Static and Moving Patterns

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Pattern learning

- People who work with visualizations must learn the skill of seeing patterns in data.
- In terms of making visualizations that contain easily identified patterns, one strategy is to rely on pattern-finding skills that are common to everyone.
- Good idea to use *priming* to enhance perceptual receptivity

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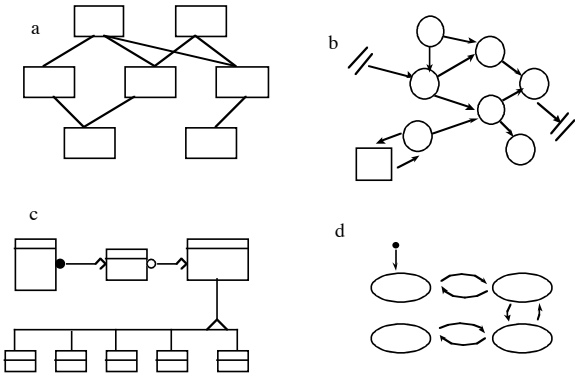
Patterns in Diagrams

- Patterns applied to node-link diagrams



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Node-link diagrams

- Most common way of showing relation
- Node == entity, object
  - Closed contour
- Link == relation
- Visual grammar has a perceptual basis for how it conveys meaning

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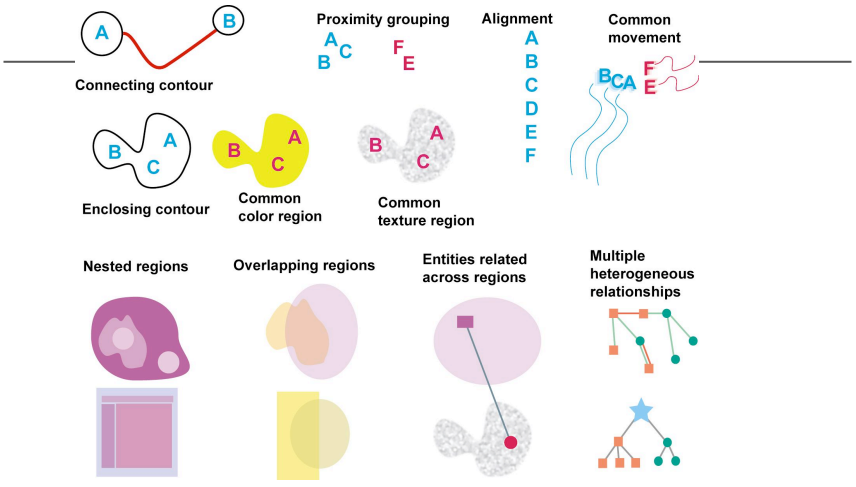
- Visual grammar for node-link diagrams
- Static patterns

Graphical Code	Visual Instantiation	Semantics
1. Closed contour.		Entity, object, node.
2. Shape of closed region.		Entity type.
3. Color of enclosed region.		Entity type.
4. Size of enclosed region.		Entity value. Larger = more.
5. Partitioning lines within enclosed region.		Entity partitions are created, e.g., TreeMaps.
6. Attached shapes.		Attached entities. Part-of relations.
7. Shapes enclosed by contour.		Contained entities.
8. Spatially ordered shapes.		A sequence.
9. Linking line.		Relationship between entities.
10. Linking-line quality.		Type of relationship between entities.
11. Linking-line thickness.		Strength of relationship between entities.
12. Tab connector.		A fit between components.
13. Proximity.		Groups of components.

Visual Grammar of diagrams



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Semantics of structure

Graphical Code		Semantics
Shapes connected by contour		Related entities, path between entities
Thickness of connecting contour		Strength of relationship
Color and texture of connecting contour		Type of relationship
Shapes enclosed by a contour, or a common texture, or a common color		Contained entities. Related entities
Nested regions, partitioned regions		Heirarchical concepts
Attached shapes		Parts of a conceptual structure

Grammar of maps

- Common features of geographic maps
  - Areas,
  - line features
  - point features

Maps

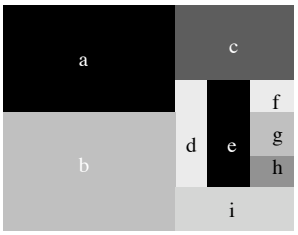
- Visual grammar of maps

Graphical Code	Visual Instantiation	Semantics
1. Closed contour.		Geographic region.
2. Colored region.		Geographic region.
3. Textured region.		Geographic region.
4. Line.		Linear map features such as rivers, roads, etc. Depends on scale.
5. Dot.		Point features such as town, building. Depends on scale.
6. Dot on line.		Point feature such as town on linear feature such as road.
7. Dot in closed contour.		Point feature such as town located within a geographic region.
8. Line crosses closed-contour region.		Linear feature such as river crossing geographic region.
9. Line exits closed-contour region.		A linear feature such as a river terminates in a geographic region.
10. Overlapping contour, colored regions, textured regions.		Overlapping geographically defined areas.

