order of A → B → C → D, if any eye movement has been made as A→C, or B→D, it was flagged as a panel skip.

- Only B and C can be skipped.

- Out of 25,355 whole saccades, we recorded 11,061 saccades as skips. Thus, we have 43.6% skips in saccadic movement.

Results: Panel Skips

Term	β (logit)	Robust SE	z	p	OR	95% CI
Intercept (Grid)	-0.79735	0.06393	-12.47	<.001	0.4505*	[0.3975, 0.5107]
Horizontal vs Grid	-1.1557	0.09666	-11.96	<.001	0.3149	[0.2605, 0.3805]
Overlap vs Grid	-0.02347	0.06227	-0.377	0.706	0.9768	[0.8646, 1.1036]
Blocked vs Grid	-0.31039	0.08793	-3.530	0.000415	0.7332	[0.6171, 0.8711]
Separated vs Grid	0.62869	0.06823	9.214	<.001	1.8752	[1.6404, 2.1435]
Staggered vs Grid	-0.02151	0.05786	-0.372	0.710	0.9787	[0.8738, 1.0962]

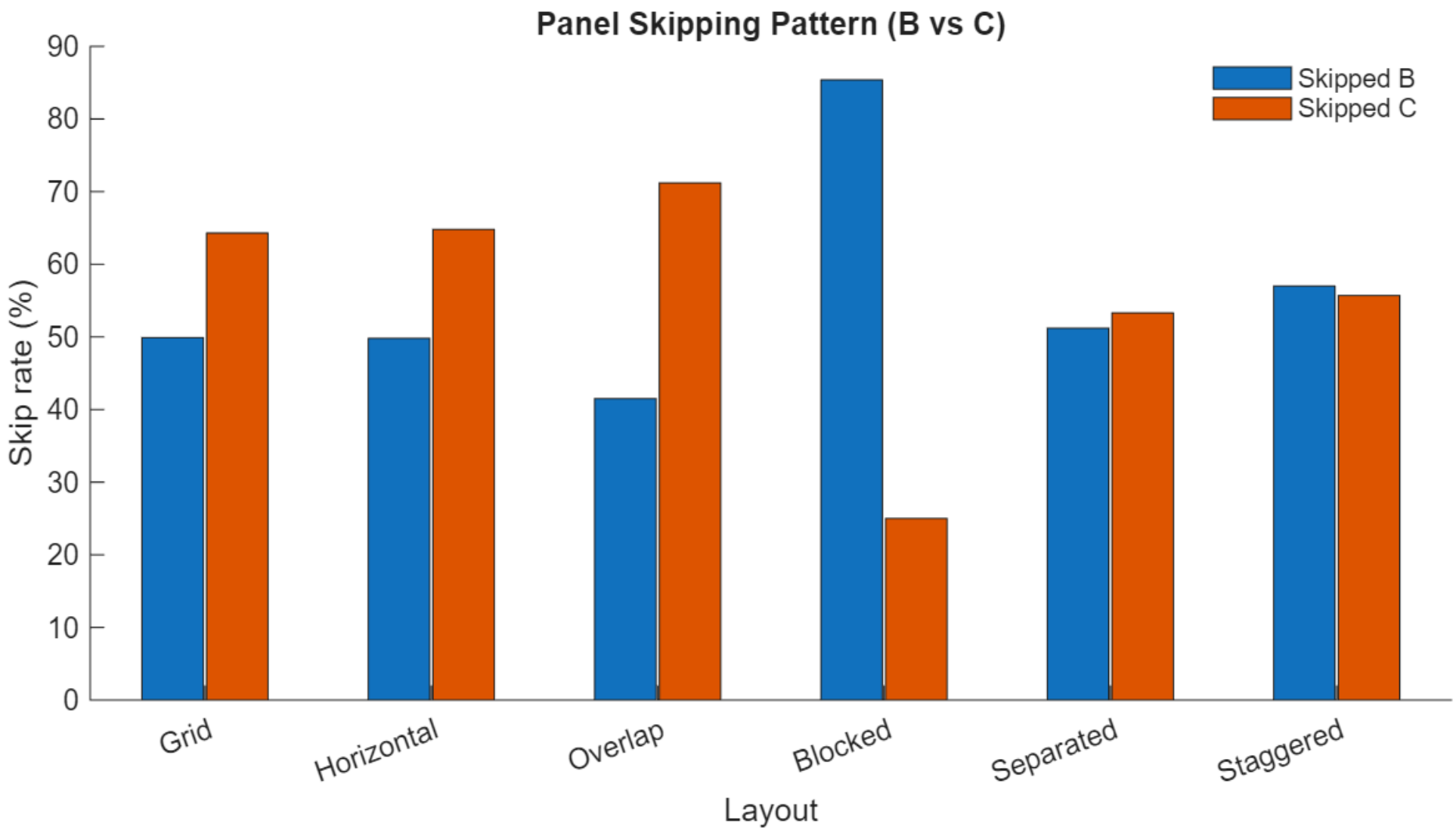
Layout	Predicted skip probability	95% CI
Grid	0.31059	[0.28442, 0.33804]
Horizontal	0.12423	[0.10883, 0.14145]
Overlap	0.30559	[0.27745, 0.33526]
Blocked	0.24829	[0.22760, 0.27021]
Separated	0.45794	[0.42386, 0.49241]
Staggered	0.30601	[0.28085, 0.33238]

