



# Human perception, action, and motor control 101

Game Analysis 2020

Aalto University

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Fourth Edition

# Motor Learning and Performance

## A Situation-Based Learning Approach

- Includes access to
  - online study guide
  - 20 experiential labs



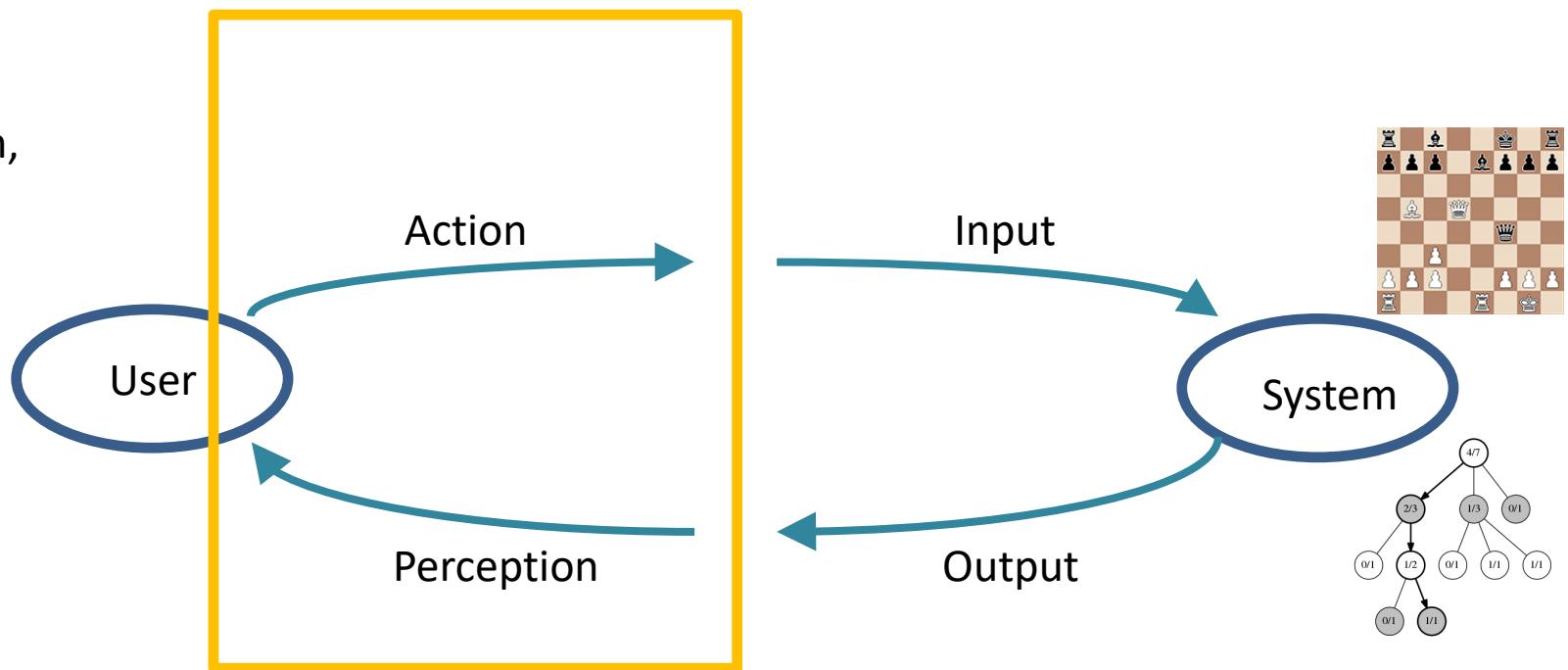
Richard A. Schmidt  
Craig A. Wrisberg

# Topics

- Reaction time
- Aiming, hitting, catching
- Importance of automation
- Limits of attention



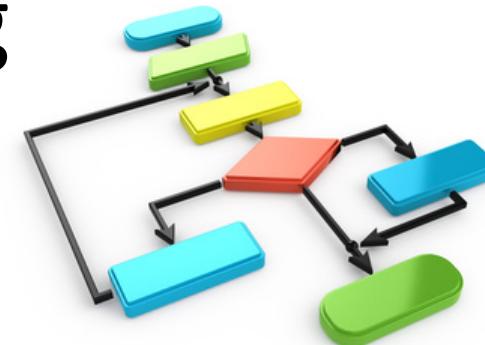
Cognition,  
motivation,  
emotion



Action games & exergames: perceptual and motor challenges are central part of the game

# Theoretical framework: two types of thinking

SYSTEM 2: EXPLICIT/CONSCIOUS:  
SLOW, ALGORITHMIC, EFFORTFUL

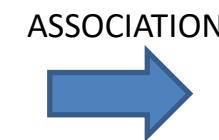


ATTENTION,  
PRIMING,  
INHIBITION



IDEAS,  
ASSOCIATIONS,  
IMPULSES  
(AUTOMATION)

SYSTEM 1: IMPLICIT/UNCONSCIOUS:  
FAST, ASSOCIATIVE, EFFORTLESS,  
INTUITIVE



©Warren Photographic

# Topics

- **Reaction time**
- Aiming, hitting, catching
- Importance of automation
- Limits of attention

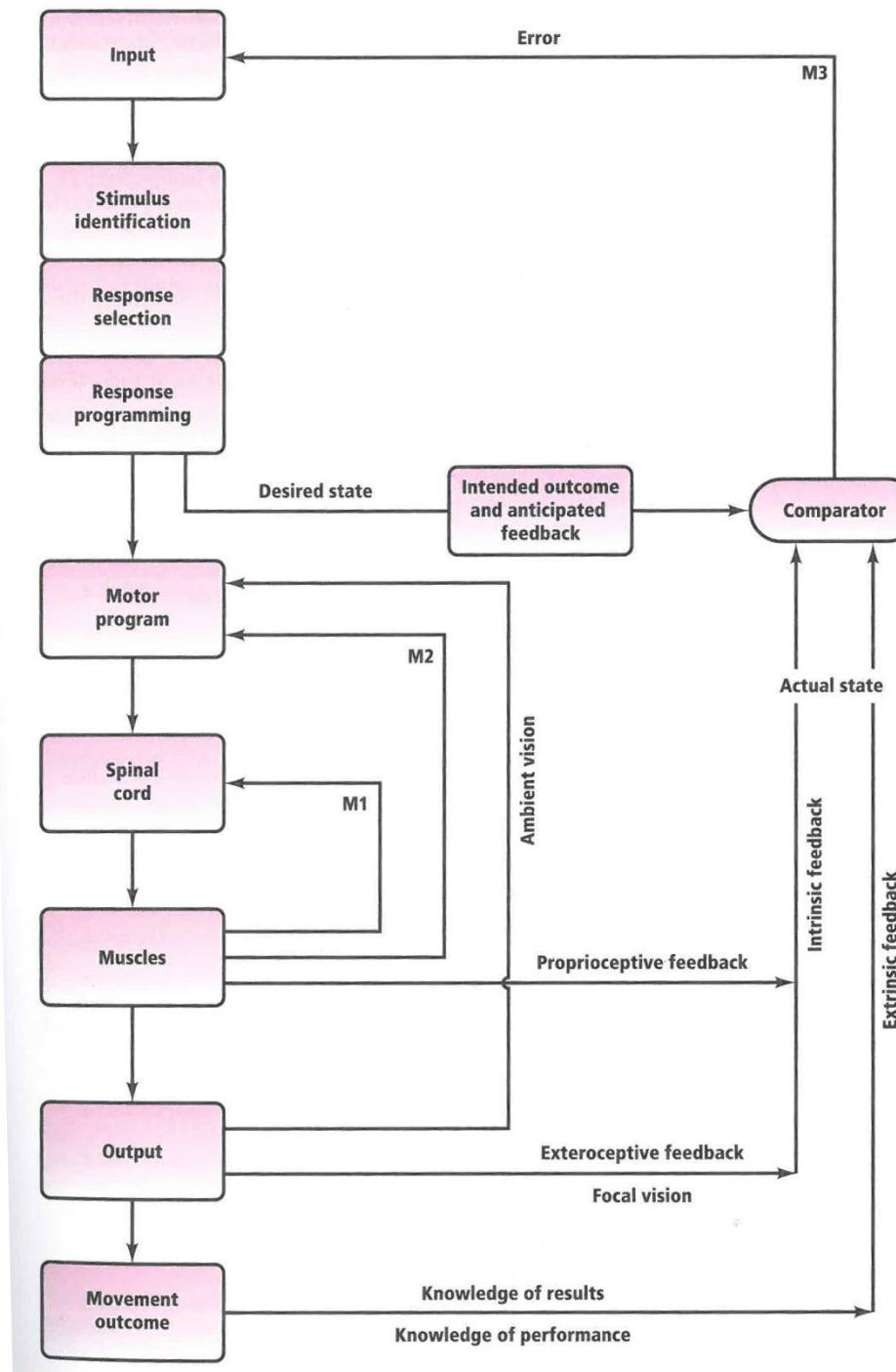
# Reaction time

- QTEs
- Blocking, evading, countering

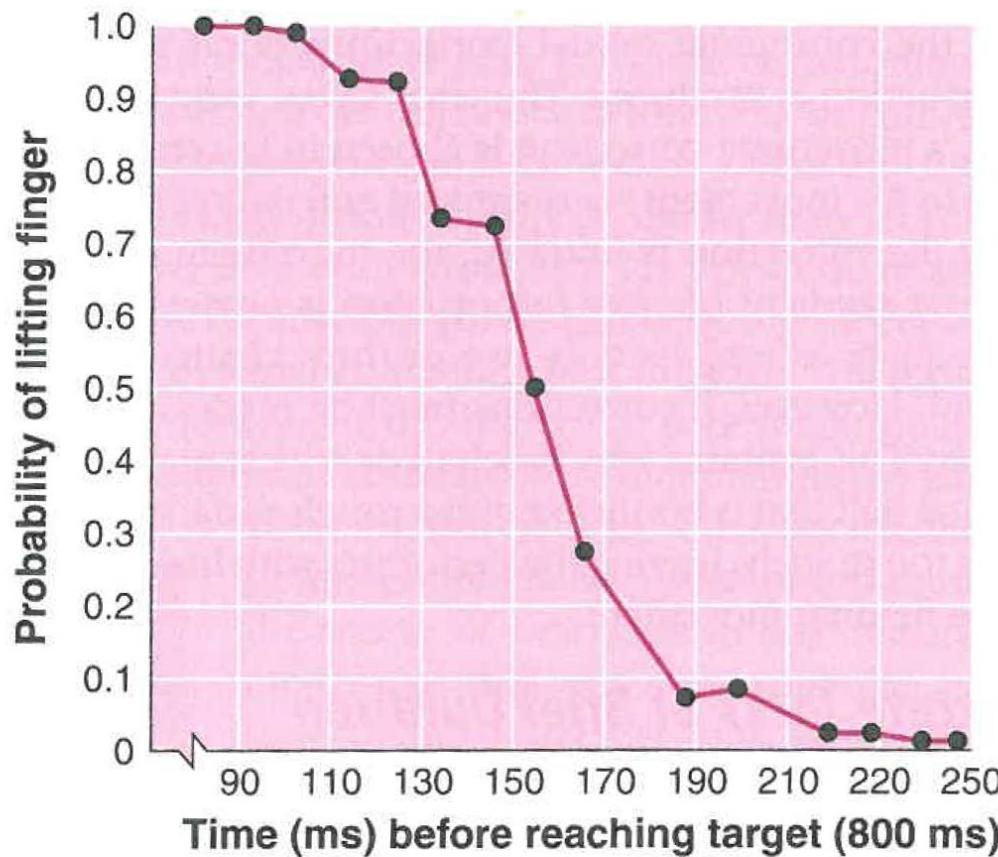


# Reaction time

- Our reactions can be controlled or automatic
- Controlled reactions are slower
- In general, our reaction time is around 150-200ms
- Even faster reactions possible through automatic processing, acting without thinking
- Stimulus intensity, size and location matter



# Slater-Hammel's Experiment



Movements are initiated 150-170ms ahead and can't be inhibited once initiated.