Treemaps and hierarchies

- Treemaps use areas (size)
- SP tree
- Graph Trees use connectivity (structure)

a



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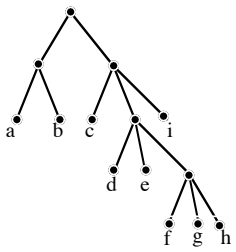

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Part II: Patterns in Motion

- How can we use motion as a display technique?
- Gestalt principle of common fate

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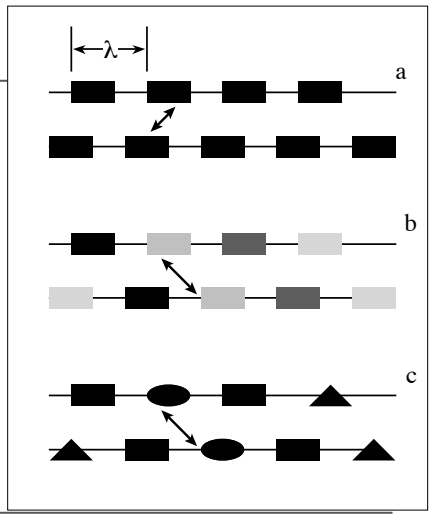
Limitation due to Frame Rate

- Can only show motions that are limited by the Frame Rate.
- Maximum displacement of λ/2 before perception of reversed direction
- λ is aperture size
- We can increase by using additional symbols.
- Limitation on throughput related to *correspondence problem*



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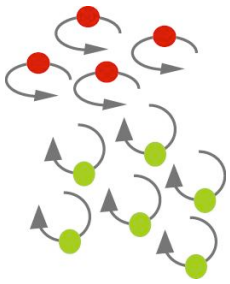
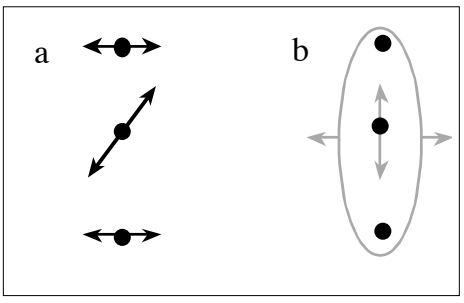
Motion as a visual attribute (Common fate)



correlation between points:

- frequency, phase or amplitude
- Result: phase is most noticeable (Ware)
- Shape is also a strong grouper (Bartram)

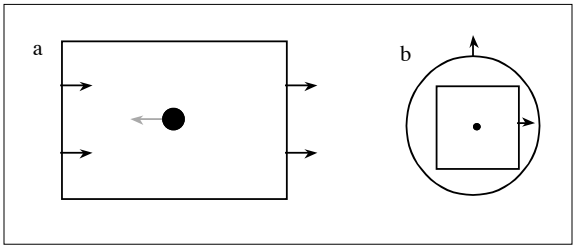
Motion is Highly Contextual



- Group moving objects in hierarchical fashion.

Frame as motion context

- The stationary Dot is perceived as moving in (a).
  - *Vection*
- The circle has no effect on this process in (b).



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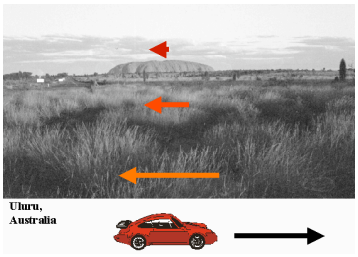
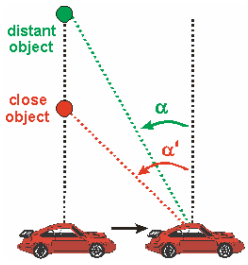
Motion parallax

- when you look out of the side window of a car or a train, you see close objects translating very fast (bushes) and distant objects passing very slow (mountains) or even being stationary (sun)
- *Motion parallax*: the inverse relation between angular speed and distance





Motion parallax

- Demo1: http://psych.hanover.edu/Krantz/MotionParallax/MotionParallax.html
- Demo 2 http://www.psypress.co.uk/mather/resources/swf/Demo10_2.swf

Patterns in motion

- We can also use motion as a display technique to represent data that is either static or dynamic.
- The perception of dynamic patterns is not understood as well as the perception of static patterns.
- But we are very sensitive to patterns in motion and, if we can learn to use motion effectively, it can be a good way to display certain aspects of data.