Post hoc

Contrast	OR ratio	95% CI	p (raw)	p (Holm)
Grid vs Horizontal	3.1761	[2.6280, 3.8386]	<0.001	<0.001
Grid vs Separated	0.5333	[0.4665, 0.6096]	<0.001	<0.001
Horizontal vs Separated	0.1679	[0.1377, 0.2048]	<0.001	<0.001
Overlap vs Separated	0.5209	[0.4514, 0.6012]	<0.001	<0.001
Blocked vs Separated	0.3910	[0.3249, 0.4705]	<0.001	<0.001
Separated vs Staggered	1.9159	[1.6789, 2.1864]	<0.001	<0.001
Grid vs Blocked	1.3640	[1.1480, 1.6205]	<0.001	0.002
Overlap vs Blocked	1.3323	[1.1141, 1.5933]	0.001	0.006
Blocked vs Staggered	0.7491	[0.6329, 0.8866]	<0.001	0.003
Grid vs Overlap	1.0238	[0.9061, 1.1566]	0.706	1
Grid vs Staggered	1.0217	[0.9122, 1.1444]	0.710	1
Overlap vs Staggered	0.9980	[0.8813, 1.1303]	0.975	1

Layout	Total skip events	Skipped B (count)	Skipped C (count)	Skipped B (prop)	Skipped C (prop)
Grid	733	366	471	0.499	0.643
Horizontal	321	160	208	0.498	0.648
Overlap	749	311	533	0.415	0.712
Blocked	691	590	173	0.854	0.250
Separated	1007	516	537	0.512	0.533
Staggered	754	430	420	0.570	0.557

Layout	Skipped B (%)	Skipped C (%)
Grid	49.9%	64.3%
Horizontal	49.8%	64.8%
Overlap	41.5%	71.2%
Blocked	85.4%	25.0%
Separated	51.2%	53.3%
Staggered	57.0%	55.7%


Panel Skipping Pattern (B vs C)
Skipped B
Skipped C
Skip rate (%)
0
10
20
30
40
50
60
70
80
90
Grid
Horizontal
Overlap
Blocked
Separated
Staggered
Layout

Path Compliance

- We computed path compliance as saccadic movements that follow the prescribed reading order A → B → C → D.

- We have only taken those saccadic movements that followed through the entire order from A to D. Even if they included skips and regressions.

- The reading order always started at A and ended at D.

- Out of 5,150 recorded trials, 4,729 trials completed the entire trajectory. Therefore, 91.8% of completed trials followed the prescribed reading order of different panel layouts.