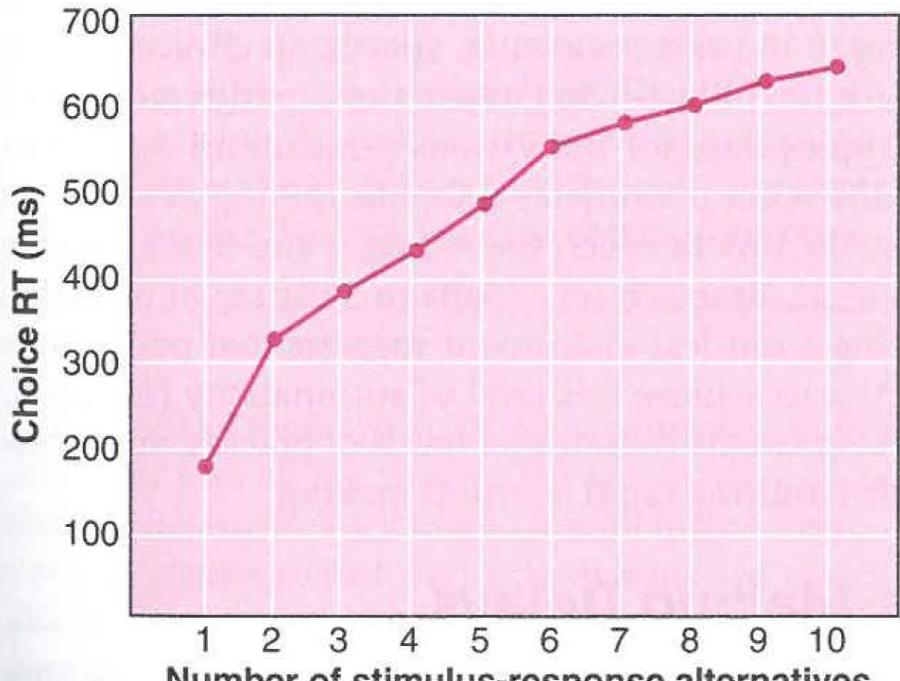
**Figure 3.7** The probability of lifting the finger though the clock hand had stopped, plotted as a function of the interval of time before the 800 ms position. (Adapted from Slater-Hammel, 1960.)



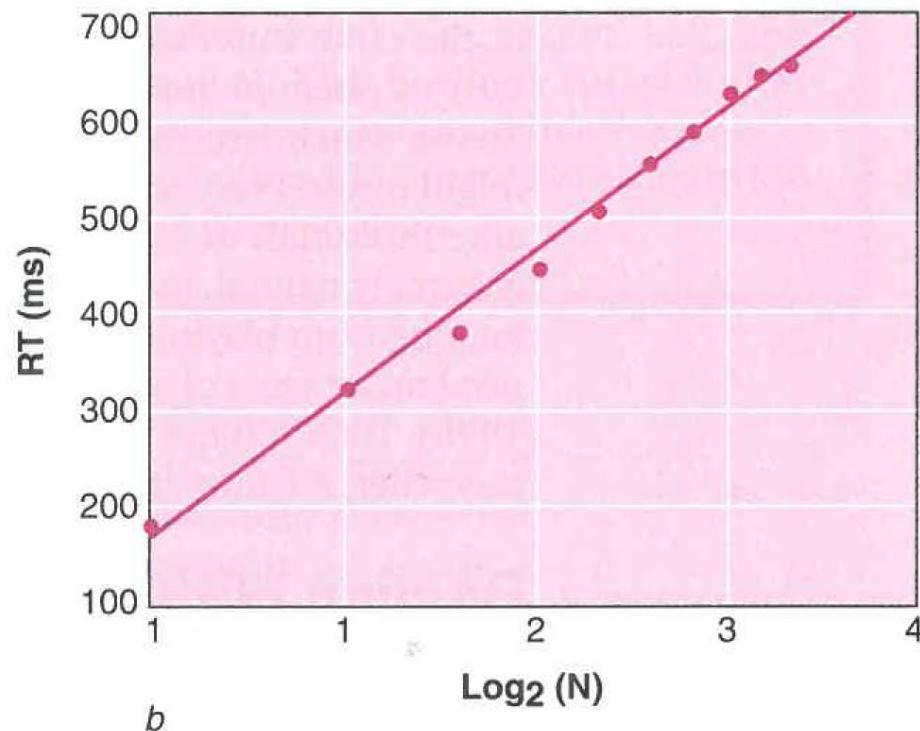
# Things affecting reaction time

- **Hick's Law (number of alternative reactions)**
- Intuitiveness (stimulus-response compatibility)
- Anticipation (animations matter)

# Hick's law



a



b

**Figure 2.3** (a) The relationship between choice reaction time and the number of stimulus-response alternatives and (b) the linear relationship between choice reaction time and the  $\log_2$  of the number of stimulus-response alternatives, which is the relationship known as Hick's law. (Adapted from Woodworth, 1938; data obtained by Merkel in 1885.)



# Things affecting reaction time

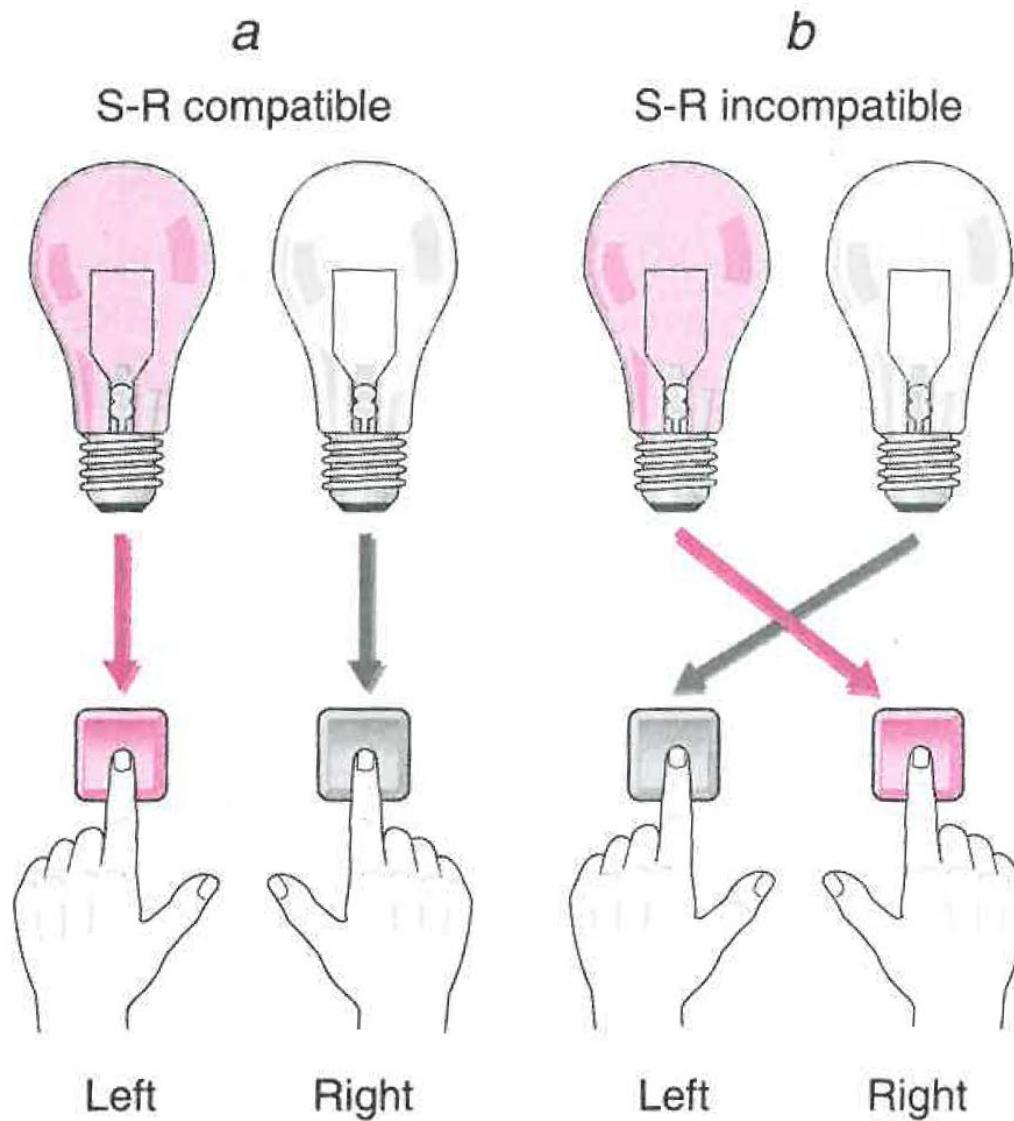
- Hick's Law (number of alternative reactions)
- **Intuitiveness (stimulus-response compatibility)**
- Anticipation (animations matter)

“Intuitive use of products involves utilising knowledge gained through other experience(s). Therefore, products that people use intuitively are those with features they have encountered before. Intuitive interaction is fast and generally non-conscious, so people may be unable to explain how they made decisions during intuitive interaction (Blackler, 2008; Blackler, Popovic, and Mahar, 2002; Blackler, Popovic, and Mahar, 2003)”



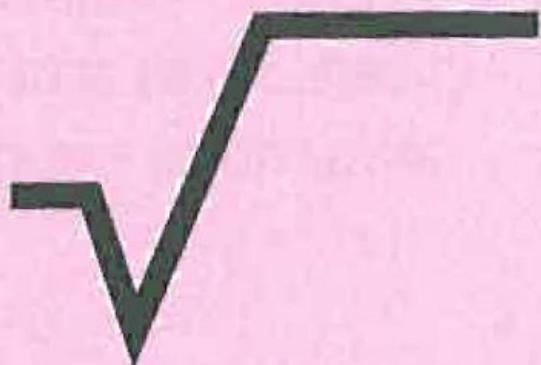
# Intuitiveness

- Stimulus-response compatibility
- Mouse look inverting
- Even more important with full-body control where common design patterns yet to emerge



**Figure 2.4** Stimulus-response compatibility. The relationship between stimulus and response is more natural, or compatible, in the situation on the left (*a*) than on the right (*b*).

Irrelevant forms



vs.

±

A red plus-minus symbol, with a vertical line through a horizontal bar, used here as an irrelevant form.

