Lecture 5: Perception and Action

Part 1 of 4

Perception and Action: General Introduction

Relevance

Young, D.E., Wagenaar, R.C., Lin, C.C., Chou, Y.H., Davidsdottir, S., Saltzman, E. and Cronin-Golomb, A., 2010. Visuospatial perception and navigation in Parkinson’s disease. Vision research, 50(23), pp.2495-2504.

Mohler, B.J., Thompson, W.B., Creem-Regehr, S.H., Willemsen, P., Pick, Jr, H.L. and Rieser, J.J., 2007. Calibration of locomotion resulting from visual motion in a treadmill-based virtual environment. ACM Transactions on Applied Perception (TAP), 4(1), pp.4-es.

Ni, R., Bian, Z. and Andersen, G.J., 2009, June. Age-related differences in using optical flow and landmark information for steering control. In 2009 IEEE Intelligent Vehicles Symposium (pp. 691-694). IEEE.

Steed, A., Pawar, V., Friston, S. and Srinivasan, M.A., 2016, March. Ambient fields: representing potential sensory information. In 2016 IEEE 9th Workshop on Software Engineering and Architectures for Realtime Interactive Systems (SEARIS) (pp. 1-2). IEEE.

Bruder, G., Wieland, P., Bolte, B., Lappe, M. and Steinicke, F., 2013, October. Going with the flow: Modifying self-motion perception with computer-mediated optic flow. In 2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR) (pp. 67-74). IEEE.

Bruder, G., Steinicke, F., Wieland, P. and Lappe, M., 2011. Tuning self-motion perception in virtual reality with visual illusions. IEEE Transactions on Visualization and Computer Graphics, 18(7), pp.1068-1078.

Learning Objectives

To understand the connection between perception and action

To develop an understanding of the concept of an ecological approach to perception

To develop an understanding of the design of experiments used to study ecological optics

To understand the concept of self-produced information (in relation to optic flow) and be able to describe some of the key associated experimentation

Learning Outcomes

To be able to explain what ecological optics refers to and provide relevant examples

To be able to describe the concept of ecological optics and the ambient optic array

To be able to describe the effect of movement on the optic array and optic flow

To be able to describe some key experiments in relation to optic flow and human perception

Perception and Action- What is the link?

Motor activity and perception are closely linked.

Some examples are:

Walking or Riding a bike/driving a car - navigating the path ahead.

Crossing a road - making sure the path is clear before crossing

In the library - looking for the correct book

Making a choice online- selecting and moving the cursor

Navigating a virtual scene –

An individual with limited sight can learn to use additional tactile or audio information in order to navigate the path ahead.

Perceptual information from the environment

Work on the connection between perception and action by Gibson in the 1950-1970's into how we may use information from our environments can provide information for perception that influence our action(s) in/on that environment.

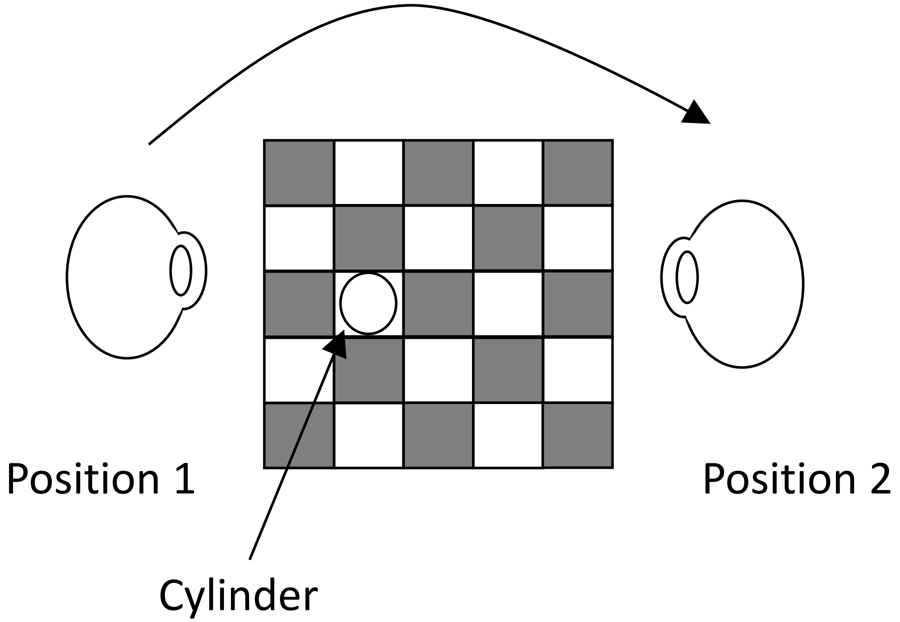
This area of perception is referred to as "the ecological approach to perception".

This approach focuses on studying perception as it occurs in the natural environment and in particular looks at the connection between a person's perceptions and the person's movement through the environment.

The emphasis here is on determining which information in the environment is available for perception.

Sometimes this idea has been investigated by comparing the two possible sources of information for perception- information available on the retina of the eye vs. the information available in the environment.

Environmental Information and Perception: Ecological Optics



a) Observer looking at cylinder on a checkerboard from 2 different positions

An example of a cylinder resting on a checkerboard.

