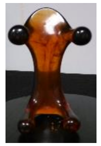
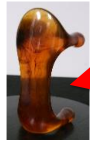
Lecture 10: Visual Event Perception

Perceiving 3D objects: better with motion


A


B


C

But we really don't know for sure if they are the same object…due to the problem of occlusion.

Object Recognition: Are they the same objects or not?

According to the Recognition by Component Model (a kind of featural analysis models), is it easier to recognize from images A and B, or from B and C? What is the measure?

Perceiving objects: better with motion


A


B


C

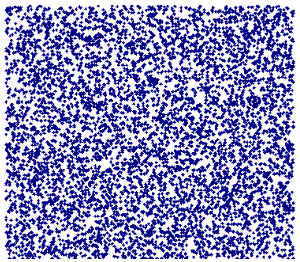
Occlusion is no longer a problem if we add in motion… Motion generated optic flow differentiates occlusion from annihilation. Recognizing 3D objects becomes trivial.

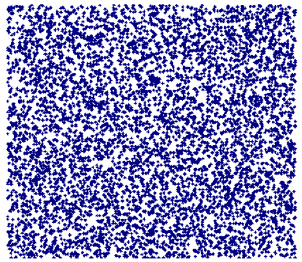
Structure from motion (SFM)

Object in motion = Event !

SFM

- Unambiguously perceiving 3D structures when objects moves.





SFM

- Unambiguously perceiving 3D structures when objects moves.

SFM

But what about after motion?

Embodied Memory for Efficient and Stable Perceptually Guided Performances:

The Advantage and Necessity to Combine Optic Flow and Image Structure Information

Overview

- What is the optical information that allows observers to effectively perceive objects / events / scenes in 3D environments?
  - Effective: accurate, efficient and stable
- Proposed answer: combined **optic flow** and **image structure** info
- Studies showing that combined optic flow and image structure yielded effective perception in:
  - Identifying previously observed but currently hidden objects
  - Identifying camouflaged targets
  - Identifying targets with orientation change
  - Identifying events with low vision
  - Identifying scenes with simulated low vision

In a 3D environment, occlusion specifies spatial relations.

When static → Image structure info

When moving → Optic flow info

Image structure

Image structures: **static** optical structures/patterns that are detectable by the eye and may specify properties of objects (e.g. size, spatial structure).

Optic flow

Optic flow is produced by relative **motion** between an observer and surrounding objects/surfaces; and specifies the relation between them.

For a given surface in the world, the optic flow pattern (its speed) is inversely proportional to the distance between it and the observer.

Optic flow provides a depth map of the surrounding surfaces/objects.

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In normal viewing, image structure and optic flow are both available.

When static → Image structure info → Weak in specifying 3D structure

When moving → Optic flow info → Powerful in specifying 3D structure


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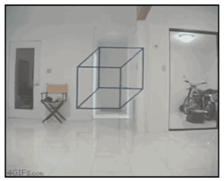
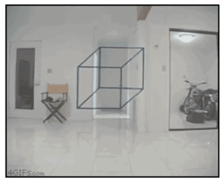



Theoretical Background

Visual perception

Optic flow — e.g. control of locomotion

Image structure — e.g. visual object recognition

Strong spatial specification	Temporal stability
~~Transient~~	~~Weak spatial specification~~

Unitary system of vision:

Optic flow calibrates image structure. Image structure forms **embodied memory** for spatial relations specified by optic flow.

aka: how to cheat in a hide-and-seek game

STUDY 1: IDENTIFYING (PREVIOUSLY PERCEIVED BUT CURRENTLY) OCCLUDED OBJECTS

Pan, J. S., Bingham, N. & Bingham, G. P. (2013): JEP: HPP

Theories

The Unitary System of Vision Hypothesis

Image structure	Optic flow
Weak in specifying spatial relations	Strong in specifying spatial relations
but	but
Stable	Transient