Term	β (logit)	Robust SE	z	p	OR	95% CI
Intercept (Grid)	-1.8566	0.1547	-12.00	<.001	0.156	[0.115, 0.212]
Horizontal vs Grid	0.8620	0.1431	6.025	<0.001	2.368	[1.789, 3.134]
Overlap vs Grid	0.2320	0.1378	1.684	0.092	1.261	[0.963, 1.652]
Blocked vs Grid	-0.1310	0.1736	-0.755	0.450	0.877	[0.624, 1.233]
Separated vs Grid	-0.5413	0.1925	-2.813	0.004	0.582	[0.399, 0.849]
Staggered vs Grid	-0.00146	0.1517	-0.0096	0.992	0.999	[0.742, 1.344]

Layout	OR (vs Grid)	OR 95% CI	Predicted accuracy (%)
Grid	1.0000	[1.0000, 1.0000]	13.51
Horizontal	2.3678	[1.7888, 3.1343]	27.00
Overlap	1.2611	[0.9627, 1.6521]	16.46
Blocked	0.8772	[0.6243, 1.2327]	12.05
Separated	0.5820	[0.3991, 0.8487]	8.33
Staggered	0.9985	[0.7417, 1.3444]	13.49

Post hoc

Contrast	OR ratio	95% CI	p (raw)	p (Holm)
Horizontal vs Separated	4.069	[2.956, 5.600]	<0.001	<0.001
Horizontal vs Blocked	2.699	[2.025, 3.598]	<0.001	<0.001
Horizontal vs Staggered	2.371	[1.795, 3.132]	<0.001	<0.001
Grid vs Horizontal	0.422	[0.319, 0.559]	<0.001	<0.001
Horizontal vs Overlap	1.878	[1.430, 2.465]	<0.001	<0.001
Overlap vs Separated	2.167	[1.543, 3.042]	<0.001	<0.001
Separated vs Staggered	0.583	[0.424, 0.800]	0.0008	0.007
Grid vs Separated	1.718	[1.178, 2.506]	0.004	0.039

Path Prediction

- We further decided to find out the trials that performed a more stricter route from the first AOI to the last across each layout.

- We took only those trials into consideration that have followed the viewing order A → B → C → D without skips or regression or any repair movement.

Term	Beta_logit	SE_robust	z	p	OR	OR_CI_low	OR_CI_high
(Intercept: Grid)	-0.5363	0.20909	-2.5649	0.010	0.58491	0.38824	0.88118
Horizontal vs Grid	-1.0951	0.29743	-3.6819	0.0002	0.33450	0.18673	0.59920
Overlap vs Grid	-0.099684	0.29809	-0.33441	0.738	0.90512	0.50462	1.62350
Blocked vs Grid	-0.98814	0.28370	-3.4830	0.0004	0.37227	0.21348	0.64915
Separated vs Grid	-0.74952	0.25911	-2.8926	0.003	0.47259	0.28440	0.78533
Staggered vs Grid	-0.093329	0.20530	-0.45459	0.649	0.91089	0.60913	1.36210

Layout	PredProb	CI_low	CI_high	PredProb_%	CI_low_%	CI_high_%
Grid	0.36905	0.27967	0.46842	36.905	27.967	46.842
Horizontal	0.16364	0.10714	0.24185	16.364	10.714	24.185
Overlap	0.34615	0.22973	0.48447	34.615	22.973	48.447
Blocked	0.17881	0.11854	0.26065	17.881	11.854	26.065
Separated	0.21656	0.14940	0.30315	21.656	14.940	30.315
Staggered	0.34759	0.27127	0.43264	34.759	27.127	43.264