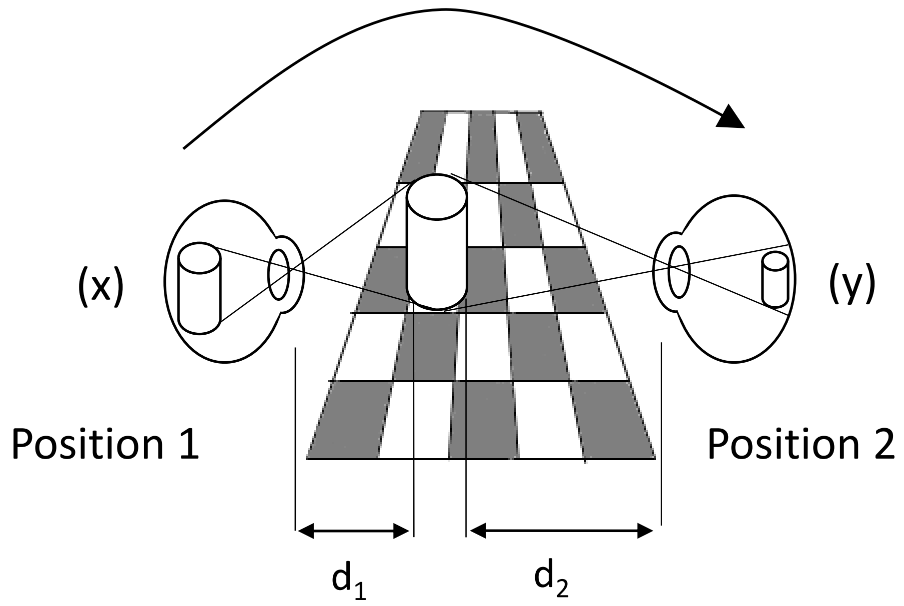
The example on the left (a) shows the view from the top.

The cylinder is shown as a circle (in the top view). The positions of 2 different viewpoints of a person on either side of the board are also shown by the two eyes.

The person first views the cylinder from position 1, then moves to position 2.

Moving from viewpoint 1 to viewpoint 2 doubles the distance between the eye and the cylinder.

Environmental Information and Perception: Ecological Optics



b) Perspective view of checkerboard

An example of a cylinder resting on a checkerboard.

The example on the left (b) shows the perspective view of the checkerboard and the retinal information for the cylinder as viewed from the two viewing positions. This information is depicted by the two images formed on the retina (x) and (y).

This retinal information is different for each viewing position, since the cylinder becomes smaller as the distance between the person and the cylinder increases.

However, even though the image becomes smaller as the person moves from position 1 to position 2, the person perceives the cylinder as remaining the same size.

This is called size constancy. If there is good depth information, we can perceive an object's size as remaining constant no matter what its distance.

Environmental Information and Perception: Ecological Optics

Size constancy

An explanation for this is that the perceptual system takes the object's distance into account.
So even when the retinal image of the cylinder is smaller when the person is at position 2 compared to when the person is at position 1, the perceptual system takes the two distances d1 and d2 into account, and the cylinder is perceived to be the same size from both viewpoints.

Another explanation is that the person takes the environmental information for the size of the cylinder into account.

Environmental Information and Perception: Ecological Optics

View from position 1

View from position 2

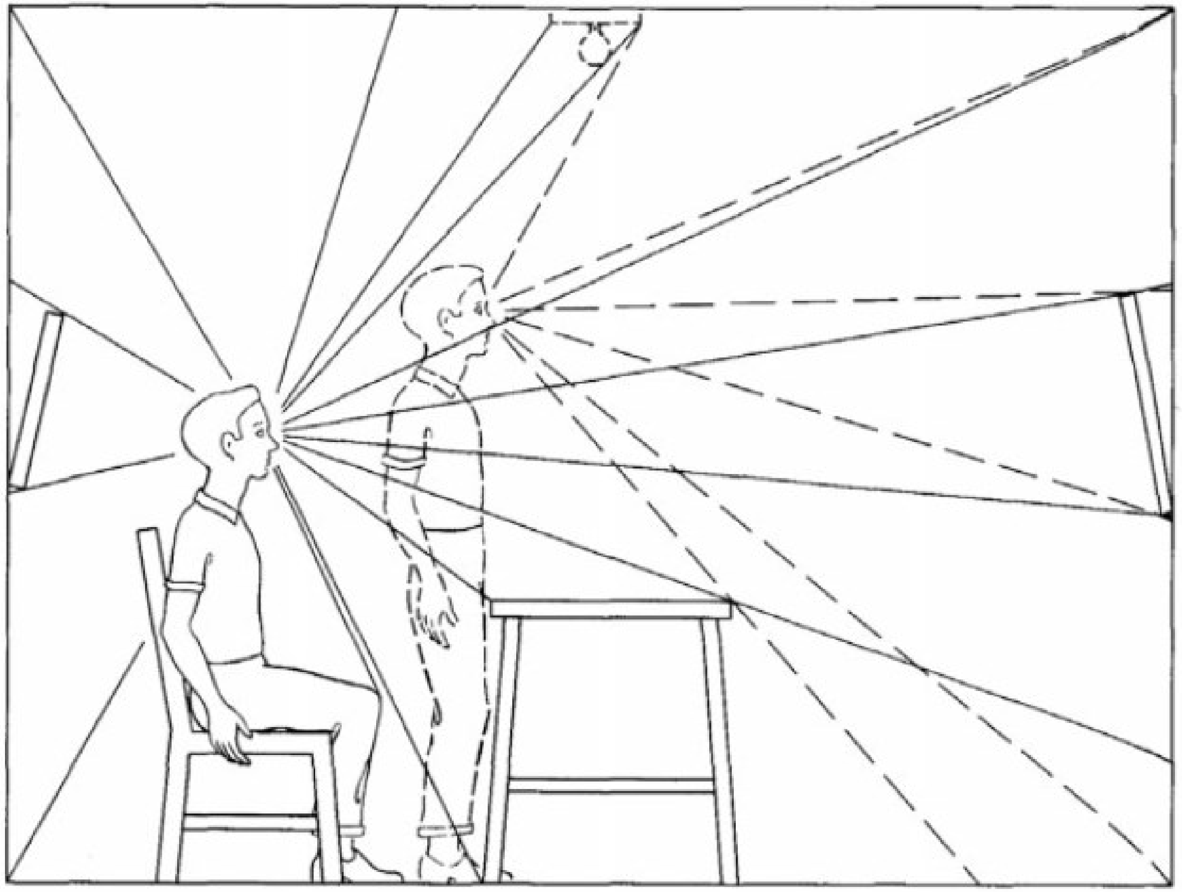
Environmental information for the size of a cylinder

The figure on the left shows the environmental information for the size of the cylinder as viewed from the two positions.