Which patterns are useful?

- Rich literature for design of static representations
- Motion perceptually powerful but no principled guidelines for use

- Features shown to be perceptually powerful are
  - Phase (Ware)
  - Direction, flicker, velocity (Healey)
  - Shape (Bartram)

- Experiments show motion-based techniques very effective - but there are caveats
  - distraction
  - false association

- Empirically based guidelines for appropriate use

Potential uses?

- *Signaling*: cognitive tools for managing attention
  - events (external dynamic information)
  - markers (navigation, history, guides)

- *Integration*:
  - linking heterogeneous, scattered elements (brushing)
  - filtering in context

- Current codes have limitations:
  - over-use and saturation
  - poor detection outside focal area (*acuity*)

Why Motion?

- Perceptually efficient
  - strongest cue across entire visual field
  - track multiple motions in parallel [Pylyshyn]

Why Motion?

- Perceptually efficient
- Interpretatively rich
  - Rich disciplines of expression and performance
  - Socially meaningful (Heider, Kassin)
  - motion conveys structure and behaviour [Johanssen,Heider,Cutting,Berry]

Why Motion?

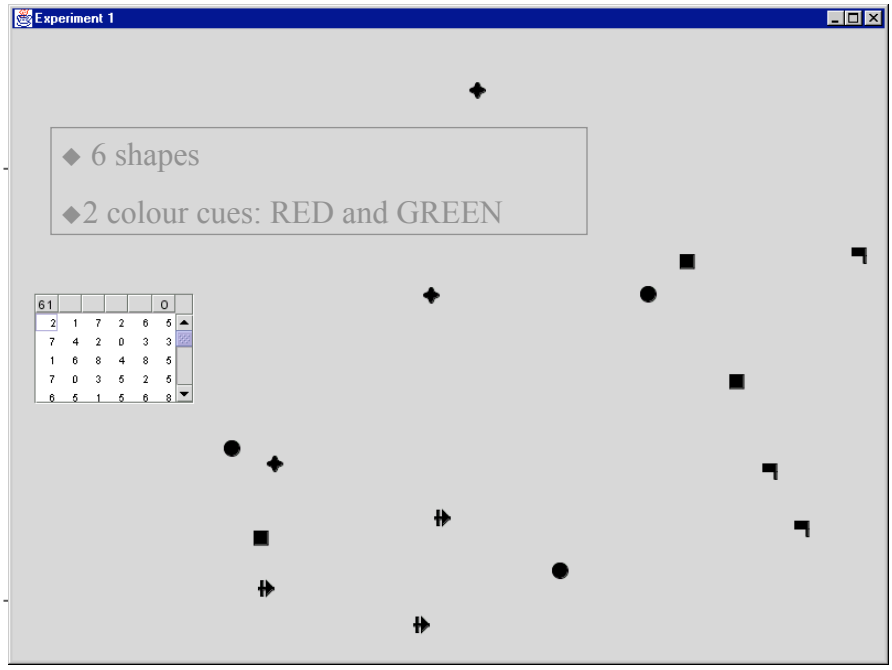
- Perceptually efficient
- Interpretatively rich
- “free” display dimension ?