Understandability, Enjoyability, Navigation Difficulty

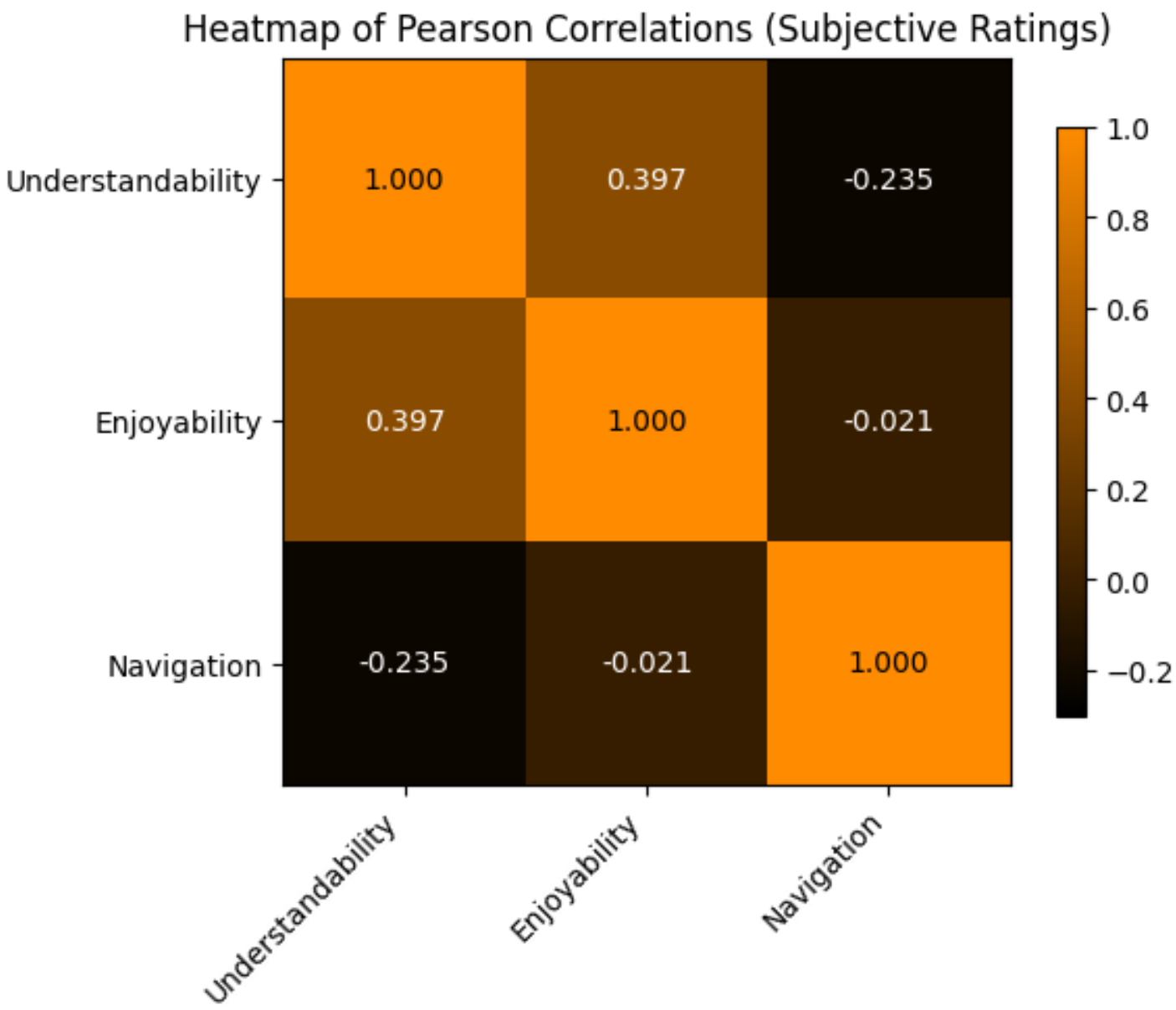
- Our experiment consisted of Likert scale ratings of each panel.
- The respondents were asked to three questions based on understandability, enjoyability, and navigation difficulty.
- Individual Likert ratings were obtained on a scale from 1 to 7.