The environmental information in this case is the number of units on the checkerboard covered by the base of the cylinder.

Since the cylinder base always covers one unit on the checkerboard, even as the person’s viewpoint changes, this environmental information is used to perceive the cylinder’s size as constant (unchanged), without having to take the person’s distance from the cylinder into account.

The Ambient Optic Array



From Todd, J. (2020). iPerception, 11(5), 1-20

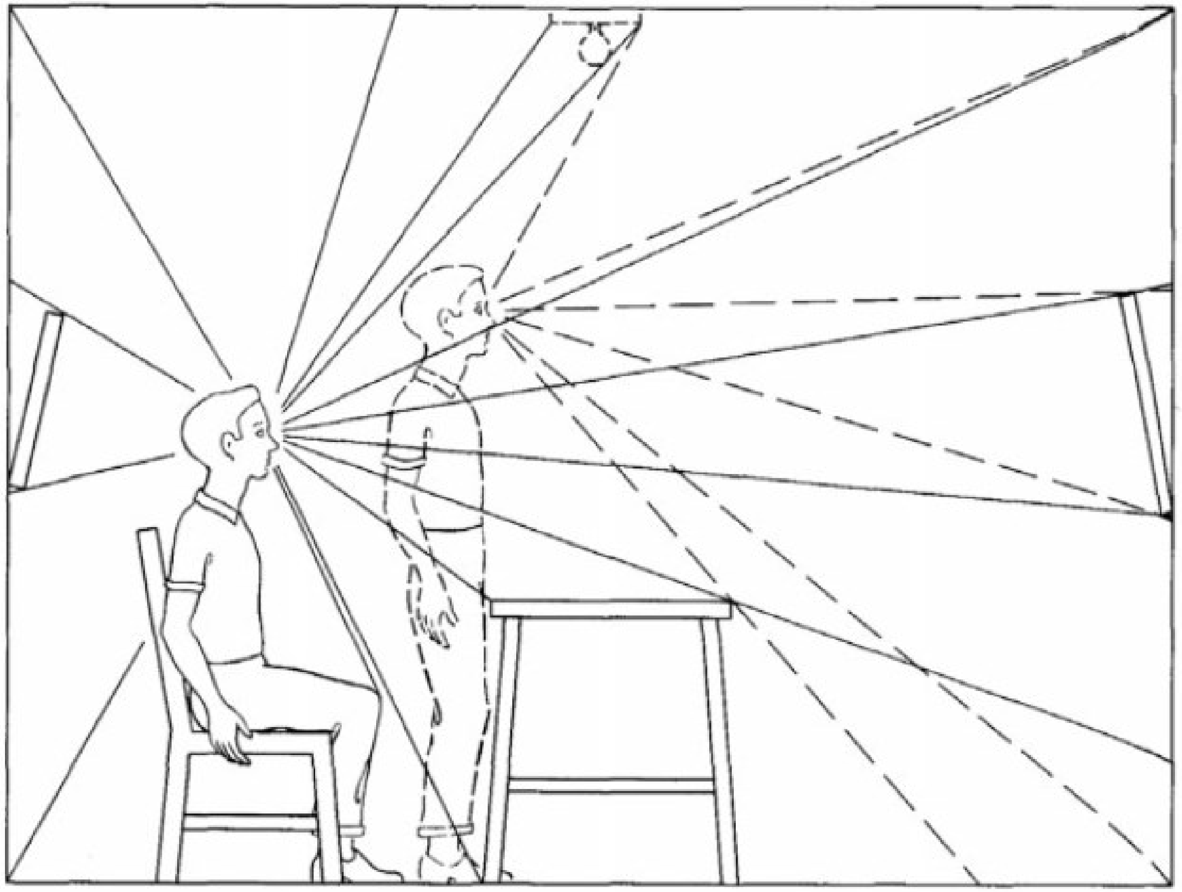
Gibson developed a way of describing perceptual-based stimuli – called ecological optics.

This is the description of stimuli based on the ambient optic array (optic array); the structure of stimulation (created by the surfaces, textures, contours of the environment) available at a point in the environment.

The example on the left shows a schematic in which is shown a person seated in a room.
The optic array for this person is the structured pattern of light reaching the person’s eye. When the person stands the optic array also changes.

The person perceives the objects, surfaces and textures in the scene because of the way the light is structured by these objects surfaces and textures.

The Ambient Optic Array and Optic Flow



From Todd, J. (2020). iPerception, 11(5), 1-20

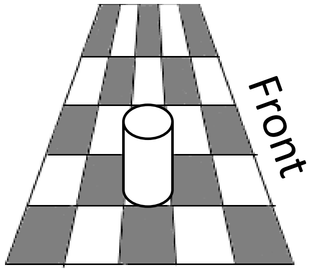
The effect of movement on the optic array: When the person stands up from the seated position, the optic array changes accordingly.

