




Intermittent Exotopia Requirements Engineering

Alessandra Luz (Lam)


My PhD dissertation goals

In 2020 I started reflecting on the possibilities of topics and focus that I would like my PhD to take and the following wishlist:

1. A useful contribution to society
2. Health focus
3. Buy-in from health practitioners relevant to the subject
4. A human-centred approach
 - Use HCI knowledge to improve processes/systems for all stakeholders
 - No intention to remove humans from the process but to aid them



Use the **power of design tools and techniques**, on off shelf devices already used by general population to improve health systems, processes and interactions between doctors, patients and caregivers.



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YAY!



I have an hour
booked for us to
meet. Let's chat!









**One
Eternity
Later**

Major Goal: Oculomotor Disease Diagnostics

- **Focus:** Intermittent Exotropia
- Partnership with the **University of Waterloo School of Optometry and Vision Science** (CO-PI + Practicing Optometrist)



Intermittent what?

- A sub-type of **strabismus**
- Eyes fail to work together and show misalignment, which can be extremely or barely visible
- We are focusing on Intermittent Exotropia (IXT)

Normal eyes



Esotropia



Exotropia



Hypertropia



Hypotropia



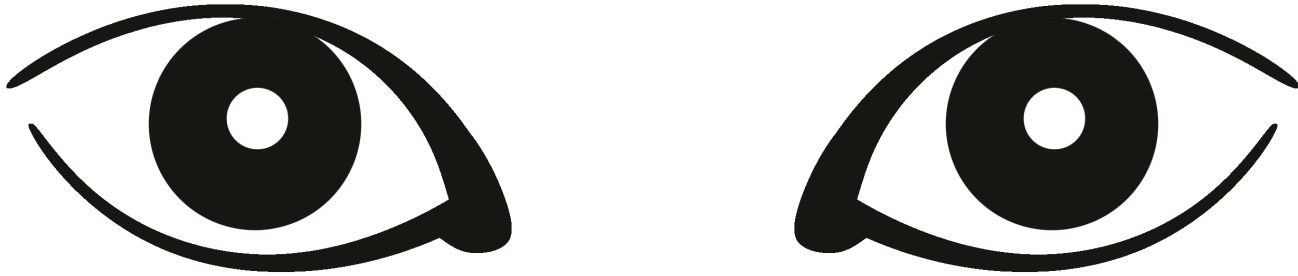
What is Intermittent Exotropia?

- The type of eye deviation, where one eye moves “outwards” and is mostly present when the person is fixating on an object at a distance;
- Also called: distance exotropia, divergence excess exotropia, periodic exotropia and exotropia of inattention, etc.



Source (2022)

What can happen when one's eye alignment fails?



- Double vision
- Lazy eye or Amblyopia
- Anomalous retinal correspondence

What are the consequences if left untreated?

- Academic difficulties¹
 - Reading difficulty
 - Other: Math, spelling, language, memory/attention, physical education
- Other issues¹
 - Pain: headaches, eye strain
 - Motor: stumbles, walks into walls, spills, poor catching
- Higher risk of mental health issues
- Lower score of health-related quality-of-life for both children with IXT and caregivers²

1. Reed et. al. 2004 2. Hatt et. al. 2010



Why is this work important?

- Diagnosing eye-related disorders is complex, especially with young children between the ages of 2 and 8
 - Expensive
 - Long wait
 - Out of reach
- Eye deviation observation depends on the following:
 - Exhaustion, sickness, boredom, overwhelmed
 - Personality - Is the child willing to collaborate? Eager to please?
- Long-term effects on the patient and caregivers can be disruptive to their health, opportunities and mental health

Goals and Purpose

- Trigger the eye deviation in toddlers/children
- Measure the eye deviation angle
- Become a useful tool for
 - Optometrists
 - Caregivers
 - Children with IXT
- Keep track of a child's eye deviation

My RE Problem

System: Diagnose IXT

Elicit child's eyes deviation

Specification 1

Specification 2

My RE Problem

System: Diagnose IXT

Elicit child's eyes deviation

Specification 1

Specification 2

IXT Requirements

R:

- (A) The child is not going to be interacting with any human being

AND

- (B) Their eyes are going to deviate naturally (with no use of chin rests or other optometry apparatus)

How to elicit IXT eye deviation?