Once combined,

Optic Flow $\xrightarrow{\text{Calibrates}}$ Image Structure

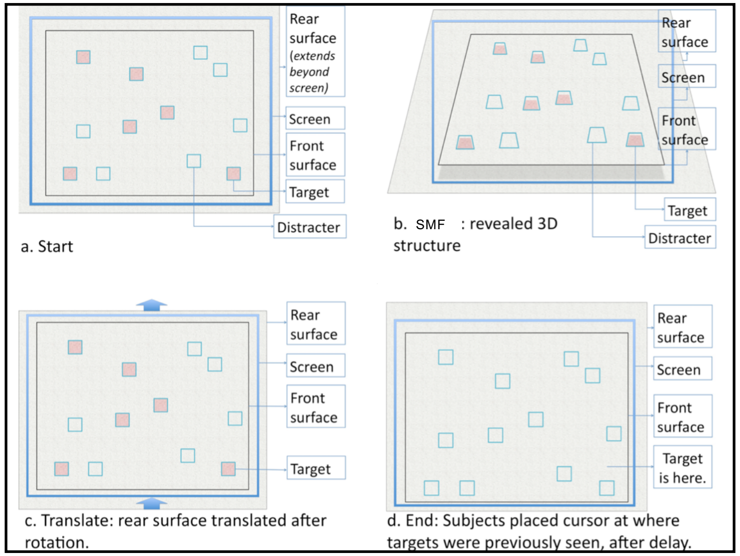
Image Structure $\xrightarrow{\text{Preserves}}$ Optic Flow

<u>EMBODIED MEMORY</u>
Holds more items and lasts longer

Experimental Approach

Optic flow → Strong but unstable → 3D layout / spatial relations

Image structure → Weak but stable → 3D layout / spatial relations



Exp 1: Optic flow alone

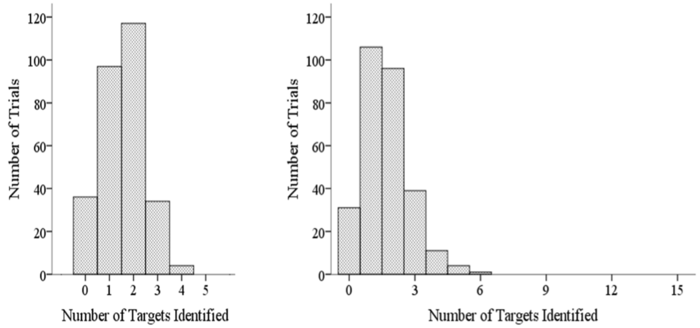
Information: Optic Flow

Version 1 :	Version 2:
N Targets: 2, 3, 4 or 5	N Targets: 6, 9, 12 or 15
N Distracters: 2, 3, 4 or 5	N Distracters: 6, 9, 12 or 15

Watch time: SFM = 8 s, progressive occlusion time = 3 s.
Delay : 2 s.

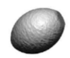
demo

Exp 1: Optic flow alone is able to specify spatial relations.



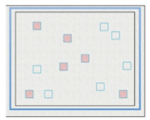
Exp 2: Image structure alone

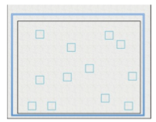
Remember This?



A static view before motion (rotation).

A static view after motion (rotation).





A static view before motion (translation).

A static view after motion (translation).

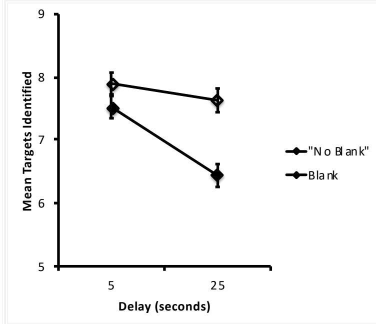
demo

Exp 2: Image structure alone does not specify locations of hidden objects

Participants did not identify any target.

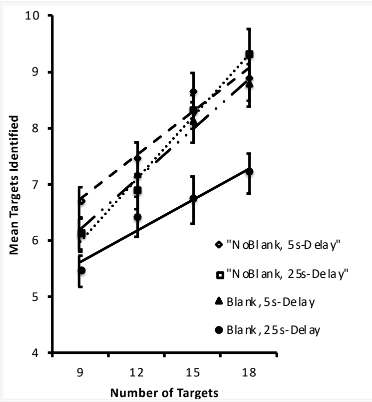
Exp 3: Combined information

- Information: Image structure + Optic Flow
- N Targets: 9, 12, 15, or 18
- N Distracters: 12
- 2 levels of delays: 5s, 25s
- Manipulated persistence of image structure:
  - Blank vs. No blank