Movement of the person causes changes in the optic array.

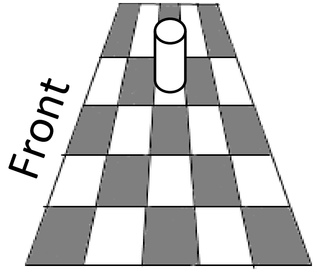
If the person started to walk around the room then the continuous changes that occur in the optic array as the person moves creates an <u>optic flow</u>. (the movement of elements of the environment relative to the observer).

Environmental Information and Perception: Ecological Optics

Effect of movement on the optic array

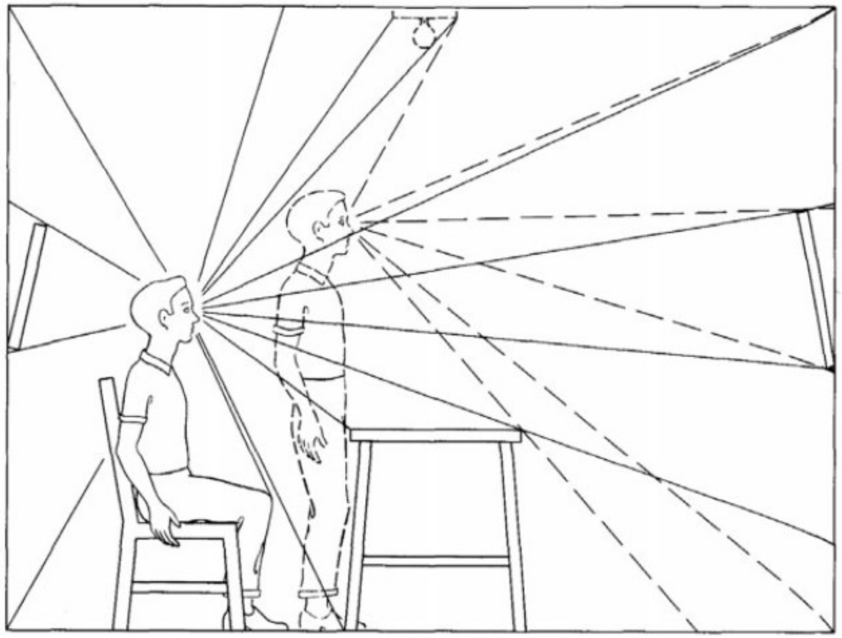


View from
position 1



View from
position 2

Optic array created by the checkerboard provides information about the size of the cylinder as the viewpoint changes.



Optic array created by the elements in the room change as the person changes from a seated to standing position.

Self-produced Information

Optic Flow

Figure 5. *The arrows show the expansion pattern of motion that would be created if the viewing position (observer) moves towards the end of the corridor. This pattern of motion not only specifies that the viewing position has moved but also the direction and speed of that movement*. From Roger (2021)., i-Perception, 12, 1-15.

As previously discussed: If the person started to walk around then the continuous changes that occur in the optic array as the person moves creates an optic flow. (the movement of elements of the environment relative to the observer).

Another example is driving a car through a tunnel. The tunnel opening can be seen ahead (the destination), as the car drives forward you observe elements outside of the car, i.e., tunnel walls, road below to move past you at speed in a direction opposite to your direction of travel.
This movement of the surroundings is the optic flow.

Optic Flow

There are two characteristics of the optic flow:

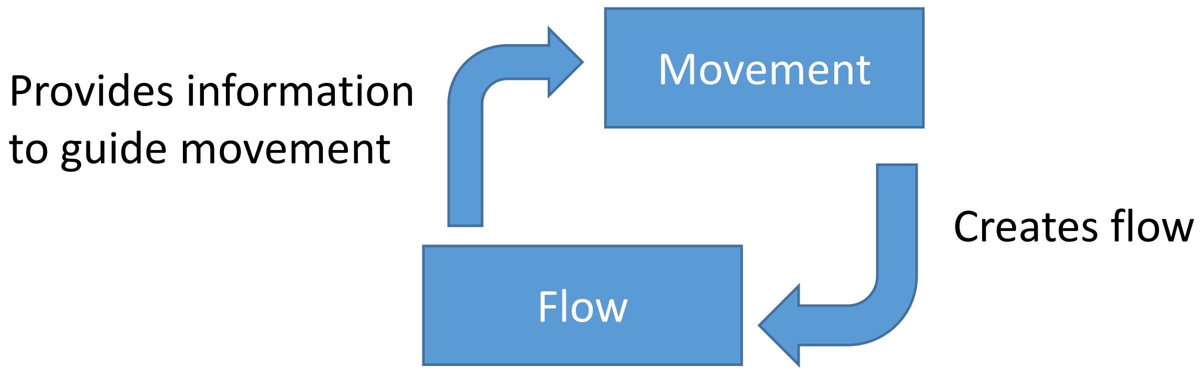
1. The flow is more rapid near the moving observer. [The different speed of flow, fast near the observer and slower farther away is called the gradient of flow.]
2. There is no flow at the destination towards which the observer is moving. [This is often called the focus of expansion (FOE).]

3. Optic flow can produce invariant information (a property that remains constant under different conditions); properties that remain constant as an observer moves through the environment (the FOE) is also an invariant property.

Self-produced information

Another idea that stems from the ecological approach is that self-produced information from a person's movement within an environment provides information to guide further movement.

I.e.., movement is useful for perception.



Self-produced information

Some examples are:

A gymnast making adjustments whilst in the air somersaulting.

