

Discriminating News-Reading Behavior and Cognition Using Eye-Tracking Methodologies

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Summary

Informed design choices can lower the cognitive load required to detect, parse and prioritize available visual information, which in turn allows more cognitive resources to be available for in-depth processing, learning and storage.

This dissertation systematically studies news reading to suggest how to begin sequencing and testing news design.

Rationale

- We used to have newspapers, radio and television news with homogenous narrative structures.
- Now we have phones, tablets, laptops and gaming systems all capable of news delivery. Content scopes and frequencies are controlled by the reader.

Rationale

- Given more choices and more control, how do people find information?
- How can information be delivered to maximize cognition?
- What structures and scope optimize cognition and economics?

Literature Review

- Eye-tracking directly measures visual detection and information processing (Yarbus, 1967).
- Scanpath Theory (Noton & Stark, 1971).
- Feature Integration Theory (Treisman & Gelade, 1980).
- Schema Theory (Wicks & Drew, 1991).

Eye movements

- 50ms orienting response.
- 50ms to 300ms temporary hold and detect.
- ≥ 300 ms for a fixation and pass to visual processing and storage.
- < 50 ms for saccade, or shutdown twitch.

Visual attention

- Peripheral (parafoveal) scanning compiles temporary multidimensional mental array of components and attributes of objects in the visual field.
- Component and attribute ambiguity increases saccadic friction.
- Foveal vision allows for primary attention and isolated cognitive processing.

Scanpath Theory

- Readers scan and detect visual attributes.
- Then the reader selects and processes.
- Second selection is probabilistically chosen.
- Mental maps are generated associating objects in the visual field.
- Heuristics decrease time and cognitive effort for selections. More processing.

Feature Integration Theory

- Use color, size, positioning and distance as shortcuts to detect what information is available.
- Select the most salient information.
- Evoke prior experiences to process and assimilate this information.
- Elements grouped to form “conjunctions.”

Schema Theory

- Information is stored in an organizational structure abstracted from prior exposure.
- New information assimilated with existing.
- Data are stored relationally and linked with multiple associations.
- Semantic categories are bounded entities sharing criterial attributes.

Hypotheses

- H1: Visual elements, or structural types of news content, on a stimulus will not have equal probabilities of being fixed upon by the reader.

Hypotheses

- H2: Readers given prototype news pages that utilize smaller, discrete storytelling elements will perform better information recognition.

Hypotheses

- H3a: The frequency of elements fixated by a person will be greatest during initial exposure.
- H3b: The frequency of fixated elements will decrease as exposure time increases.

Research Questions

- RQ1: Will medium or story structure be more important in determining how people read the news?

Research Questions

- RQ2a: How does gender relate with reading patterns?
- RQ2b: How does age relate with reading patterns?
- RQ2c: How does education relate with reading patterns?
- RQ2d: How does self-reported media usage relate with reading patterns?

Methodology

- Content Analysis of news design elements.
- Sequential data of news reading.
- 200 participants from St. Petersburg, Fla.
- 3 (prototype) x 2 (media) quasi-experimental design.

Methodology

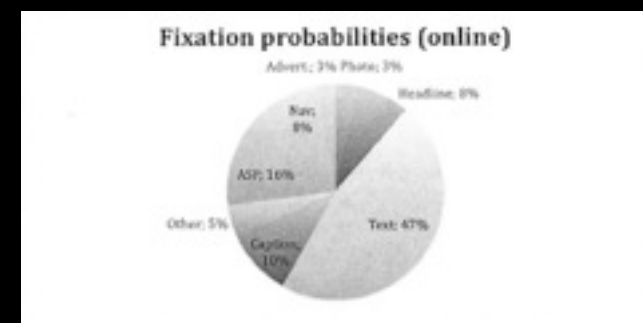
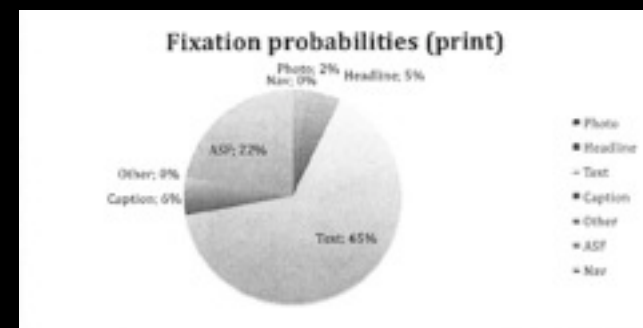
- Dependence-based contingency tables.
- Markov; first-order autoregressive process.
- Scanpaths are invertible and stationary.
- SDIS for state and event sequences.
- Transitional probabilities of B following A.