Word names

MAROON

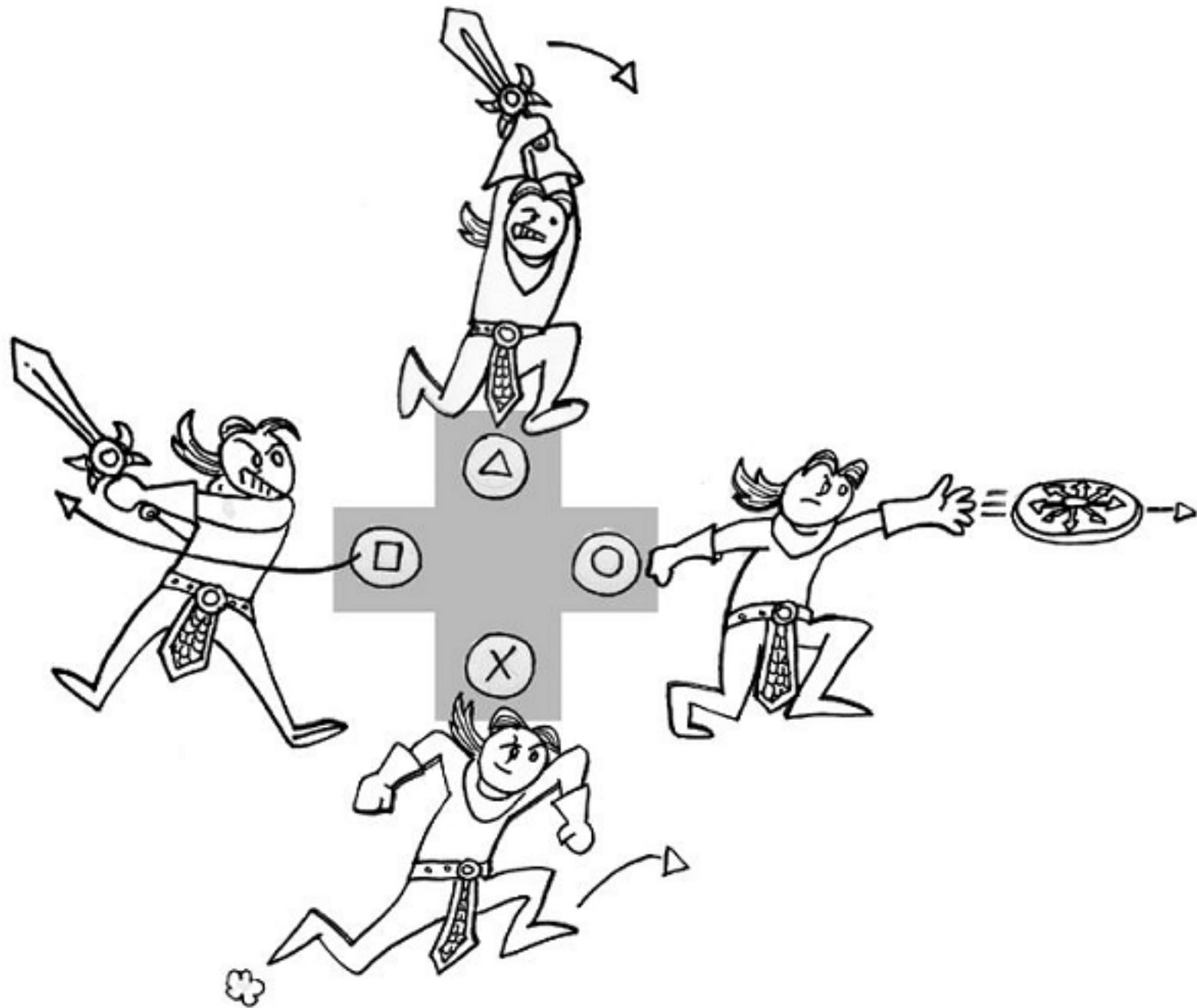
vs.

BLACK

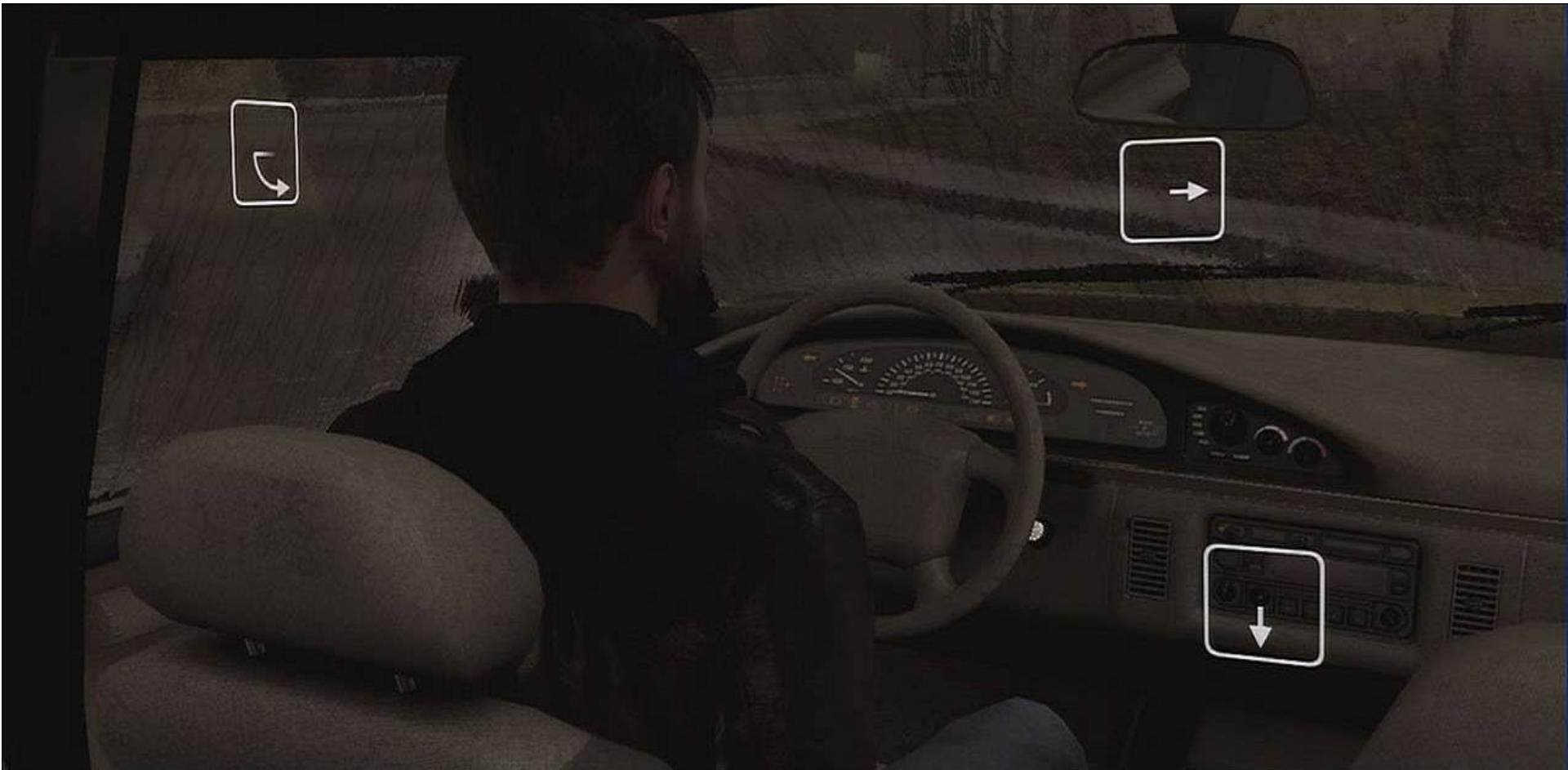
**Figure 2.9** The Stroop effect. When ink color and form of stimulus conflict, reaction time to name the ink color is slowed.

# Control-response compatibility





# Heavy rain



<https://youtu.be/Z91z9fGR-t0?t=1m6s>

# Things affecting reaction time

- Hick's Law (number of alternative reactions)
- Intuitiveness (stimulus-response compatibility)
- **Anticipation (animations matter)**

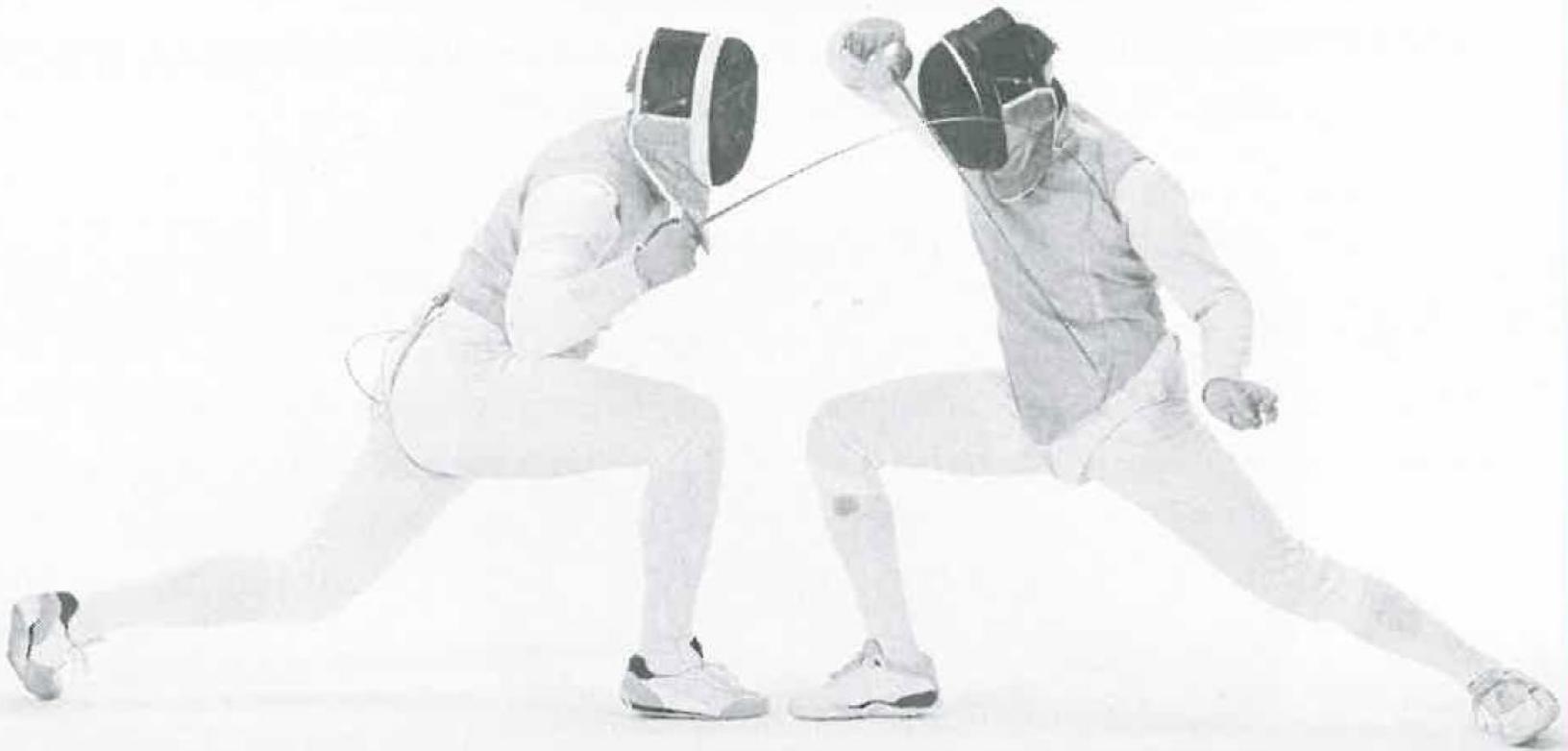
# Anticipation

- Spatial and temporal anticipation can make reactions both fast and controlled
- Orchestra starting synchronously (notes, count-in)
- Anticipation can be trained (e.g., tennis with shutter glasses)