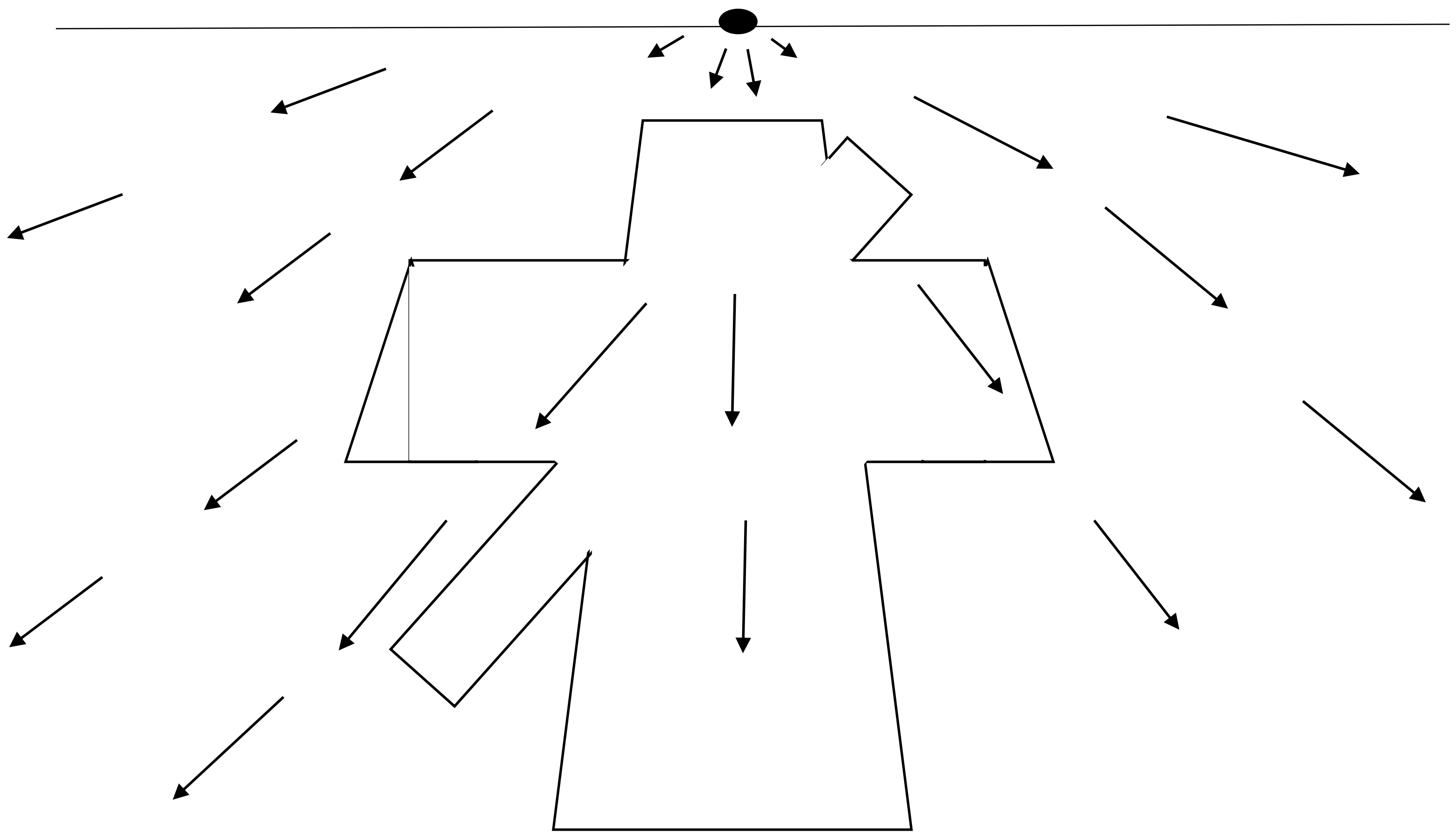
Bardy and Laurent (1998): Expert gymnasts performed somersaults more poorly with eyes closed. Analysis of film recordings showed that gymnasts appeared to make adjustments to their body in the air so as to correct their positioning and to be able to complete the sequence in the way intended. I.e., there is constant regulation of action during the continuous flow of perceptual information when carrying out the task.

Also found that closing eyes did not affect performance of novice somersaulters as much as it affected the performance of expert somersaulters. It appeared that experts learn to coordinate their movements with their perceptions, but novices have not yet learned to do this. When novices close their eyes loss of visual information had less of an effect than it did for the experts.

Bardy, B.G., & Laurent, M. (1998). J. Exp. Psychol: Human Perc & Perf, 24, 963-977.

Optic Flow: Self-produced information for perception

Optic Flow for a plane flying over a runway



<u>Optic Flow and Focus of Expansion</u>

According to the optic flow idea, the flow generated by movement provides information about where the person is heading.