Results

- Stimulus manipulation check.
- Participant awareness same across all prototypes.
- Intercoder agreement Kappa 0.89.

H1 confirmed

- H1: Visual elements, or structural types of news content, on a stimulus will not have equal probabilities of being fixated upon by a reader.
- $\chi^2 = 3593$, $df = 35$, $p < 0.001$
- $G^2 = 4041$, $df = 35$, $p < 0.001$
- Different visual elements do not have equal probabilities of being fixated upon.



H2 confirmed

- H2: Readers given prototype news pages that utilize smaller, discrete storytelling elements will perform better information recognition.
- $y = \text{media} + \text{proto} + \text{media} * \text{proto} + \text{error}$
- proto effect sig. ($F = 7.39$, $df = 2$, $p = 0.001$)
- R Squared = 0.118, Adj. R Squared = 0.088
- proto means (0.432, 0.506, 0.552)
- Participants exposed to ASFs had better information recognition on average.

H3a, H3b confirmed

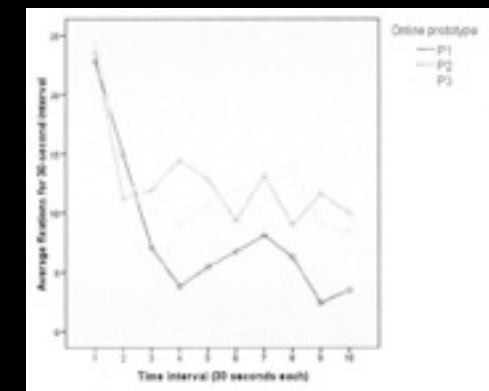
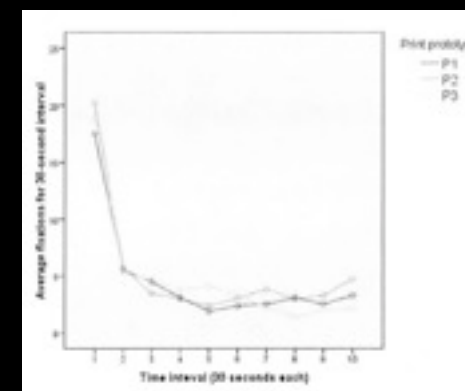
- H3: (a) The frequency of elements fixated by a person will be greatest during initial exposure. (b) the frequency of fixated elements will decrease as exposure time increases.
- First interval Normal; others Poisson.
- RMANOVA effect significant for fixation frequency between intervals ($F = 14.01$, $df = 7.55$, $p < 0.001$)
- Fixation frequencies are not same for each time interval throughout the exposure.

H3a, H3b confirmed

- The first and second intervals had a significant difference in means ($|\Delta u| = 11.70$, $s.e. = 0.97$, $p < 0.001$) as did the second and third intervals ($|\Delta u| = 2.54$, $s.e. = 0.81$, $p = .002$)

Estimates of average fixation frequencies over time

Interval	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	21.12	.80	19.55	22.70
2	9.43	.62	8.20	10.65
3	6.90	.66	5.59	8.19
4	6.16	.61	4.95	7.37
5	6.13	.52	5.10	7.16
6	6.16	.52	5.13	7.19
7	6.83	.63	5.59	8.07
8	6.22	.60	5.04	7.40
9	5.13	.58	4.00	6.27
10	5.28	.58	4.14	6.41



H4 support suggested

- H4: The variability of scanpaths between participants will increase as the visual complexity increases.
- Scanpaths couple now and next.