- Eye movement depends on the cognitive state of the patient
- A visit to the Optometrist is counterproductive to the states of mind that allow the eye to misalign
- If observation is not possible, the diagnosis will be dependent on a parent reporting the observation

Cognitive States of Low Attention

- Exhaustion / Overwhelmed
- Daydreaming / Spaced Out
- Sleepy
- Sick

Stakeholders



Patient



Eye Doctor



Caregiver(s)

Stakeholders



Eye Doctor



Caregiver(s)



Patient

- ↑ Could use help to induce eye deviation naturally
- ↑ Will observe the eye movement and not rely on parental report
- ↓ Potential surveillance
- ↓ Opening space for tech to “take over their job”?
- ↓ ...

Stakeholders



Eye Doctor



Caregiver(s)



Patient

↑ Needs a reliable tool to check their child's eye

↑ ...

↓ ...

Stakeholders



Eye Doctor



Caregiver(s)



Patient

- ↑ Needs adults' help
- ↑ Conflicting expectations
- ↑ ...
- ↓ Electronic medical surveillance potential downsides
- ↓ ...

Two pillars to test the RE

- ITX Eye Movement "tool"
 - Design Technique
- Measurement of cognitive state and eye deviation
 - Eye tracking
 - Self Reported Measures



Juicy Design

- Non-functional feedback
- Improve user experience
- Rewarding/ exciting/ stimulating
- Excessive varied sensual positive feedback
- Arouse emotions through sensory stimuli:
 - Animation
 - Sound
 - Haptic



Useful Junk? The Effects of Visual Embellishment on Comprehension and Memorability of Charts - Bateman et. al., 2010

- Chart visual embellishments
 - Benefits
 - Issues
- Compared embellished graphs to basic graphs
 - Interpretation accuracy
 - Long-term recall
 - Eye-tracking

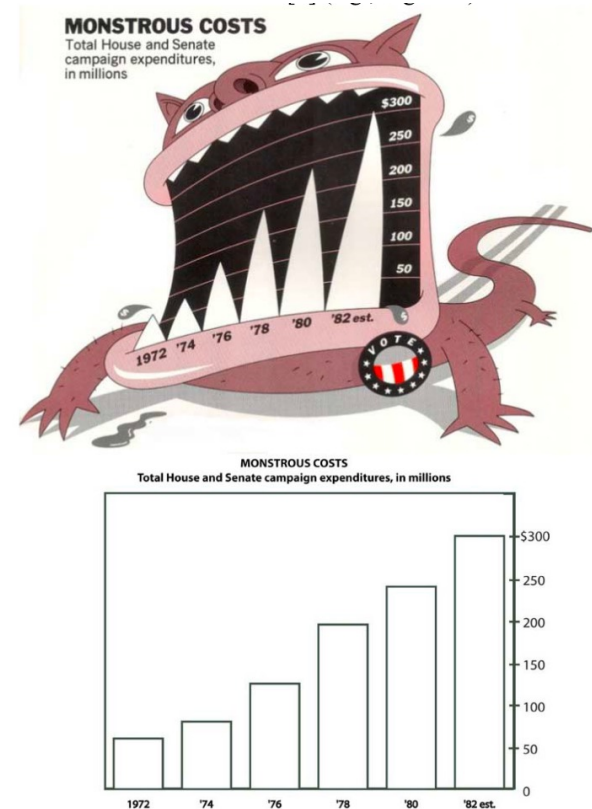


Figure 1. A chart by Holmes [7] (above), and a 'plain' version.

Bateman et. al., 2010

Results:

- Accuracy was similar
- Recalled embellished graphs better
- Juicy can have benefits beyond engagement and preferences

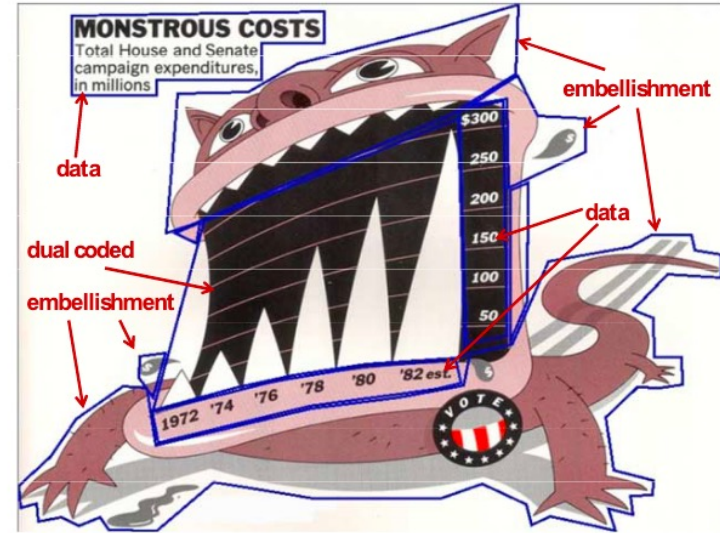


Figure 3. Area of interest analysis: gaze falling in any of the areas defined by the blue borders were labeled as data, embellishment, dual encoded, or other.