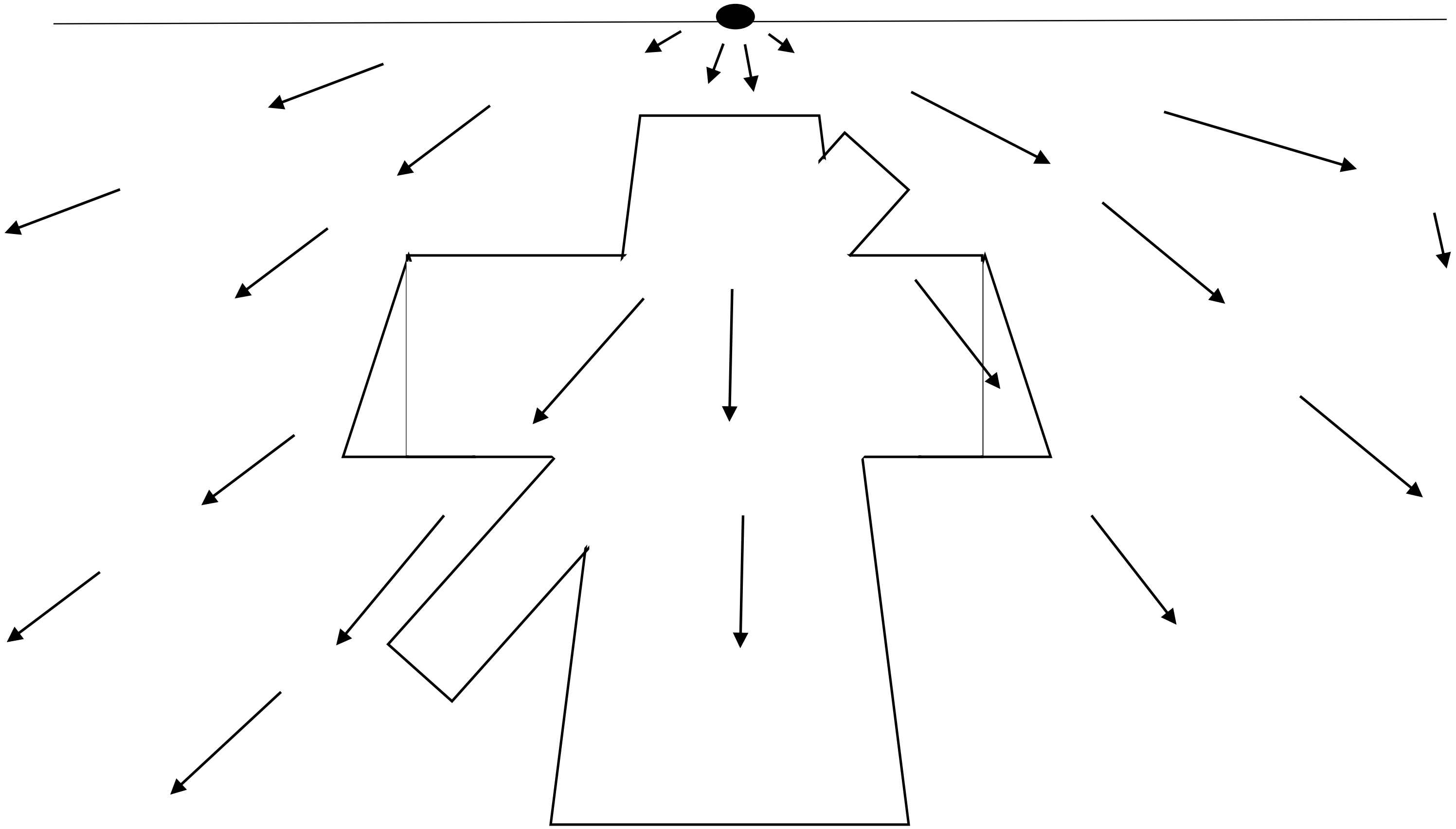
Example on the left shows the optic flow experienced by a plane flying over the runway. The pilot sees a pattern of elements that flow along the ground as shown.

Long arrows = rapid flow
Short arrows = slower flow

So, faster flow in foreground and slower flow towards horizon.