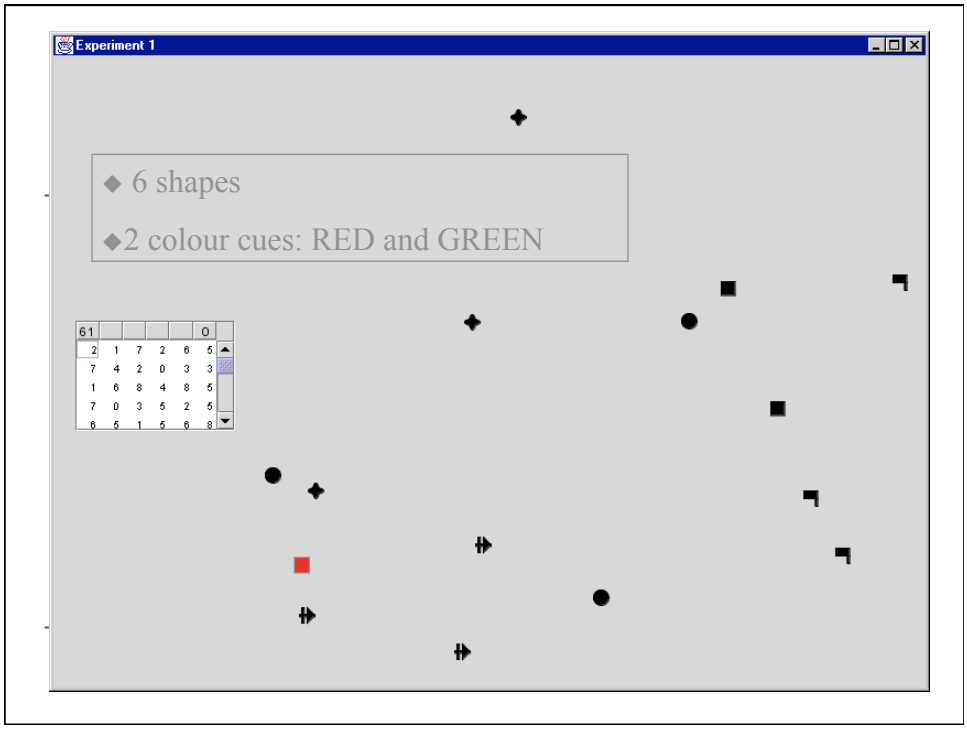
Why Motion?

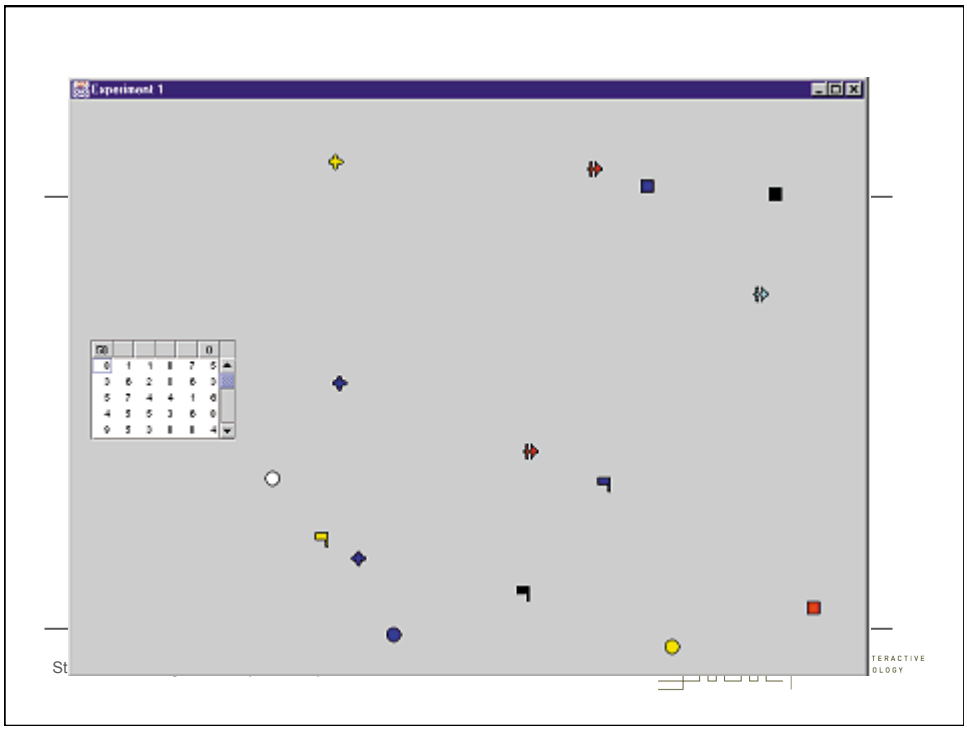
- Perceptually efficient
- Interpretatively rich
- “free” display dimension
- **grouping effect**:
  - conveys relationships [Bartram, Ware, Michotte, Alvarado]