Exp 3: Combined information led to efficient and stable perception

- Information: Image structure + Optic Flow
- N Targets: 9, 12, 15, or 18
- N Distracters: 12
- 2 levels of delays: 5s, 25s
- Manipulated persistence of image structure:
  - Blank vs. No blank



So far…

Perceiving to identify locations of occluded objects is:

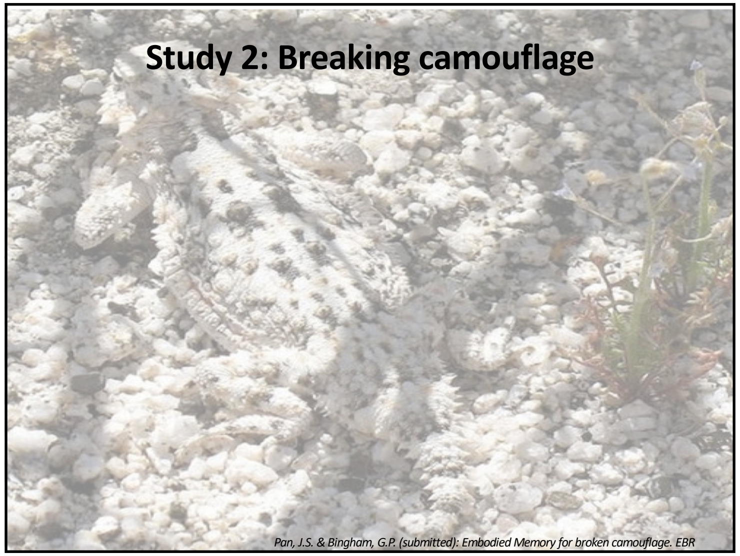
(1) possible but unstable with optic flow alone.

(1) impossible with image structure alone.

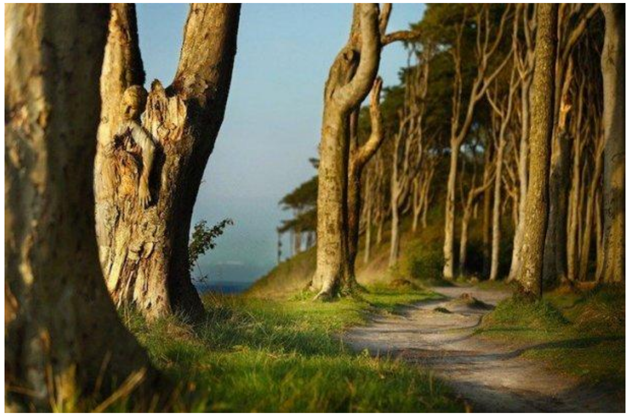
(1) effective with combined optic flow and image structure.

- Optic flow calibrates image structures;
- Image structures preserve info in optic flow.

Study 2: Breaking camouflage



Pan, J.S. & Bingham, G.P. (submitted): Embodied Memory for broken camouflage. EBR



Study 2: Camouflage

What optical information breaks camouflage
and enables accurate and stable perception?

THEORETICAL BACKGROUND

Camouflage (crypsis) – to match the appearances between T's and D's, such that target detection becomes difficult

T's and D's are of unique spatial (depth) relations w.r.t. the observer → Intricate manipulation of image information to mask the spatial distinction

THEORETICAL BACKGROUND

Camouflage (crypsis) – to match the appearances between T's and D's, such that target detection becomes difficult

T's and D's are of unique spatial (depth) relations w.r.t. the observer → Intricate manipulation of image information to mask the spatial distinction

regain

undo

To break camouflage

Study 2: Camouflage

What optical information breaks camouflage and enables accurate and stable perception?

Optical flow

Exp 1

Accurate perception, lack of stability

Image structure

OVERVIEW

What optical information breaks camouflage and enables accurate and stable perception?