Optic Flow: Self-produced information for perception

Optic Flow for a plane flying over a runway



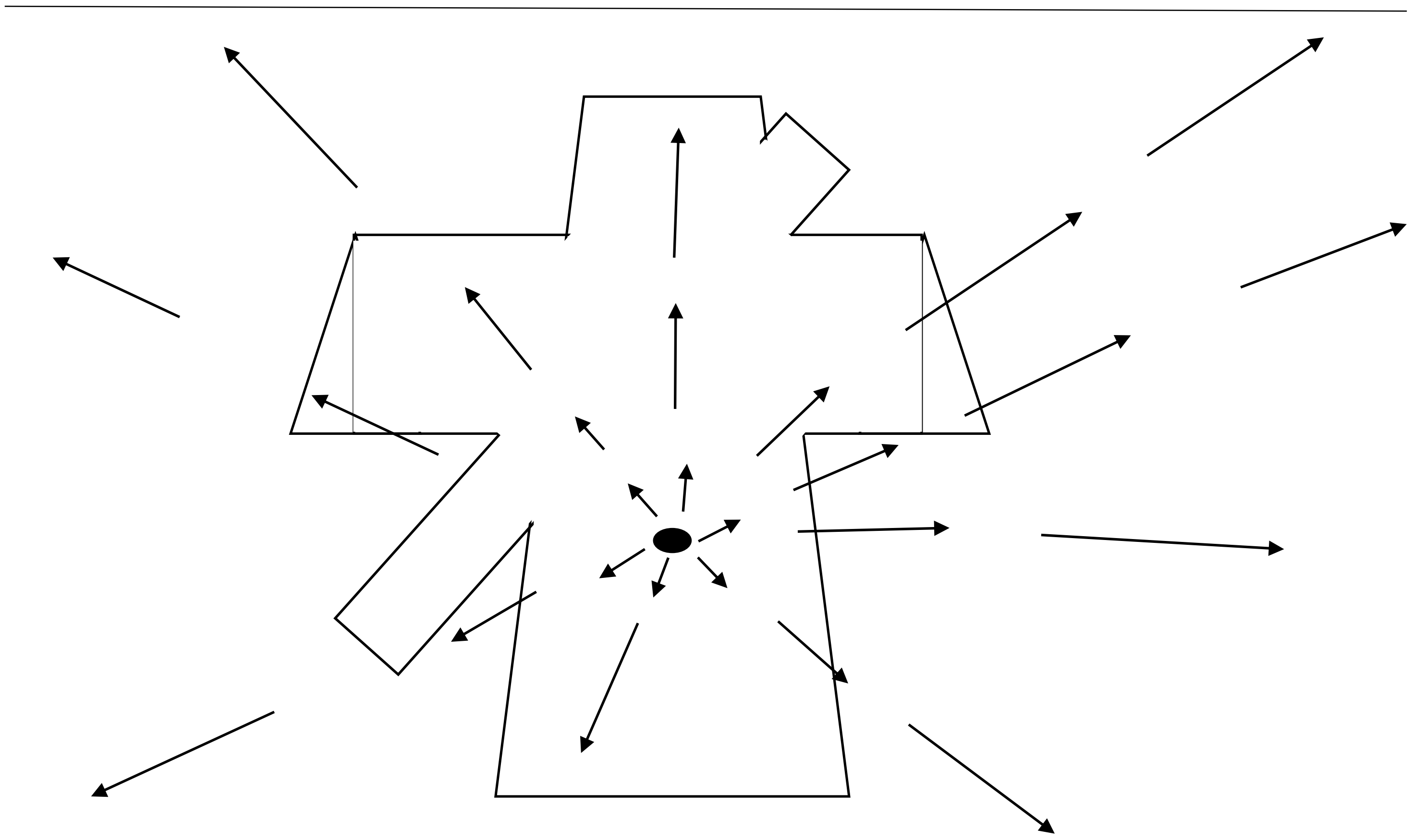
Optic Flow and Focus of Expansion

Also a point in the distance where there is no apparent flow , focus of expansion FOE.

The FOE ⬬ is centred on the person's (pilot's) destination and provides information about where the person is heading

Optic Flow: Self-produced information for perception

Optic Flow for a plane coming into land



<u>Optic Flow and Focus of Expansion</u>

Schematic on the left now shows what the optic flow would look like for a plane coming in for a landing. The place where the focus of expansion ⬬ is located on the runway indicates where the plane will touch down.
The pilot can determine the angle of approach by using information from the rest of the flow pattern and by also using the information provided by the texture gradient on the ground.
The texture gradient on the ground can provide information about the angle of the approaching ground.
Texture gradients can also provide invariant information (they provide information that remains constant even though the person is moving).

Is the concept of optic flow adequate?

2 main questions can be asked with respect to this:

Q1. Is the information provided by optic flow adequate to determine where a moving person is heading?
Q2. Do people actually use this information?

Is the concept of optic flow adequate?

In order to investigate Q1:

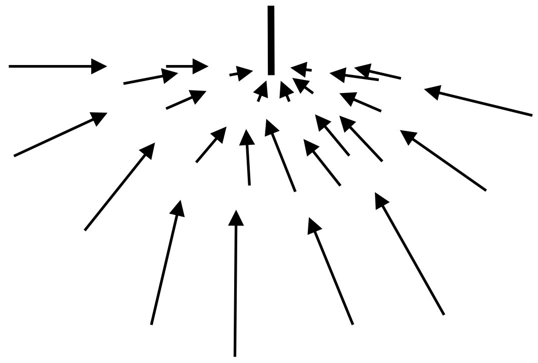
“Is the information provided by optic flow adequate to determine where a moving person is heading?”

Experiments have been conducted to investigate the types of judgments people make when heading towards a destination.

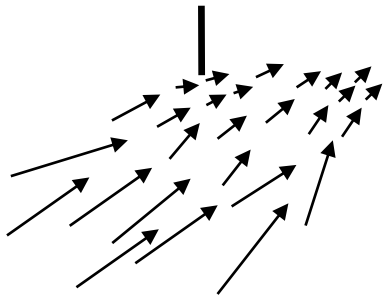
Experiments run in which participants are asked to make judgements regarding their heading based on observing computer-generated optic flow stimuli.

Is the concept of optic flow adequate?

a)



b)



Examples of types of stimuli used to investigate Q1. Participants in the experiment are asked to judge based on computer-generated optic flow stimuli, where they are heading relative to the vertical line.

Participants can do this quite accurately (to ~ 0.5 to 1 degree) (Warren, 1995).

a) Shows optic flow generated by a person moving straight ahead towards vertical line on the horizon.
b) Shows optic flow generated by a person moving in a curved path heading to the right of the vertical line.
Long line = fast speed
Short line = slower speed

(Warren, 1995, In W. Epstein and S. Rogers (Eds) Handbook of Perception and Cognition: Perception of space and motion)

Is the concept of optic flow adequate?

In order to investigate Q2:

“Do people actually use this information?”

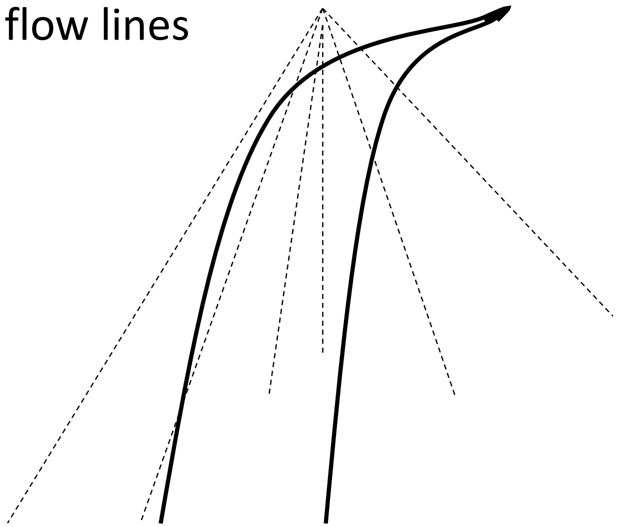
Experiments have been conducted to investigate the types of flow and information people use whilst moving or driving.