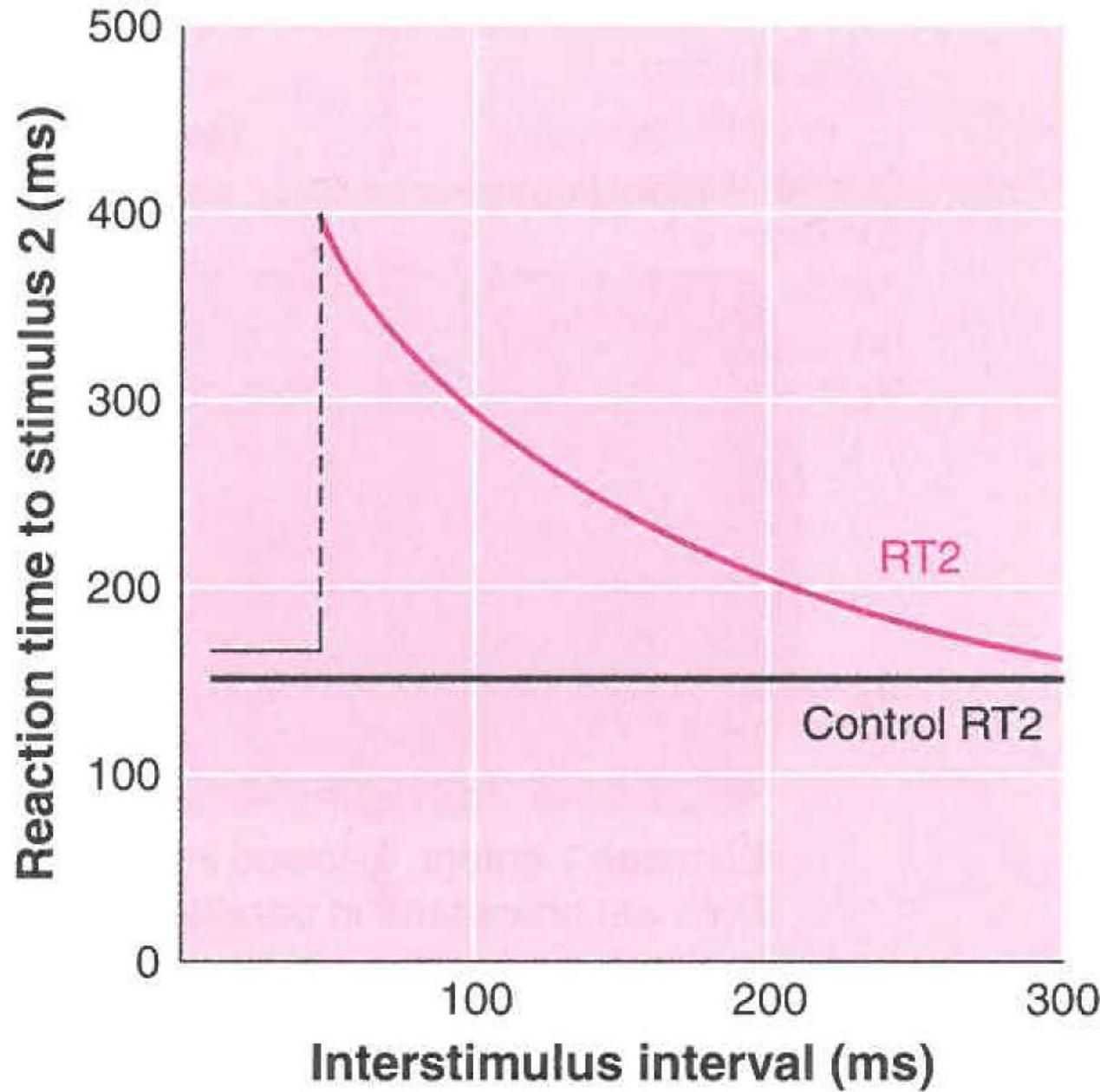
# Supporting anticipation using a timeline

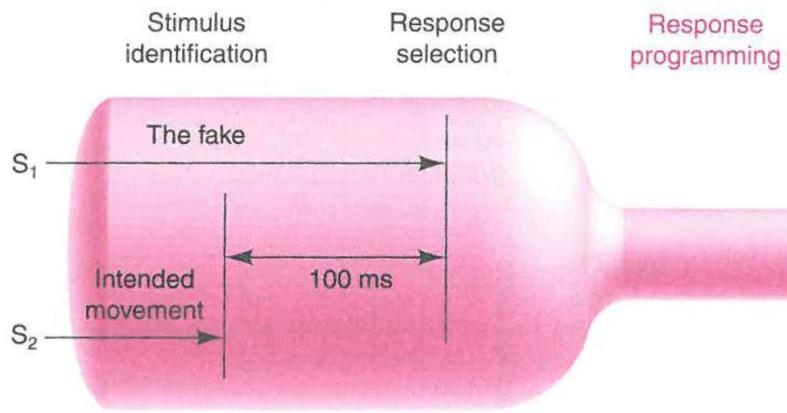


# The fake

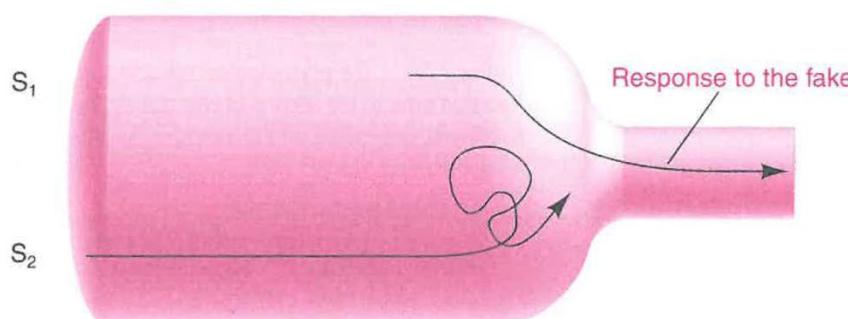


A faked movement followed closely in time by an actual movement can lure an opponent into an incorrect anticipation.

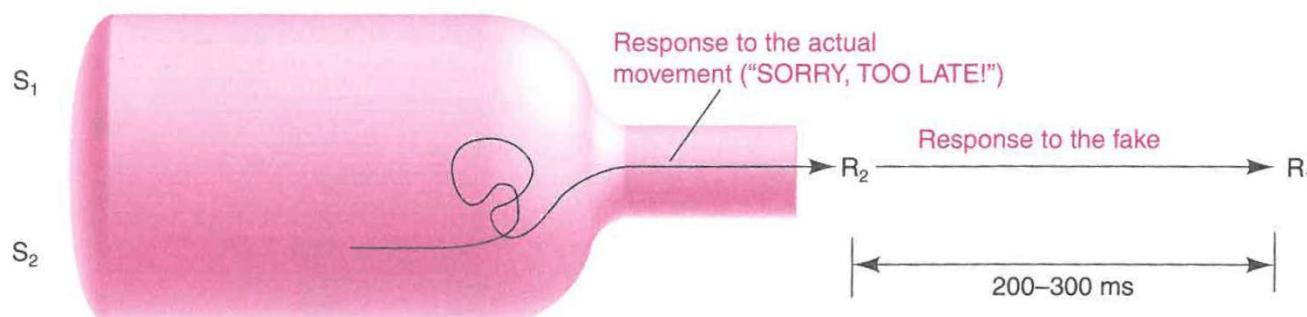




Stimulus 1 enters, followed in 100 ms by Stimulus 2.  
Both are processed in parallel until Stimulus 1 reaches  
the bottleneck in the response-programming stage, where



Stimulus 2 must wait until the response-programming  
stage is cleared for further processing, so



Response 1 and Response 2 are separated by far  
more than 100 ms.

- The optimal fake duration is 50-60ms (in the simplified experiment with a short stimulus identification time)
- Shorter: no effect
- Longer: opponent may have completed the response to the fake and can react again



# The fake & games

- How common is faking in games?
- Can and should we provide opportunities and tutorials for faking in multiplayer games?
- How do the game animation systems support faking? Blends/transitions need to be optimized
- Faking and automatic fake detection as upgrades?

# Faking in Clash Royale

- Optimal fake duration is longer than in, e.g., real-life boxing
- Card deploy latency (1s) increases pressure to react fast => fakes can be more powerful
- The slowly replenishing elixir means that reacting to a fake blocks one's further actions for a longer time.
- Optimal fake: wait for the opponent to react, select the fake such that the opponent commits a large amount of elixir

# Things affecting reaction time

- Hick's Law (number of alternative reactions)
- Intuitiveness (stimulus-response compatibility)
- Anticipation (animations matter)

# Exercise: Fight choreography

- How to allow the player to execute semi-interactive pre-choreographed fight with high tempo?
- Nice choreographies but slow: Uncharted 3 bar fight, God of War 3 intro
- Goal: Asian martial arts where several blows are exchanged per second

# Solutions (fast-paced action choreography)

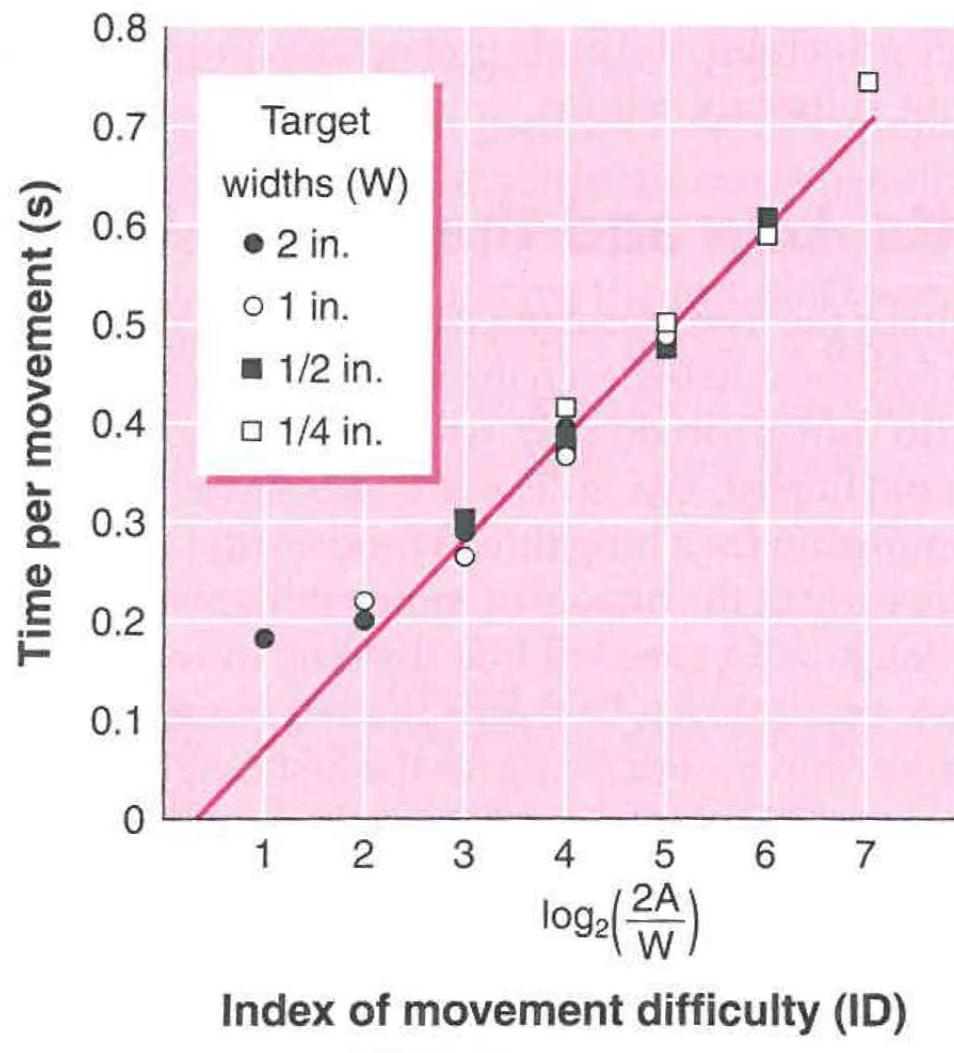
- Slow down time and let the player see the future (reaction time, anticipation), then show a real-time replay
- Some form of timeline display that allows anticipation and planning of movements in advance

# Topics

- Reaction time
- **Aiming, hitting, catching**
- Importance of automation
- Limits of attention

# Fitt's law

- Related to all kinds of aiming and reaching movements
- Movement time is proportional to the logarithm of  $2A/W + 1$ , where A is the distance and W is width of target



**Figure 5.6** Fitts' law. The average time per movement is linearly related to the index of difficulty (ID). Target widths (W) are shown by the various symbols. For any given symbol, the movement distances (A) from left to right are 2, 4, 8, and 16 in., respectively.