Print		Conditional probability for the next element					
Prototype	Start	Photo	Headline	Text	Caption	ASF	Nav.
1	Text	0.343	0.462	0.079	0.072	0	0.0151
	ASF	0	0	0	0	0	0
2	Text	0.232	0.536	0.065	0.061	0.068	0.038
	ASF	0.347	0.436	0.198	0.001	0	0.001
3	Text	0.174	0.563	0.024	0.038	0.202	0
	ASF	0.14	0.359	0.097	0.167	0.234	0.003
Overall	Text	0.258	0.516	0.059	0.059	0.079	0.03
	ASF	0.188	0.377	0.121	0.13	0.179	0.005

Online		Conditional probability for the next element							
Prototype	Start	Photo	Headline	Text	Caption	Other	Advert.	ASF	Nav.
1	Text	0.234	0.448	0.05	0.005	0.08	0.095	0	0.09
	ASF	0	0	0	0	0	0	0	0
2	Text	0.076	0.399	0.103	0.04	0.033	0.08	0.007	0.263
	ASF	0.037	0.418	0.003	0.211	0.177	0.074	0.044	0.037
3	Text	0.265	0.529	0.062	0.004	0	0.083	0.008	0.05
	ASF	0.127	0.39	0	0.195	0	0.11	0.068	0.11
Overall	Text	0.18	0.454	0.075	0.019	0.035	0.085	0.005	0.147
	ASF	0.062	0.41	0.002	0.206	0.127	0.084	0.05	0.058

H4 support suggested

- H4 cannot be statistically tested because of design confounds, but there appears to be initial support that the use of alternative story forms relate to more varied scanpaths.
- Future research could eliminate confounds.

Research questions

- Exploratory Poisson log linear models using demographics to predict fixation counts during first interval.
- $\text{count} = \text{media} + \text{proto} + \text{sex} + \text{ed} + i + e$
- $G^2 = 524.15$, $df = 135$, $\text{ratio} = 3.88$

RQ1: medium effect

- RQ1: Will medium or story structure be more important in determining how people read the news?
- Participants exposed to online prototypes, regardless of version, fixated on more visual elements during the first 30 seconds than those exposed to print prototypes ($B = 0.241$, $s.e. = 0.152$, $p = 0.113$)

RQ2a: sex effect

- RQ2a: How does sex relate with reading patterns?
- Men fixated on a significantly higher number of visual elements than women ($B = 0.463$, $s.e. = 0.143$, $p = 0.001$)
- Strongest predictor in the model.

RQ2b: education effect

- RQ2b: How does education relate with reading patterns?
- Participant education explained a significant amount of variance for fixation count ($G^2 = 28.2$, $df = 6$, $p < 0.001$)
- Participants with graduate degrees had highest fixation counts.
- Nonlinear.

RQ2c: local TV effect

- RQ2c: How does self-reported media usage relate with reading patterns?
- No clear meaning gleaned from aggregate media consumption.
- Individuals that never rely on local television news had the most fixations.
- Individuals that reported they always relied on local television news had the fewest number of fixations.

Discussion

- H1 confirms objects can be detected by peripheral and deprioritized for cognition.
- H2 confirms detectable design structures improve information recognition.
- H3 confirms readers detect, prioritize and then consume information.
- Dynamic stimuli require further detection.

Weaknesses

- Cross-media confounds.
- Huge contingency tables prevent comparisons on all unique elements.

Practical implications

- Readers detect what is available and then choose.
- Designers should use consistent visual cues and layout.
- Only change the visual field as requested by the user.
- Unrequested changes should be used sparingly and specifically to draw attention.

Practical implications

- Use appropriate story forms.
- Leverage reader experiences.
- Avoid design choices that make detection confusing.

Future Research

- Automated behavioral tracking of design variations within and between elements.
- Signal quality of audio and visual content.
- How, when and where of exposure.
- Algorithms to optimize design costs with outcomes like cognition and affect.

Questions?