The Lens of Intrinsic Skill Atoms: A Method For Gameful Design – Deterding et. Al. 2015

- Code a design space in terms of meaningless versus meaningful choice
- A design guideline that is both generative and evaluative, and devised to be self-contained

“Varied, unexpectedly excessive sensual positive feedback on small user actions and achievements can instil a sense of competence even without a big challenge to overcome. Its unexpected variety also stokes curiosity.”
(Deterding, 2015, p. 313)

Types of Eye Movement and Uncovered Cognitive States

Liversedge et. al. 2000

Pupil size, blinks, and fixation



Detected fatigue, distraction,
attention levels, mind wandering

Lallé et. al. , 2016

Pupil dilation, blink rate



Predicted states of confusion
with 61% of accuracy

Task Methodologies - Studying Cognitive States

Listening to a
limerick with an
unexpected ending
(*Scheepers 2013*)

Creating **mental
pictures** of light and
dark places
(*Laeng 2014*)

Reading
(*Danckert 2018,*
Franklin 2013)

Watching targets
on a screen
(*Maffei 2018*)

Playing Video
Games
(*Chanel 2008,*
Giakoumis 2011)

Recap - Juiciness related works

- Focus on positive experiences
- To retain or enhance attention/engagement
- Tested limits of juiciness levels and its impact
- A higher level of juiciness: negatively impacted player's performance on the game, but positively impacted playtime, satisfaction, and intrinsic motivation
- Juicy graphs improved recall ability, showing juiciness can have benefits beyond preference/engagement

Pupil Size or Pupil Dilation

- Previously linked to attention, mind wandering and focus
- A relationship between pupil size and attention
- Pupil frequency changes:
 - linked **to attention allocation**
 - can **predict performance** on visual tasks
- Participants' answers were positively correlated with mean pupil size

(Kahneman 1973, Hartmann 2014, Naber 2013, Grandchamp 2014)

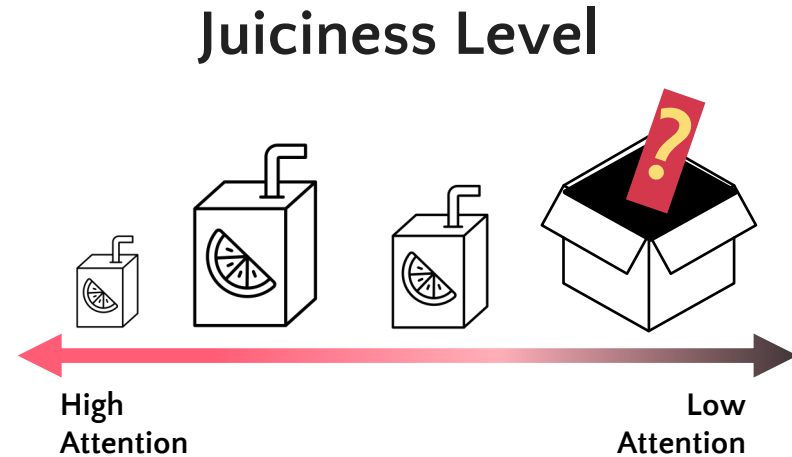
Cacioppo et. al.(2007) found pupil size variation as small as .1 mm yields statistically significant results.

“



Next steps: Empirical Validation

- Hypothesis: Using **Juicy Design**, I can create a **software** for IXT detection than if I use non-Juicy Design.
- Controlled experiment: Within-Design
- Participants: Children with and without IXT
- RE: Three levels of juicy design will be tested:
 - 🍷 None
 - 🍷 Low
 - 🍷 Extreme
- Measurements: Blinks, ITX eye deviation, self-reported cognitive states of mind



IXT Specifications

S:

- (X) An adult will provide a child with a screen playing a “*cartoon*” for them to watch

AND

- (B) The child watches the “*cartoon*”, and their eyes cross naturally as often as their body needs it.



Thank you!

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