# Exercise: Sniper mode

- A basic sniper scope doesn't change the (motor space) distance to target size ratio, only enhances vision, and thus does not improve aiming time (provided that the target is originally more than a few pixels wide)
- Design and/or describe an aim assist system or sniper mode that provides an advantage based on Fitt's law



# Answers

- A chemical weapon that actually makes the heads of enemies bigger – cheap and funny
- Magnetic reticule – reduces distance by snapping to target when close enough
- Autotargeting – cycle targets with a button
- Fitt's law says that mouse sensitivity has no effect!
- Steam controller: two parallel control methods (gyro and touchpad) that can use different sensitivities
- GDC 2013 talk: "Techniques for building aim assist"

# Topics

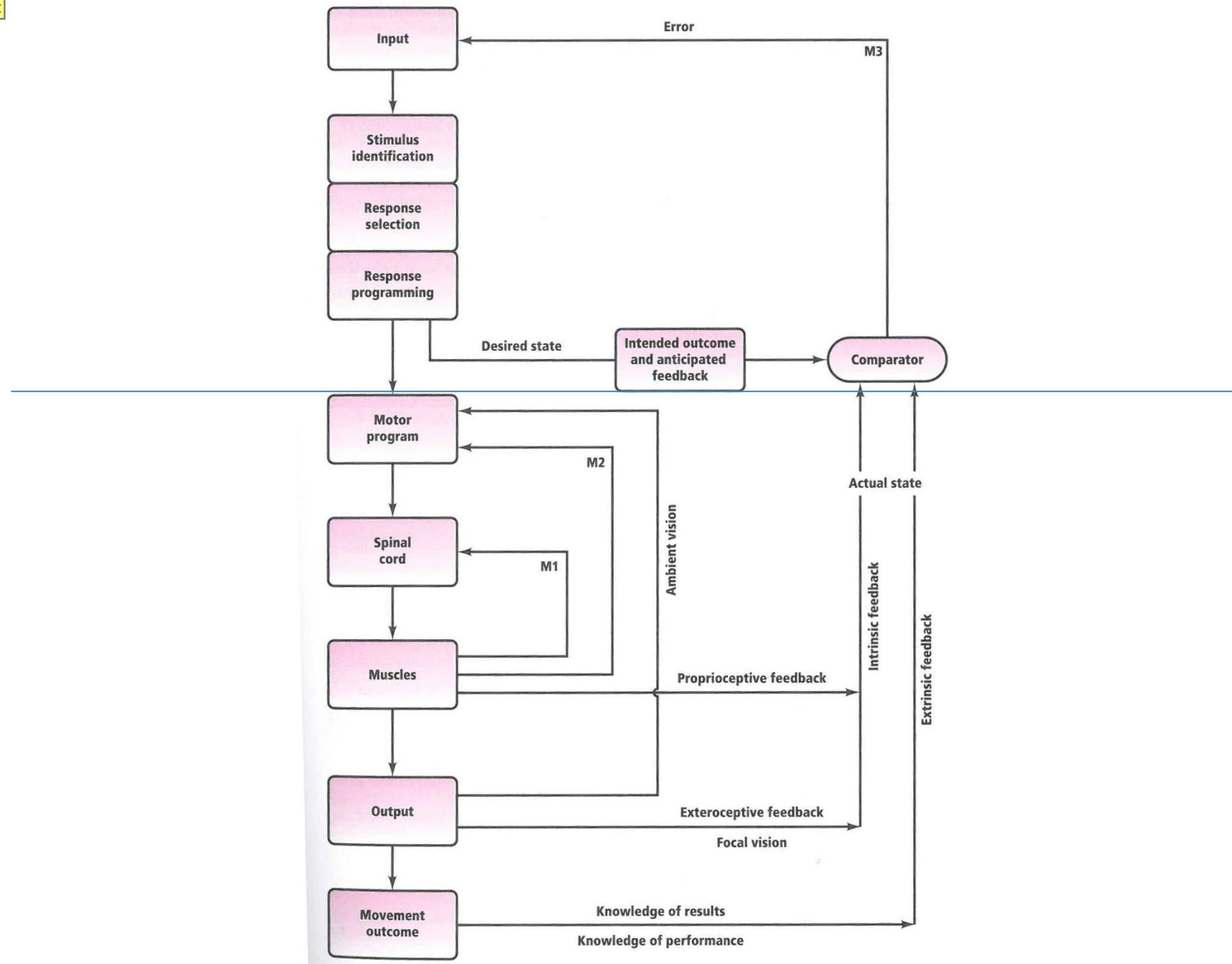
- Reaction time
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# Automatic vs. conscious

- In both cognitive and motor learning, things become automated through repetition
- Conscious = slow, effortful, requires attention
- Automated = fast, effortless, requires no attention
- Again, it's a continuum, not a clear-cut division

# Example





# Automatic vs. controlled/conscious

- Example: reading.
- Extreme example: reading aloud while thinking of something altogether different

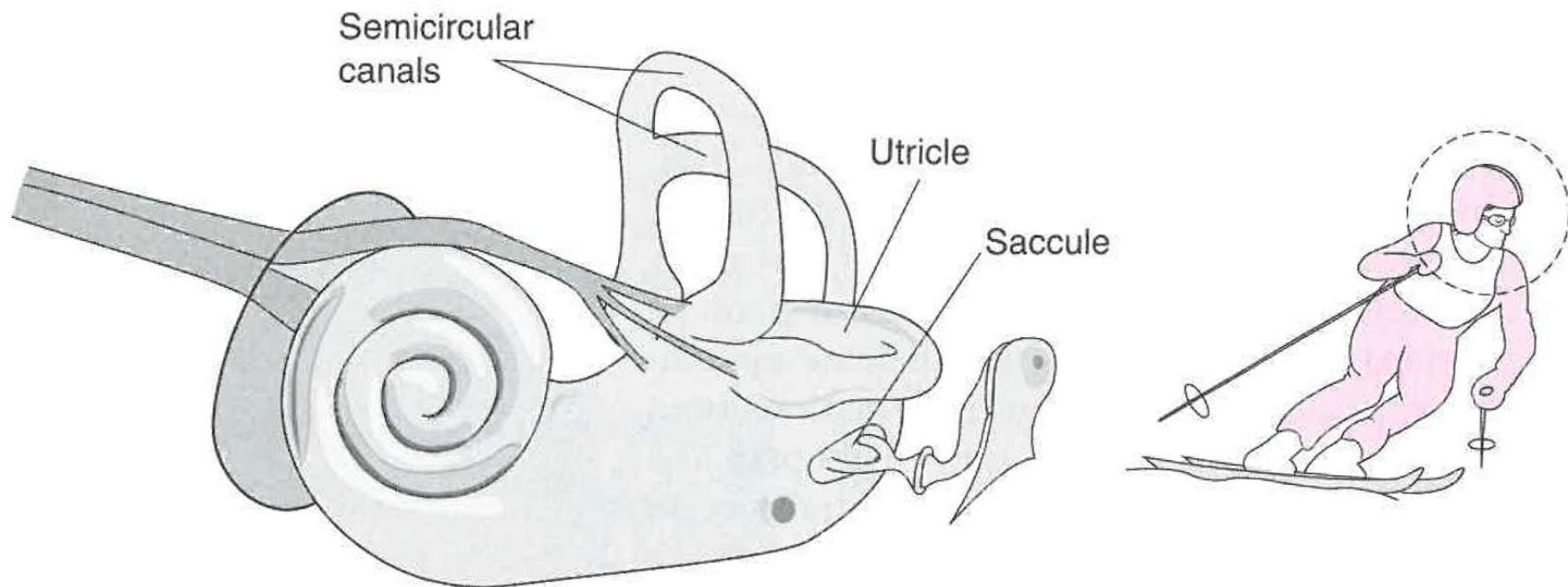
# Automatic vs. controlled/conscious

- Example: choking under pressure
- Skilled athletes perform best under automation
- Pressure may cause one to think too much, attempt to consciously control what should be automated. Focusing/trying too much may cause a failure ("lost move syndrome")

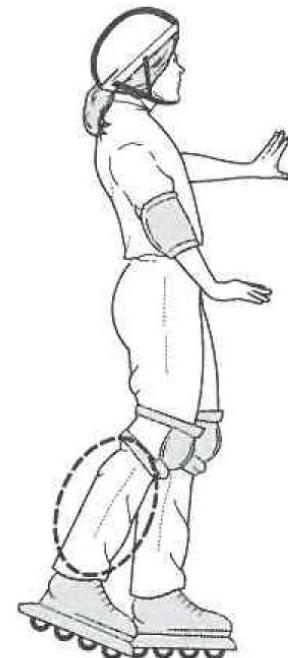
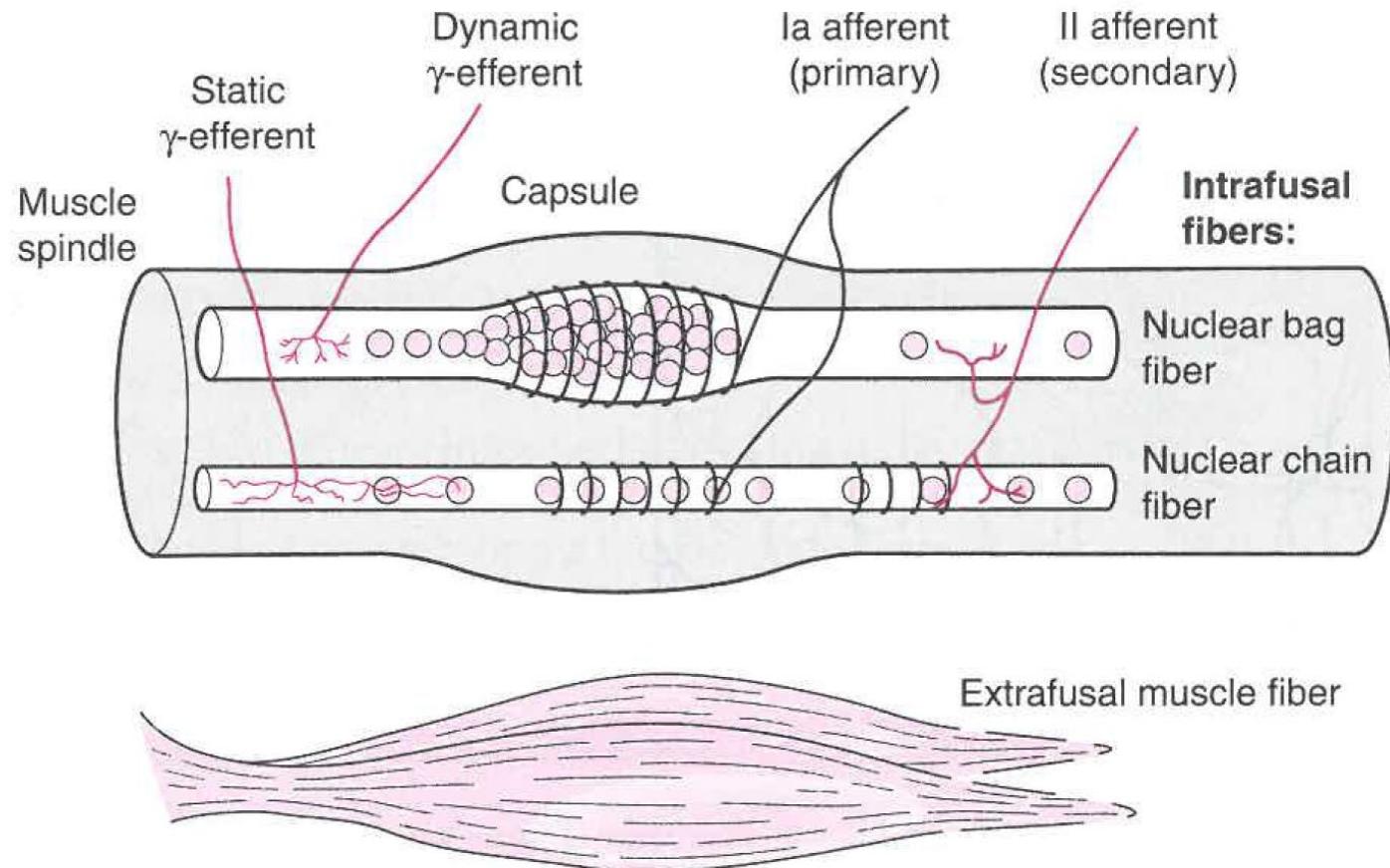