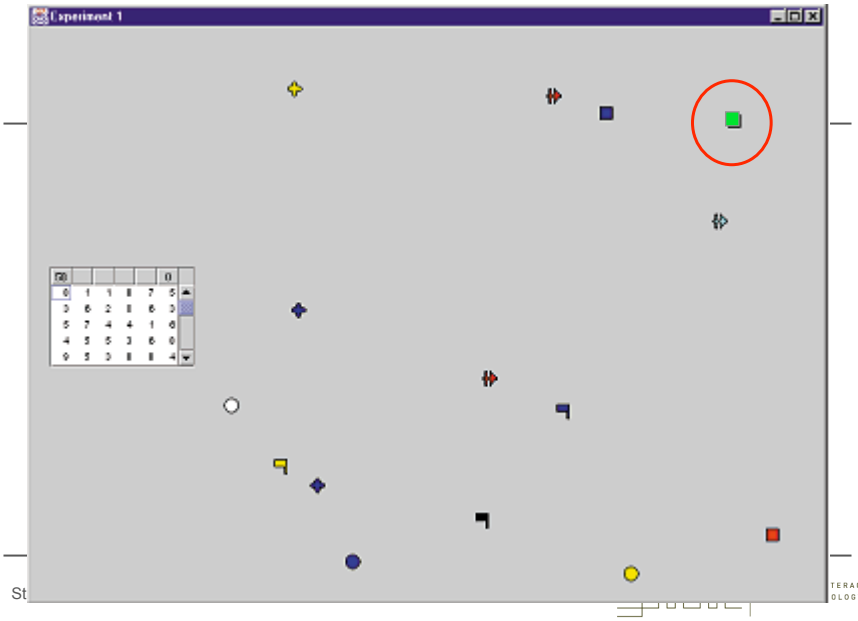
Bartram motion experiments

- Three empirical studies :
- Which motion features are useful for signals?
  - Large fields of view
- How do motions contribute to distraction?
- Features for grouping
  - Filtering
  - Brushing (association)



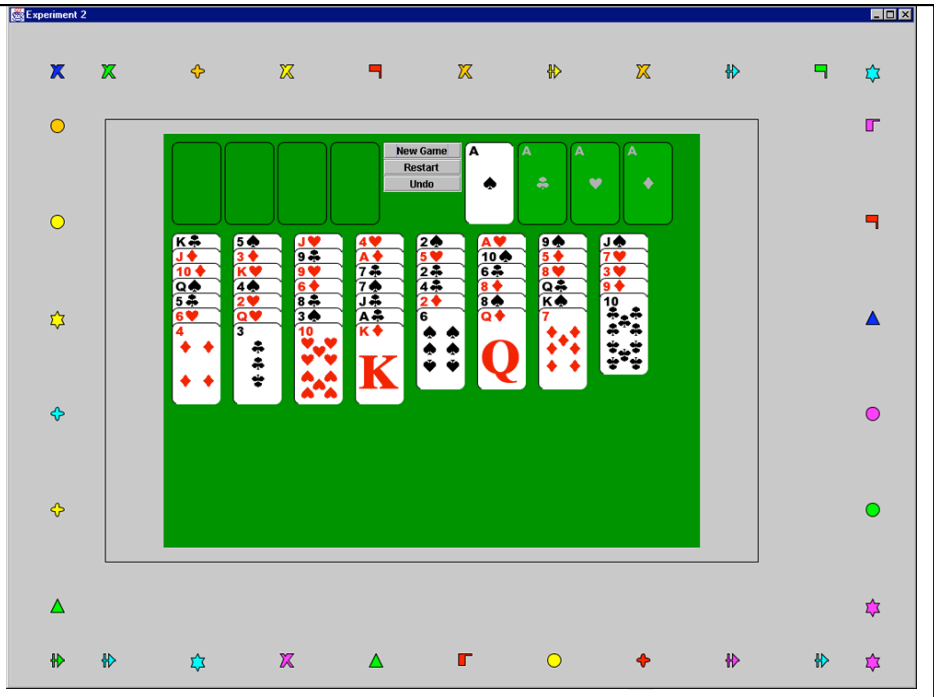

Experiment 1
◆ 6 shapes
◆2 colour cues: RED and GREEN


Experiment 1



Results

- Detection:
  - Moticons were extremely accurately detected
  - Location had large error effect on static cues
    - colour: 5% and 24% error rates
    - shape: 4% and 15% error rates
  - Location doubled static detection times; moticons were constant
- Identification – as above
  - colour: 14% and 19% error rates (of detected)
  - Moticons highly accurate: ~ 1% error