Optic flow

Image structure

Exp 2

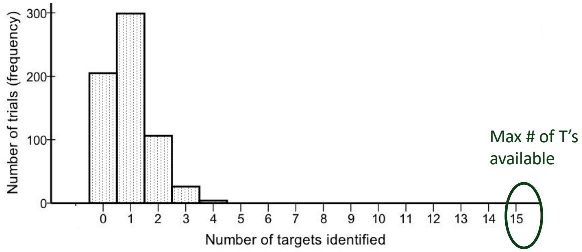
Accurate and stable perception

THEORETICAL BACKGROUND

Experimental Approach		
Target identification with simulated camouflage, where T's and D's appeared identical but occupied different depth layers.	**Optic flow** enables accurate perception of targets with ongoing motion.	Exp 1
	Combined optic flow and image structure enables accurate and stable perception of camouflaged targets.	Exp 2

EXPERIMENT 1

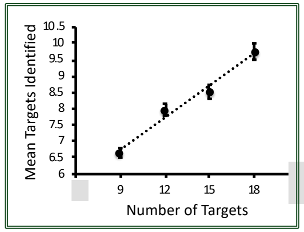
Information	Optic flow
Variable	N Targets: 6, 9, 12, or 15



Optic flow alone specified spatial relations but it was unstable.

EXPERIMENT 2

Information	Optic flow and (undifferentiating) image structure
Variables	N Targets: 9, 12, 15, or 18 (N Distracters: 12) Delay: 5s, 25s; Continuity of image structure: Blank vs. No blank



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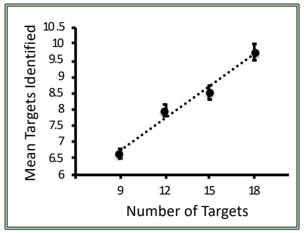
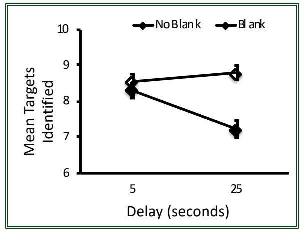




Combined optic flow and image structure yielded accurate and stable perception of camouflaged targets.

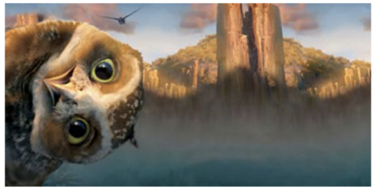
CONCLUSION

Perceiving camouflaged targets is:

Exp 1	Possible but unstable with optic flow alone. Motion-generated optical information breaks camouflage.	Accurate and stable with combined optic flow and image structure. Motion-generated and static optical information interact to achieve accuracy and stability.	**Exp 2**

Image structure $\underset{\text{preserves}}{\overset{\text{calibrates}}{\rightleftarrows}}$ **Optic flow**

The interactive system yields accurate and stable perception of camouflaged targets.



Aka: can you still find me if you tilt your head?

Study 3: Identifying hidden objects with orientation change

Pan, J. S., Bingham, N., & Binghma, G. P. (2017). JEP:HPP.

Exp 1: Baseline, No OC

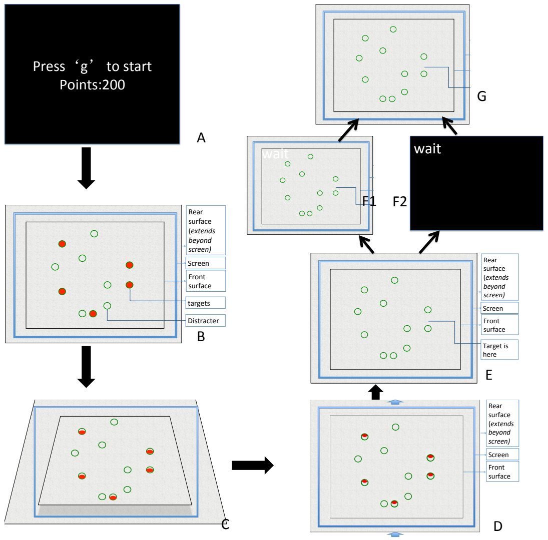
Information: Optic Flow + image structure

N Targets: 10, 15 or 20;
N Distracters: 15.

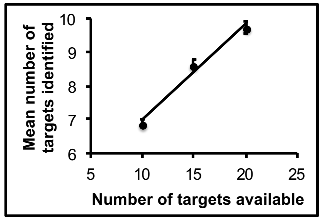
Watch time: SFM = 8 s;
Progressive occlusion time = 3 s;
Delay = 5 or 25 s.

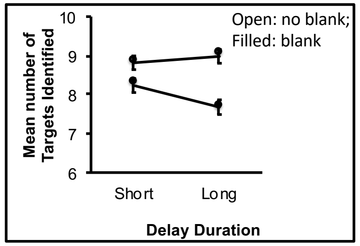
No orientation change.