# Games vs. Real life

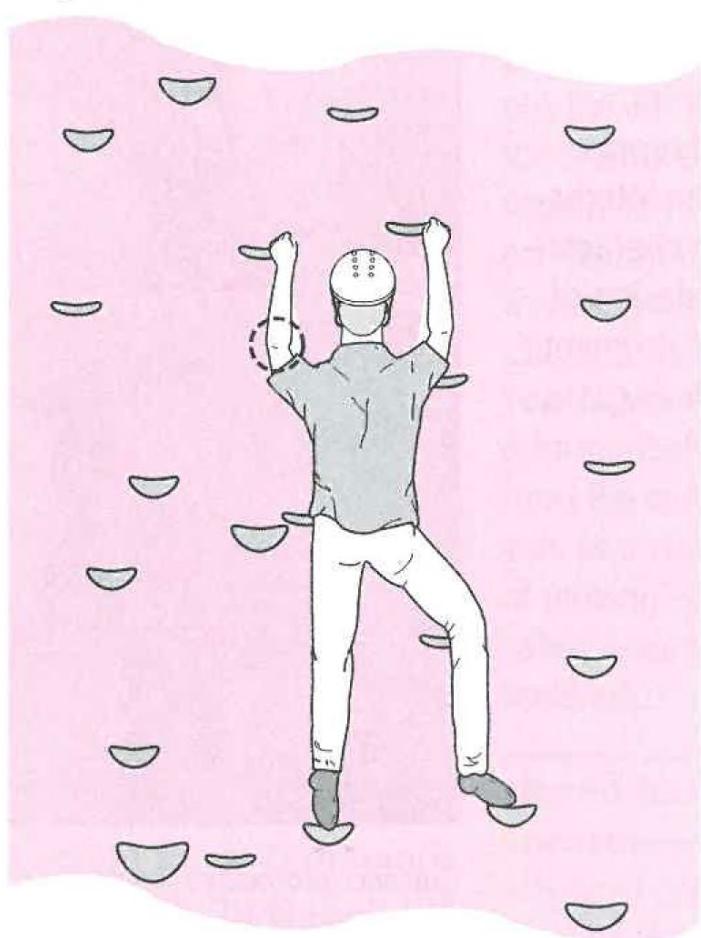
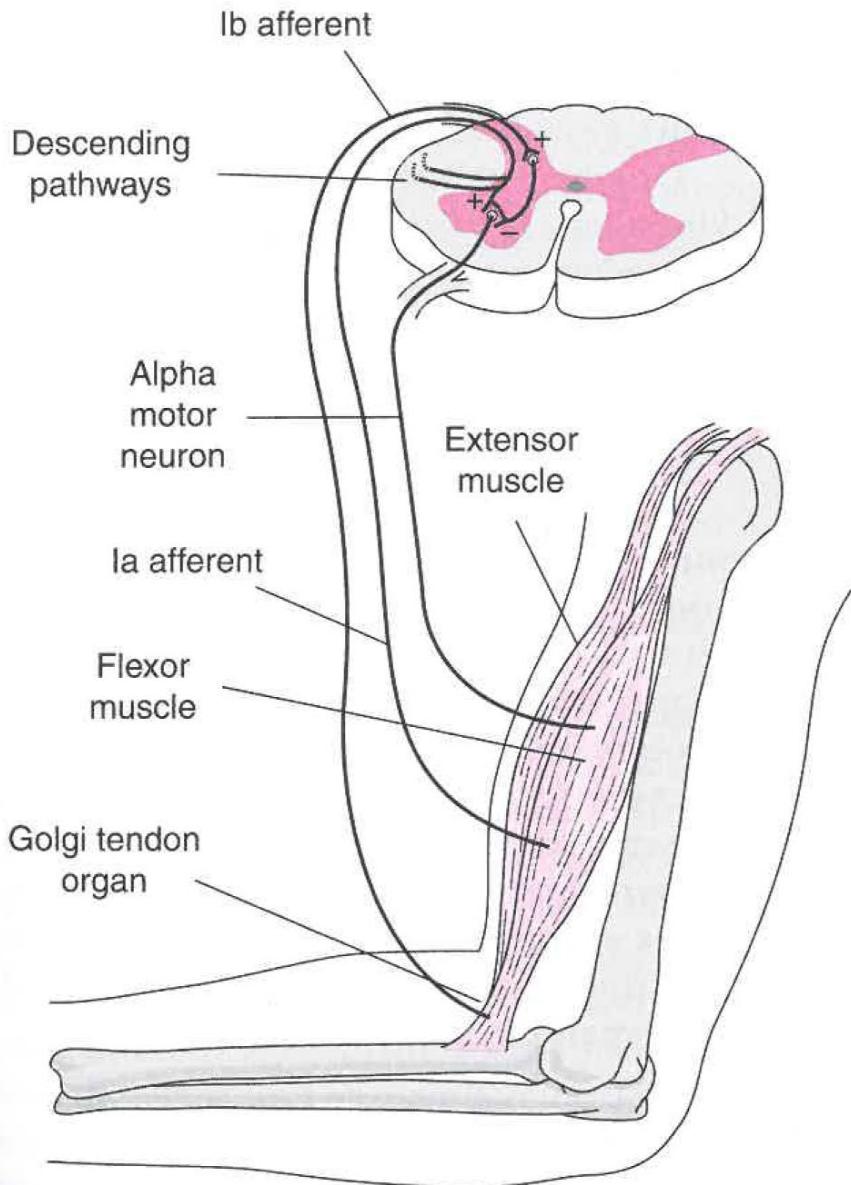
- Games lack many sources of sensory information that contribute to automatic actions and unconscious control of motor skills
- Other than 1st person immersive VR games lack or distort ambient vision => must rely on consciously controlled movements or relearn control on an automatic level.
- Input latency increases reaction time
- Input-output latency slows down the closed control loop



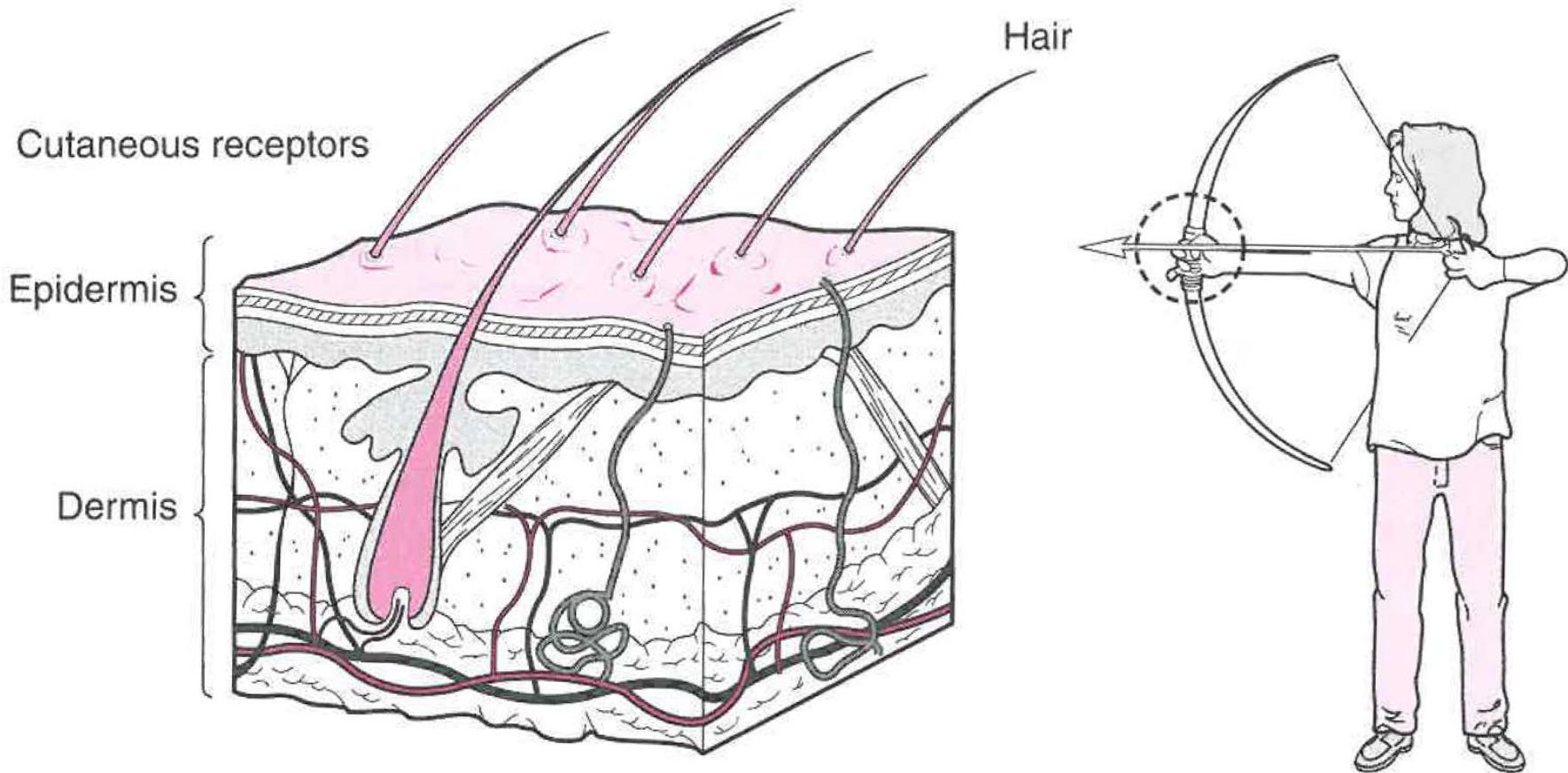
**Figure 3.1** The vestibular apparatus in the inner ear provides important information for posture and balance.