Subjective Ratings Analysis

Pair	Pearson r	p	Spearman ρ	p	rmcorr r (within-subject)	p	df
understandability × enjoyability	0.397	<0.001	0.401	<0.001	0.362	<0.001	5140
understandability × navigation difficulty	−0.235	<0.001	−0.328	<0.001	−0.192	<0.001	5140
enjoyability × navigation difficulty	−0.021	0.126	−0.101	<0.001	−0.079	<0.001	5140

Measure	Grid	Horizontal	Overlap	Blocked	Separated	Staggered
Easily understand (lower=better)	1.70 ± 1.51	1.60 ± 1.42	1.86 ± 1.61	2.13 ± 1.76	1.97 ± 1.62	1.85 ± 1.55
Enjoyed (lower=better)	2.84 ± 2.09	2.66 ± 2.05	2.98 ± 2.11	3.11 ± 2.10	3.06 ± 2.11	3.00 ± 2.11
Navigation difficulty (higher=easier; 1=difficult, 7=easy)	5.28 ± 2.10	**5.46 ± 2.19**	**5.06 ± 2.09**	4.71 ± 2.21	4.66 ± 2.15	5.03 ± 2.09

Measure	Worded	Wordless	Onomatopoeic
Easily understand (lower=better)	1.98 ± 1.67	1.77 ± 1.53	1.80 ± 1.57
Enjoyed (lower=better)	2.87 ± 2.08	2.97 ± 2.09	2.98 ± 2.12
Navigation (higher=easier)	4.91 ± 2.16	5.09 ± 2.15	5.10 ± 2.16


Heatmap of Pearson Correlations (Subjective Ratings)
Understandability
Enjoyability
Navigation
1.000
0.397
-0.235
0.397
1.000
-0.021
-0.235
-0.021
1.000
Understandability
Enjoyability
Navigation
1.0
0.8
0.6
0.4
0.2
0.0
−0.2

Background Data: Viewing Times

Predictor	Coefficient (β)	SE	t	p
Intercept (AGE model)	7656.2	2938.6	2.605	0.0092
AGE (slope)	−40.944	130.92	−0.313	0.7545
Intercept (EXPOSURE model)	6781.2	600.9	11.285	<0.001
EXPOSURE_TO_COMICS = Yes	−36.701	384.46	−0.095	0.9240
Intercept (MODE model)	6530.8	661.73	9.869	<0.001
MODE_OF_READING = Digital comics	310.74	565.64	0.549	0.5828
MODE_OF_READING = I don't read comics	88.041	575.08	0.153	0.8783
MODE_OF_READING = Paperback	807.63	773.98	1.044	0.2968

Background Data: Response Times

Predictor	Coefficient (β)	SE	t	p
Intercept (AGE model)	4915.2	0.0140	3.516×10^5	<0.001
AGE (slope)	-1.5904×10^{-9}	2.0576×10^{-9}	−0.773	0.4396
Intercept (EXPOSURE model)	4624.5	0.0167	2.766×10^5	<0.001
EXPOSURE_TO_COMICS = Yes	3.3456×10^{-13}	2.7040×10^{-9}	0.0001	0.9999
Intercept (MODE model)	4369.1	0.0106	4.110×10^5	<0.001
MODE_OF_READING = Digital comics	-1.5534×10^{-10}	3.8747×10^{-9}	−0.040	0.9680
MODE_OF_READING = I don't read comics	-1.4871×10^{-10}	3.8954×10^{-9}	−0.038	0.9696
MODE_OF_READING = Paperback	-1.7451×10^{-10}	5.2786×10^{-9}	−0.033	0.9736

Summary

- Our findings suggest that comics or visual narratives exploit a general cognitive mechanism in which the spatial organization provides a framework for temporal inference.

- This shows that the layout structure in visual narratives also carry information and cues which aid panel-to panel transitions, supporting ECS.

- However, this mechanism is also sensitive to layout cue disruptions.

Summary

- Our results also align with SPECT's distinction of front-end's information extraction and the back-end's information integration.

- When the external structure becomes non-predictable, the readers actively engage in extensive sampling and revisits, to maintain coherence in an evolving event model.

- Our work further illustrates that how the apparent 'processing costs' do not merely reflect noise or disruptions, but also structured compensatory strategies, which enable event reconstruction under fragmented information conditions.

Thank You!