Exp 1



Exp 1: Baseline, No OC





Combined optic flow and image structure information yielded accurate and stable perception of hidden targets.

Exp 2: Embodied memory for OC

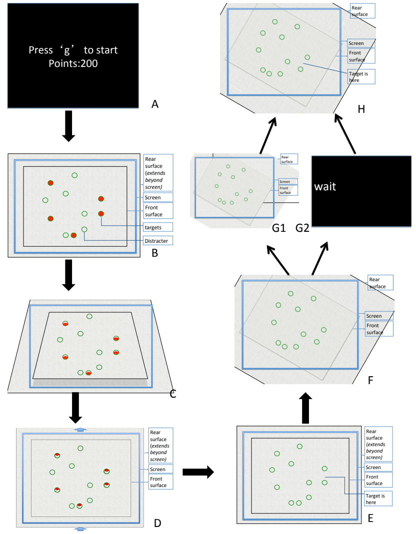
Information: Optic Flow + image structure

N Targets: 10, 15 or 20;
N Distracters: 15.

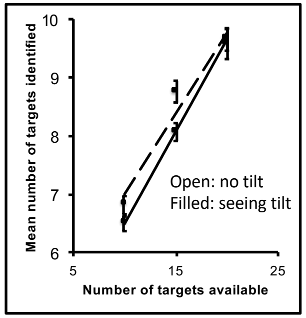
Watch time: SFM = 8 s;
Progressive occlusion time = 3 s;
OC = 3s;
Delay = 5 or 25 s.

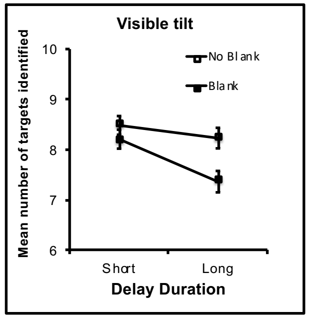
The process of tilting (OC) was always observable.

Exp 2



Exp 2: Embodied memory for OC





Combined optic flow and image structure yielded accurate and stable perception of hidden targets, despite orientation change.

Exp 3: No embodied memory for OC

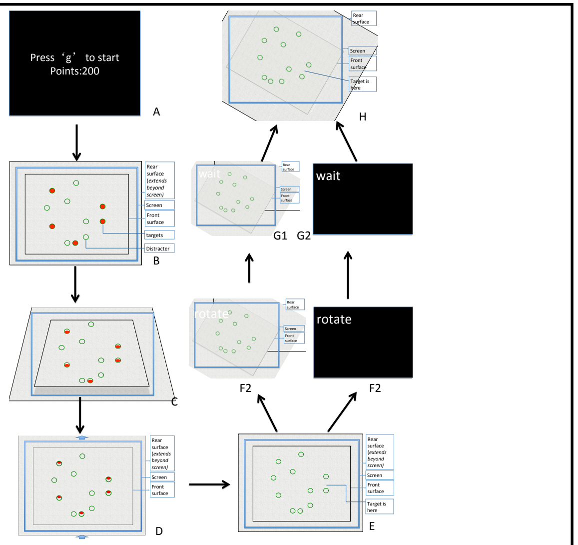
Information: Optic Flow + partial image structure

N Targets: 10, 15 or 20;
N Distracters: 15.

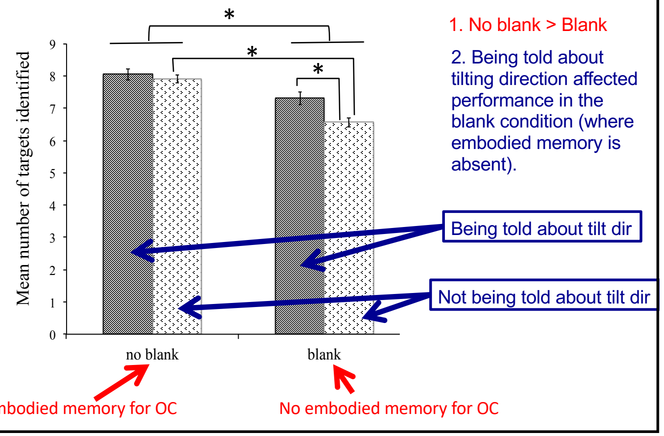
Watch time: SFM = 8 s;
Progressive occlusion time = 3 s;
OC = 3s;
Delay = 5 or 25 s.