Motion types

- Demo
- file:///Users/lyn/Research/Motion/Dev/MotionExperiments/Applets/distraction.html

Conclusions: Moticons for cueing attention, but…

- Moticons very effective for signaling
  - better than colour and shape, especially in periphery
  - Effective over many locations, types and amplitudes
- Certain motion shapes are more distracting
  - traveling worse than anchored
  - linear shape good candidate: detectable but not distracting
- Task load affects detection
  - signal can be tuned to task
  - Signal can indicate engagement?

Filtering and brushing

- User configures display to make information easily accessible and show subgroups
- **filtering** takes away superfluous data
- **Brushing** highlights data points interactively and visually connects arbitrary distributed objects [Baecker and Cleveland87]
  - brushing requires its own brushing code (colour)
  - problems with colour in periphery
- Motion can be used for brushing and filtering

Recall …

- **strong grouping effect**: things which move together in a similar fashion elicit percept they are a group
- file:///Users/lyn/Research/Motion/Dev/MotionExperiments/Applets/OneGroup.html

Questions

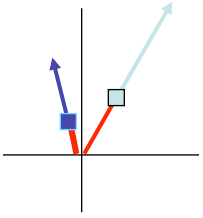
- What does it mean to move in a “similar way”?
- Similarity tolerance so that we can cause effect when desired (*grouping*); and
- ensure that multiple unrelated moving objects are perceived as distinct (*discrimination*).
  - (caveat!) Applies to many environments

Brushing with motion

- Dual task visual search experiments
- High level of distractors
- 17 motion combinations
- file:///Users/lyn/Research/Motion/Dev/MotionExperiments/Applets/TwoGroups.html

Results

- Motion groups “pop out”
- Motion type is most effective feature for both ranking and discrimination
- Circular type is most visually dominant
- Motion directions blur together < 45° and at 180°
- Large effect for *quadrant change*
- Motions work for brushing
- Care has to be taken for involuntary grouping



Visualizing relationships

- Preliminary work in representing causality
  - with Colin Ware (1999)
  - With Emily Yao (2007)
- Based on Michotte
- Can we overlay causality information on existing representations like spreadsheets and graphs?

Perception of causality from motion

- Michotte's claim: direct perception of causality
- When we see a billiard ball strike another and set the second ball in motion, we perceive that the motion of the first ball causes the motion of the second, according to the work of Michotte.
- Precise timing is required to achieve perceived causality.

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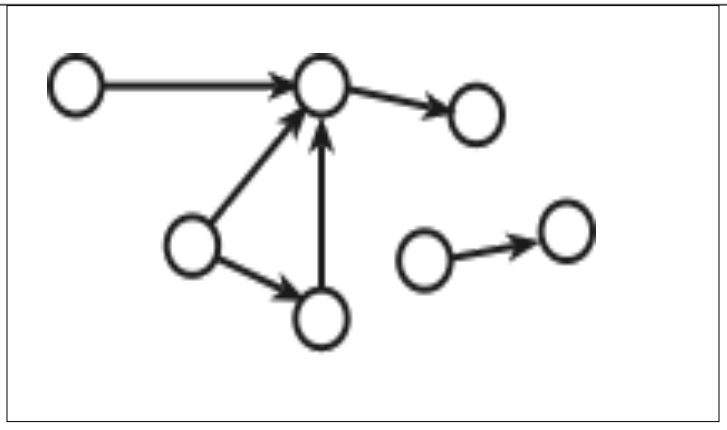
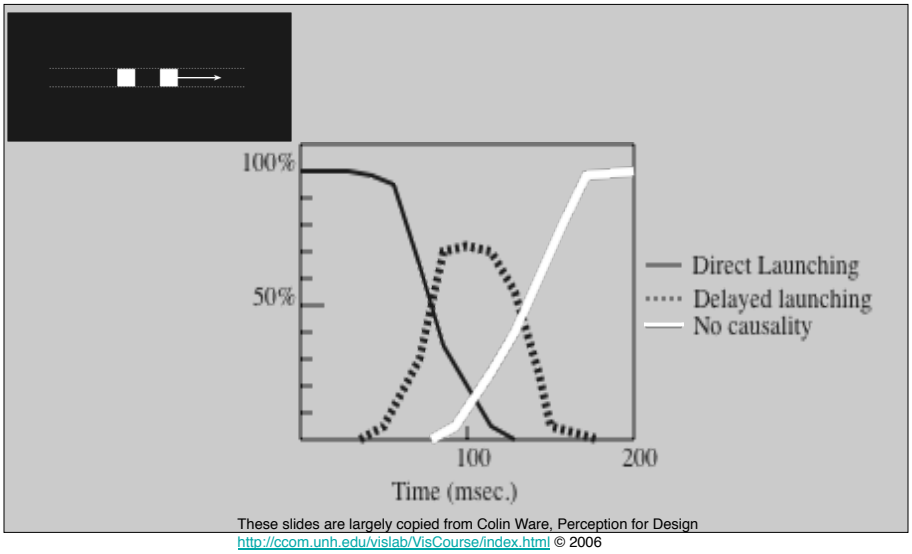
Using motion to display causality