**Figure 3.2** Muscle spindles provide important information about limb position and movement.



**Figure 3.3** Golgi tendon organs provide important information about muscle tension.



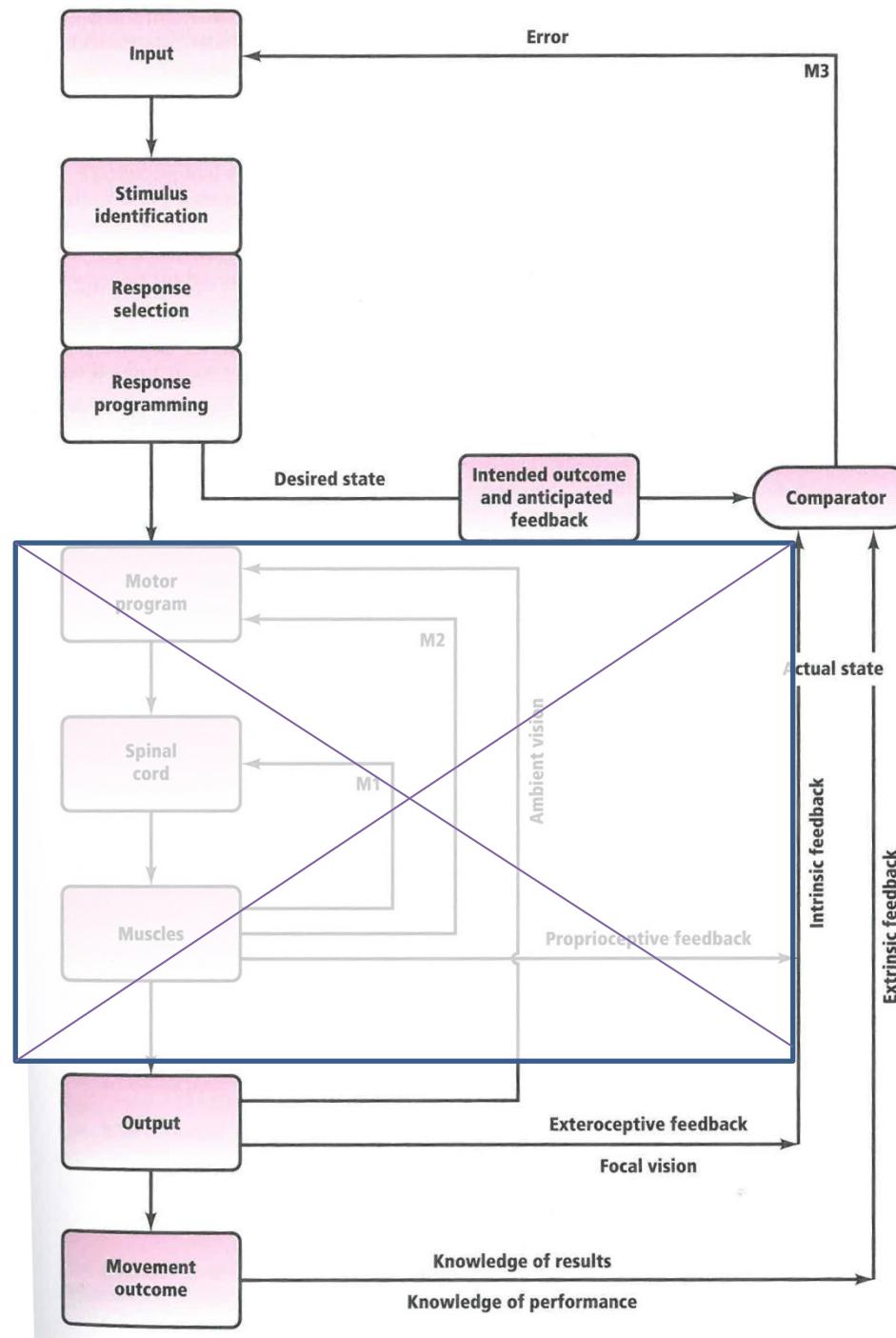
**Figure 3.4** Cutaneous receptors provide important information about pressure and touch.

# Focal and ambient vision

- Focal: center of the visual field. Answers: What is it? Processed consciously.
- Ambient: the whole visual field. Used both consciously and on an automatic/unconscious way. Information about movement, e.g., time to target.
- Optical flow: the movement of light on the retina because of movement. Can be used to compute things about movement without identifying the moving object.

# Optical flow





# Example: catching and intercepting

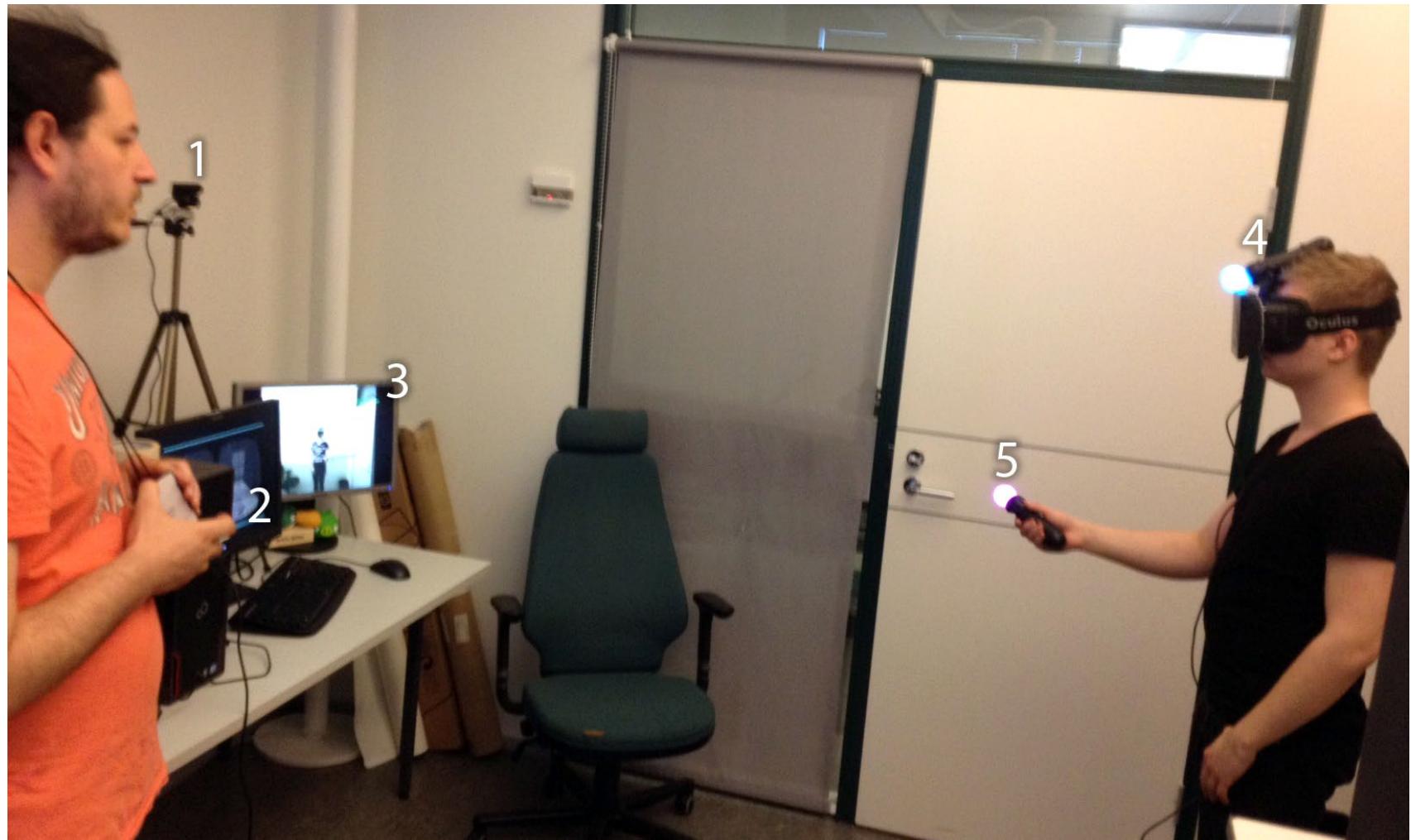
- Catching and intercepting rapidly flying objects is not possible using closed-loop control
- IRL it's learned on an automatic level based on ambient vision (optical flow on retina)



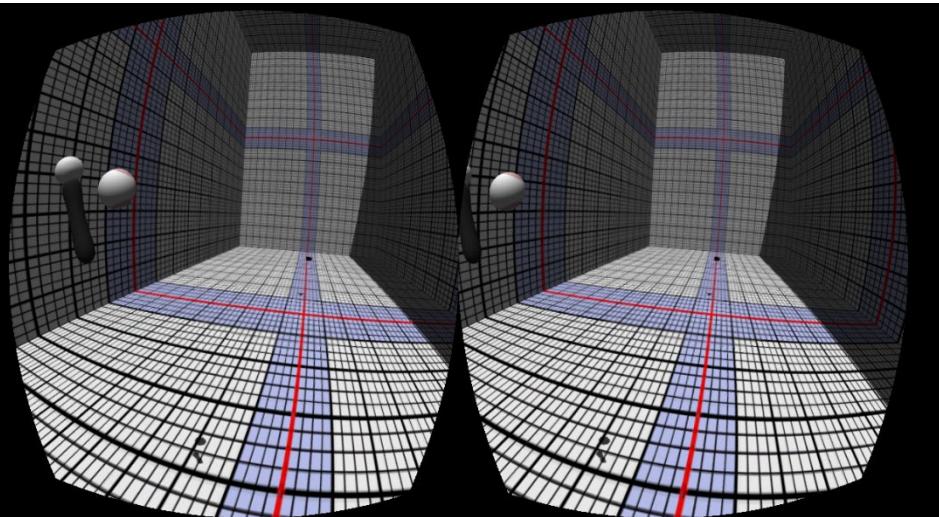
# Exercise: catching with impaired vision

- Together with a pair, throw and catch an object with a single hand in the following three ways:
  - Both eyes open (stereo and ambient vision)
  - Only one eye open (ambient but no stereo)
  - Looking through your fist (no ambient or stereo vision, only focal)
- 5 throws each. Count and write down the number of successful catches

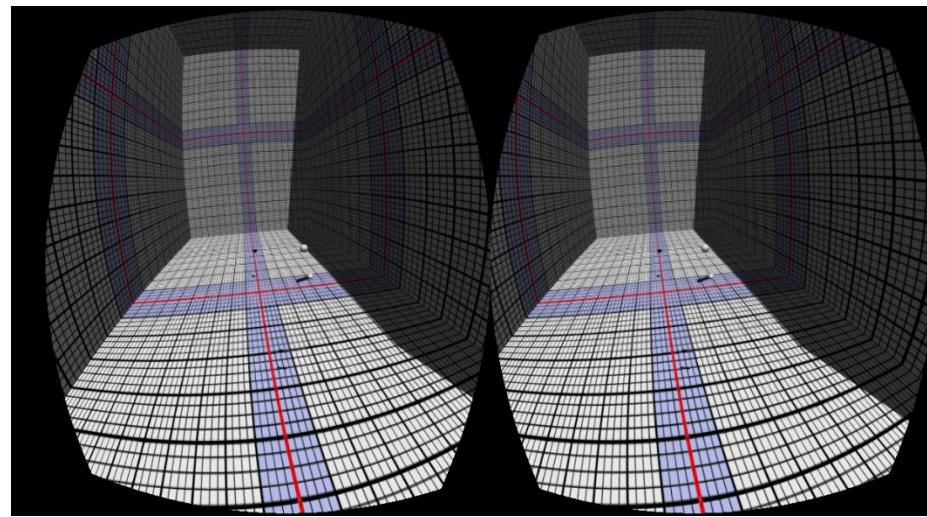
# Ball catching and camera views?