The process of tilting (OC) was sometimes observable.

Exp 3

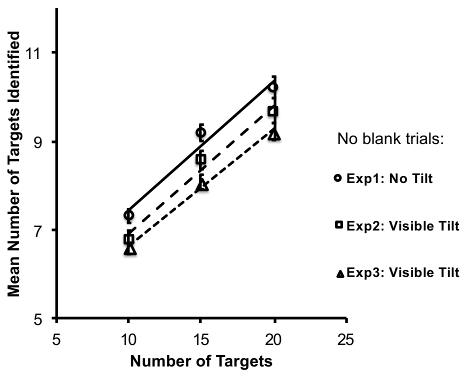


Exp 3: No embodied memory for OC

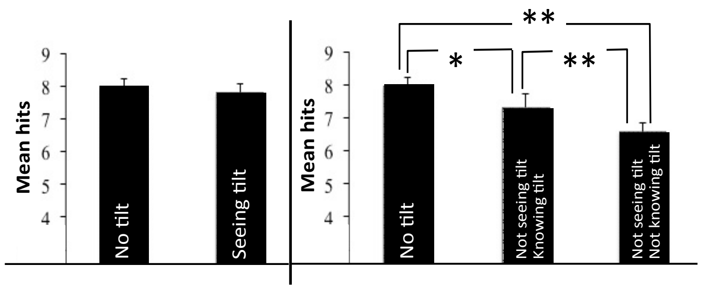


1. No blank > Blank
2. Being told about tilting direction affected performance in the blank condition (where embodied memory is absent).

Comparing across experiments



Comparing across experiments



OC did not affect target identification if tilting is seen.

Target identification in no tilt trials was higher than that in trials with unseen tilt, regardless of whether P's were informed about tilting dir/amt.

Messages from Study 3

- Embodied memory allows effective perception of hidden targets, even with orientation change.
  - If seeing tilting, then OC had no effect on identifying hidden targets (Exp 1, Exp 2).
  - If not seeing tilting, identifying hidden targets with OC became worse (Exp 1, Exp 3).
- Embodied memory > mere knowledge of OC
  - When not seeing tilting, but knowing tilting direction and amount, identification performance was not as good as seeing tilting.

A clinical application

STUDY 4: PERCEIVING EVENTS WITH BLURRY VISION

Low vision: Facts and Stats

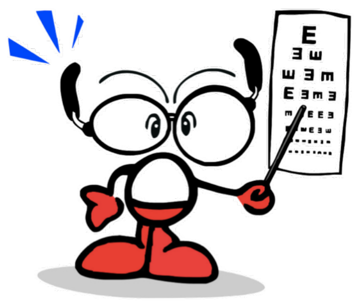
Low vision: a loss of visual acuity and/or contrast sensitivity that is uncorrectable by lens or spectacles.

- Visual acuity < 0.3, in the better eye with the best possible correction.

246 million people in the world have low vision.

Low vision occurs more in developing countries, in females and in people age 50 and above.

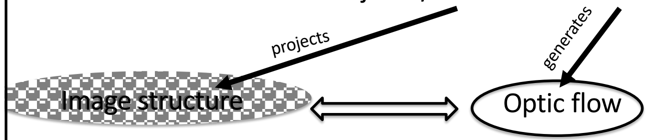
Low vision: Facts and Stats



Perceiving events with low vision

How do low vision individuals perceive daily events?

Events consist of objects / surfaces in motion.



The interaction between (poor) image structure and (unimpaired) optic flow enable effective perception of events.

Predictions

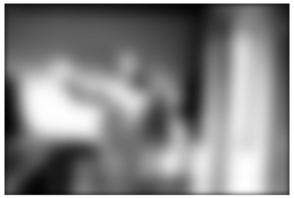
(1) Blurry images alone are unable to specify events.
(2) Optic flow calibrates the blurry images and allows events to become perceptible.
(3) Once calibrated, the image structure forms embodied memory for info in the transient optic flow.

The low vision experiment

Materials: Eight daily events; blurred to simulate low vision.

Task: Describing events depicted in the images or sequences of images, in <u>five ordered conditions</u>.

(1) Still images, one at a time.