- Michotte found that for the effect he called launching to be perceived, the second object had to move within 70 milliseconds of contact;
- After this interval, subjects still perceived the first object as setting the second object in motion, but the phenomenon was qualitatively different.
- He called it delayed launching.
- Beyond about 160 milliseconds, there was no longer an impression that one event caused the other; instead, unconnected movements of the two objects were perceived.

A causal graph



Michotte's Causality Perception



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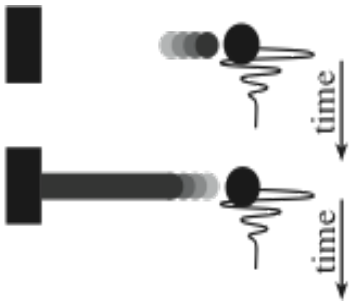
Visual Causal Vectors



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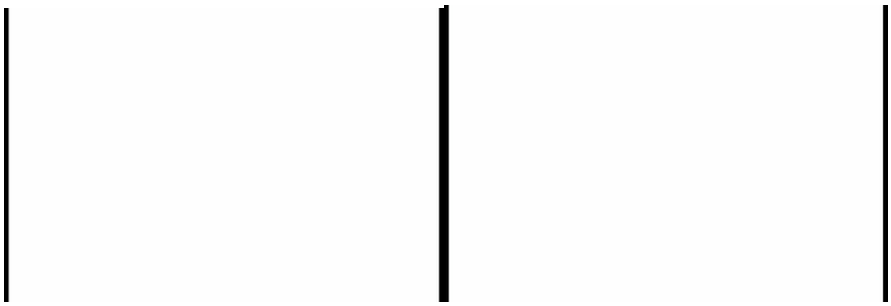
Current work on causality

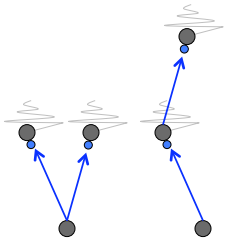
- Scholl et al. (perception of causality)
- Neufeld, Ware, Bartram, Irani
- Yao and Bartram - using motion to overlay causality on other views
  - E.g. maps and graphs
- Value: increase expressive range beyond that permitted by static diagrams

Causal motion



What we discovered

- We can successfully use motion cues to identify paths
- If we want to show just the existence of the causal path, it's sufficient to animate path and maintain timing (70-160 ms)
  - Vector effect
- However, if we want to add information about the strength of the effect we have to use some kind of node interaction
  - Node effect
- With small node effects, we can identify whether one causal hit is stronger than another
  - Phase and grouping effects
- need to explore design space



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Meaningful motion

- Motion is expressively rich (dance, theatre, mime, ….)
- What are the properties of motion that make it so expressive?
- Trajectory [Tagiuri], interaction [Lethbridge+Ware, Heider+Simmel, etc], smoothness vs jerkiness, velocity, acceleration, amplitude ???
- Experiments [Bartram+Nakatani] in what contributes to making motions meaningful
  - Application in ambient, social and therapeutic interfaces and visualizations
  - Map emotions to more abstract meanings
  - demo

Conclusion

- Motion is under-researched, but evidence suggests its power.
- Initial usable features include velocity, direction, phase, shape (type) and flicker/ blink
- There are interactions between motion features and static features that need to be investigated
  - E.g. brighter dots generate stronger motion signals (Schwartz, 2000?) http://www.settheory.com/Glass_paper/Kanizsa_observations.html

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