Even if optic flow information is available, how much, if any, of this information do they make use of?

Experiments have been designed to look at this using walking or driving tasks.
An early experiment by Lee (1974; 1980) showed that keeping the FOE centred on the destination may not work for a curved road, because the destination keeps shifting as the car negotiates the curve.
Drivers may be using other information in addition to FOE to help them stay on course.

Optic Flow: Self-produced information for perception

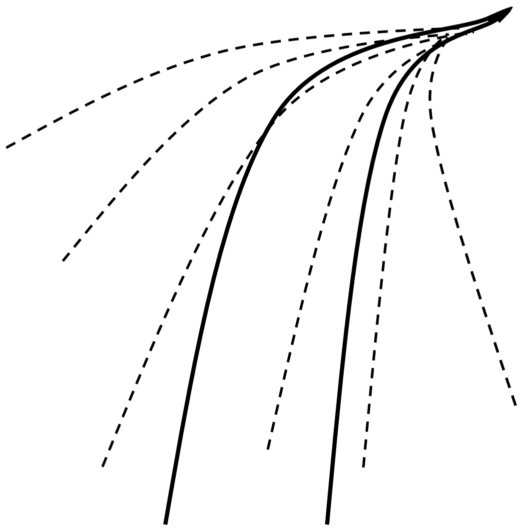
An example is provided below (Lee 1980).
a) If the driver is on a straight road, the optic flow line passing from view directly below the driver [locomotor flow line] is centred on the road. This shows the course the car will make if no adjustments are made. When driver is on course, optic flow lines and edges of the road coincide.



a) Movement along a straight stretch of road

Optic Flow: Self-produced information for perception

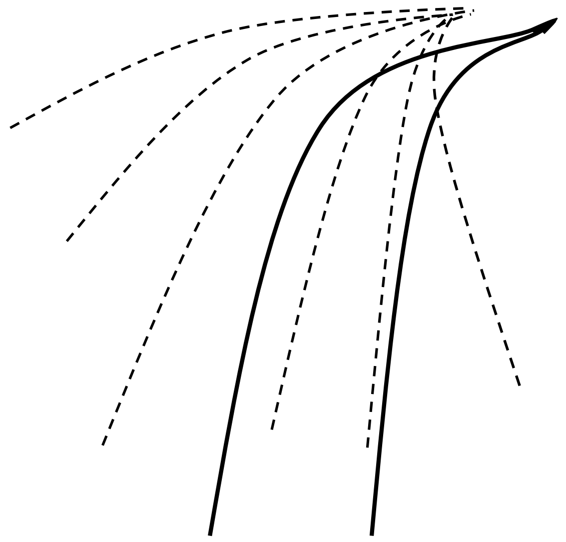
b) When changes are made to the steering, e.g., if negotiating a curve, the optic flow line changes but stays lined up with the road, as long as the driver is on course.



b) Correct negotiation of
a curved stretch of road

Optic Flow: Self-produced information for perception

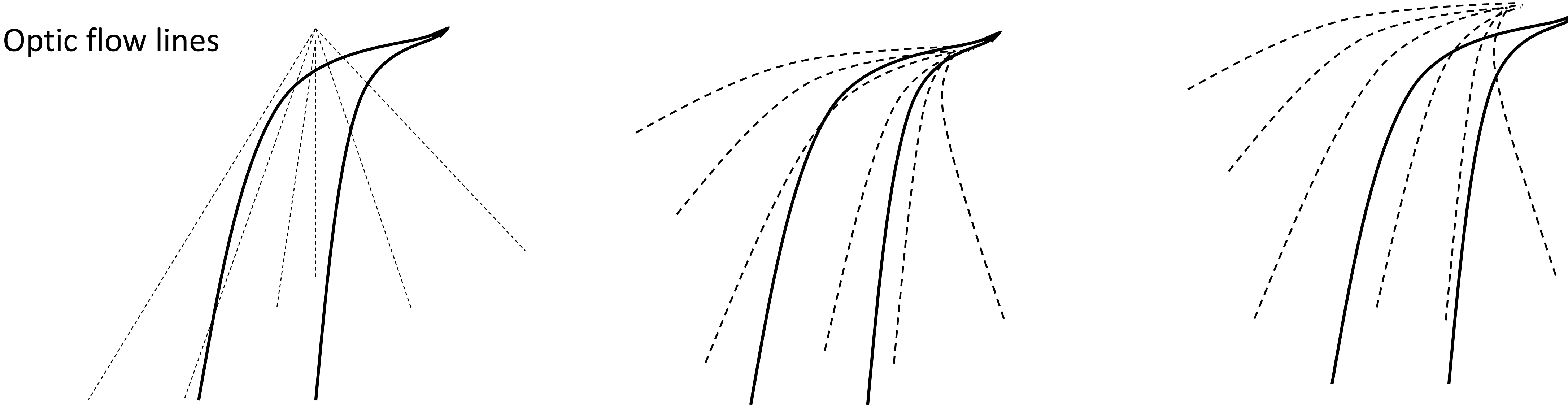
c) However, if the driver begins going off course, optic flow lines and road no longer match up.



c) Incorrect negotiation of a curved stretch of road

Optic Flow: Self-produced information for perception

It was therefore proposed by Lee (1980), that in such cases drivers probably use the "locomotor flow line" rather than the FOE to help them stay on course whilst driving.



a) Movement along a straight stretch of road

b) Correct negotiation of a curved stretch of road

c) Incorrect negotiation of a curved stretch of road