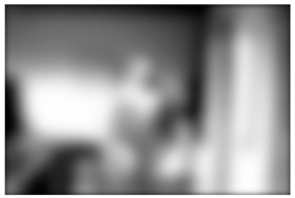


The low vision experiment

Materials: Eight daily events; blurred to simulate low vision.

Task: Describing events depicted in the images or sequences of images, in <u>five ordered conditions</u>.

(1) Still images, one at a time.
(2) 20 still images with white screens in between.



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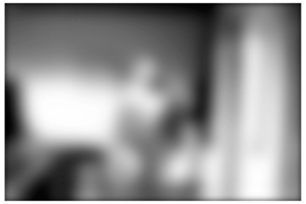
Materials: Eight daily events; blurred to simulate low vision.

Task: Describing events depicted in the images or sequences of images, in <u>five ordered conditions</u>.

(1) Still images, one at a time.
(2) 20 still images with white screens in between.
(3) 20 still images without white screens in between.



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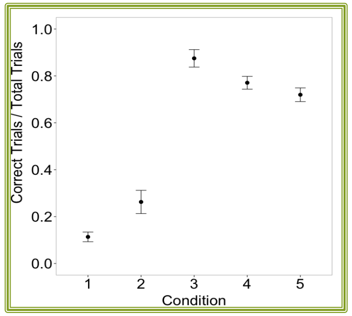
(1) Still images, one at a time.
(2) 20 still images with white screens in between.
(3) 20 still images without white screens in between.
(4) Still images, one at a time.
(5) Still images, 5 days later.

Results and conclusion



- Optic flow (motion) allows perceiving events despite poor information in image structure.
- Stability is achieved with the presence of some detectable image structure.

To understand how low vision individuals perceive and act, motion (optic flow) should be taken into consideration.

STUDY 5: PERCEIVING SCENES WITH BLURRY VISION AND DIFFERENT TYPES OF OPTIC FLOW

- Relative motions between the observer and the environment aided perception.
- What happens when a locomoting observer with blurry vision observes the stationary surround?
- Available optical info: some image structure info; translational optic flow and/or rotational optic flow
- Research question: **We examine the accuracy and temporal stability of scene perception, when blurry images are paired with translational flow, rotational flow or combined flow.**

Fig. 1: Ten scenes were recorded and treated to be grey-scale and blurry.

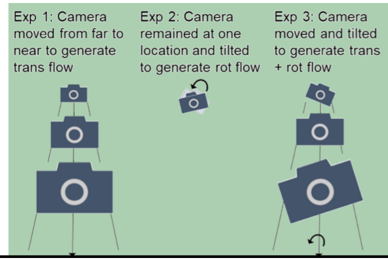


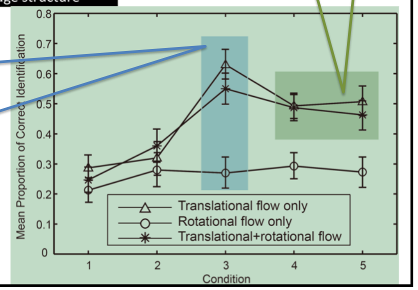
Fig. 2: Camerawork to produce the stimuli.

Rotational flow alone

Cond	Stimuli	Information
1	Single frames of blurry scenes	Image structure
2	Twenty frames from each blurry scene played in loop with energy masks between frames	Image structure
3	Twenty frames of each blurry scene played continuously forming animations	Image structure & optic flow (Exp 1: trans; Exp 2: rot; Exp 3: both).
4	Single frames of blurry scenes	Image structure
	---- ONE-WEEK BREAK ----	
5	Free recall	
	Single frames of blurry scenes	Image structure

No difference between Conditions 4 and 5 of Exps 1 and 3. Blurry image structure and translational flow interacted and led to stable performance.

No difference between Condition 3's of Exp 1 (Trans only) and of Exp 3 (Trans + Rot); both were higher than that of Exp 2 (Rot only). Translational flow yielded accurate performance.



Messages from Study 5

(1) Scenes were not perceived when there was only rotational flow

(2) Scenes were perceived as long as there was translational flow (with or without concurrent rotational flow)

(3) Translational flow interacted with blurry images and yielded stable scene perception that persisted longer than free recall

(4) A low vision observer may translation to actively generate translational flow to perceive scenes… and stringent control of posture or eye movement is not necessary

Conclusion