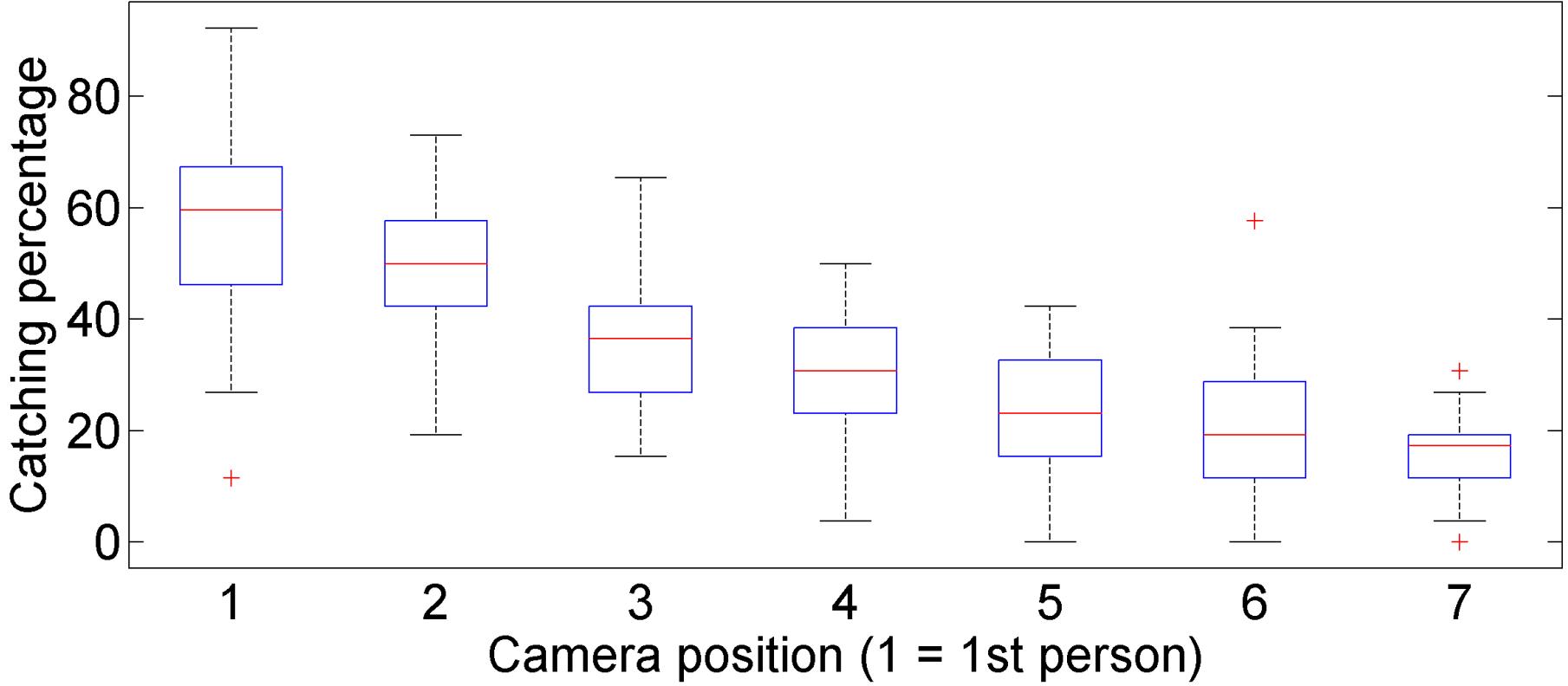


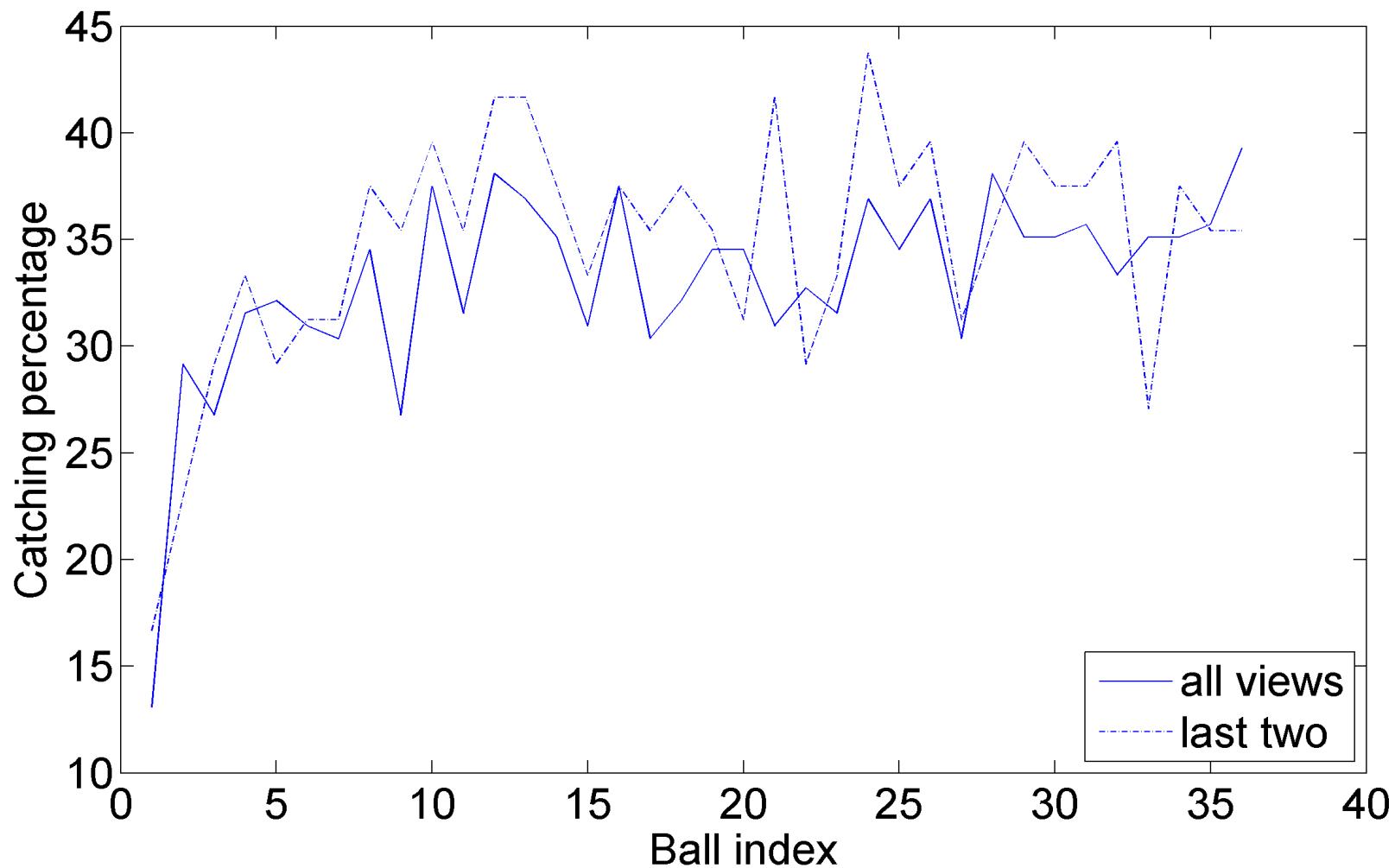
1<sup>st</sup> person



3<sup>rd</sup> person

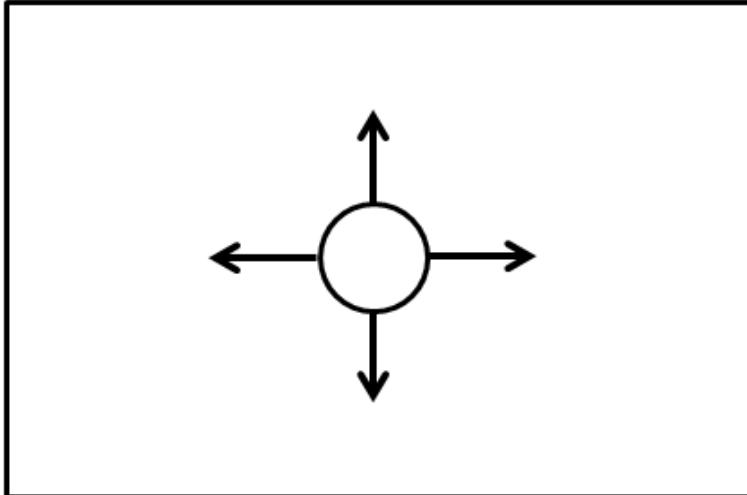




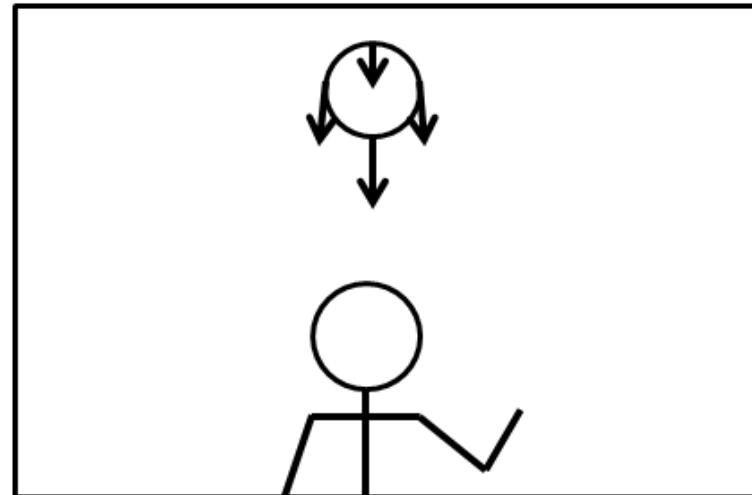


# One explanation: optical flow

1<sup>st</sup> person



3<sup>rd</sup> person



# Dealing with impaired ambient vision

- For precisely controlled action, the player typically needs more time and artificial visual aids compared to real life
- Realistically blockable punches & kicks are not enough

# Dealing with impaired ambient vision

- Snap (slide) to target
- Kung-Fu Live: anticipative attack hints
- PS Move Table tennis: snap to target, anticipative hints about ball trajectory



# Snap to target

- Common in fighting games
- Contributes to effortlessness and competence
- Makes AI and animation design easier
- Allows more dynamic movement and use of a larger space



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trial version

# Topics

- Reaction time
- Aiming, hitting, catching
- Importance of automation
- **Limits of attention**

# Multitasking and attention

- We can't really multitask consciously
- In reality, we time-slice with our "conscious CPU"
- Only automatic, unconscious actions can run in parallel



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- Kahneman: "The gorilla study illustrates two important facts about our minds: we can be blind to the obvious, and we are also blind to our blindness."



# Attentional blindness and games

- Be conscious and cautious of where you guide the player's attention and gaze. E.g., speech bubbles vs. subtitles
- Avoid making player blind to relevant feedback
  - Keep feedback visible until the player can pay attention
  - Provide feedback where the player is looking
  - If feedback not where the player is looking, draw attention to it. EXAGGERATE, ANIMATE!



# How is it done right?

- Any successful F2P game: coins/gems/X fly from action to the scoring display
- Curved flight path => harder to predict, holds gaze (a trick magicians often use)

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