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The University of Manchester
BIOL21332 Motor Systems

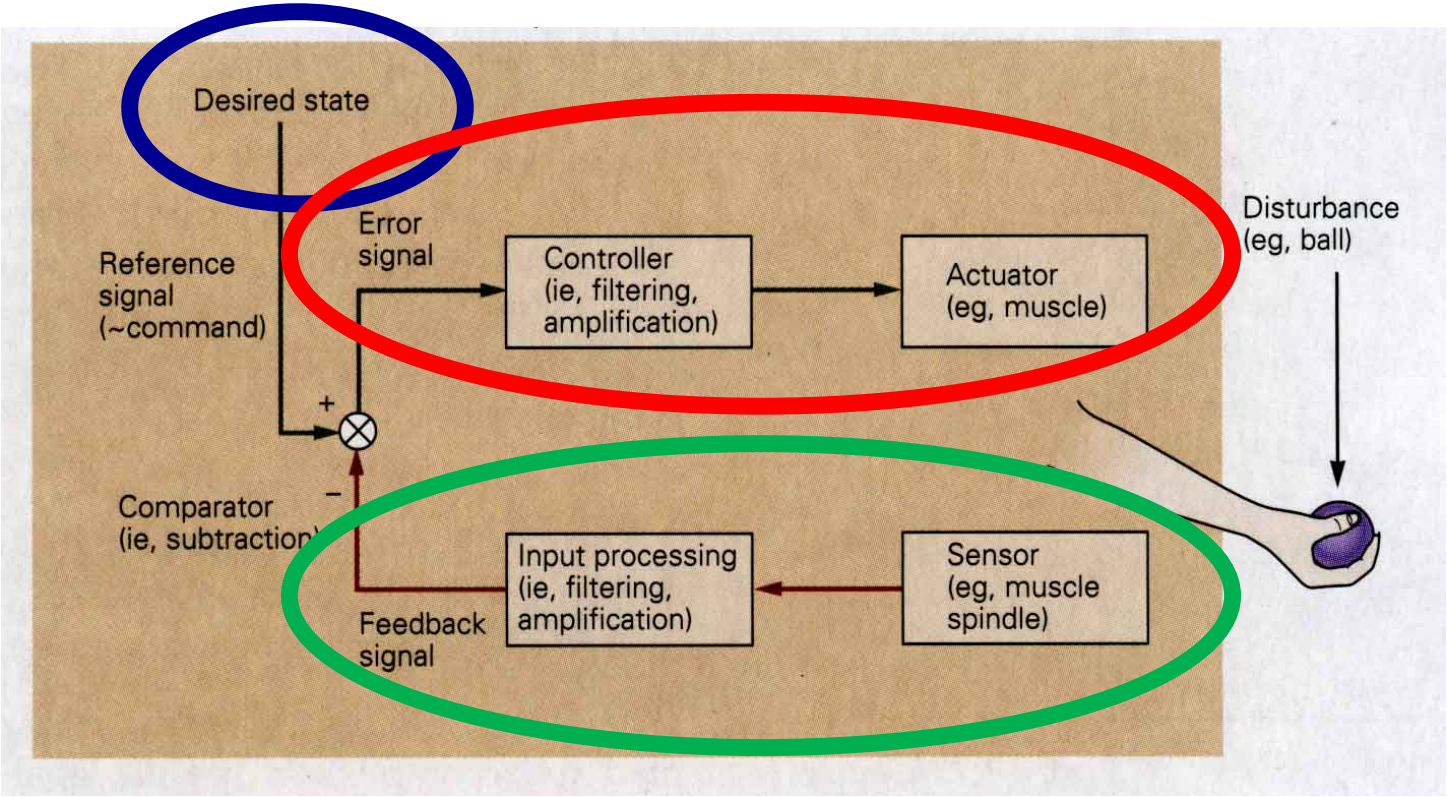
# Voluntary Movements

The nervous system learns to deal with the physical world in two ways:

***Feedforward control***: In feedforward control the nervous system anticipates future events based on prior experience. It initiates pre-emptive strategies based on this experience.

***Feedback control***: The nervous system using sensory signals from the body to monitor the position of the limbs. It uses these sensory feedback signals to modify the position and tension in limbs as needed.

# Feedback Control




In feedback control a reference signal representing the bodies desired state is compared to signals from sensors in the muscles and joints. Any between these two pathways, or error signal, is used to adjust the muscles to minimise this error.

# An everyday example of a feedback system?

*A thermostat for controlling room temperature.*

If the room temperature is below the set (desired) temperature Thermostat switches the heating on.

If the room temperature is above the desired temperature Thermostat switches the heating off.

# Feedback Control

Gain determines the efficacy of feedback systems.

A **high-gain** system acts rapidly to minimize any computed error.

High-gain systems are however unstable if there is any delay between sensing, computing the error and correcting the error.

If external conditions are changing and/or of there are any lags in the feedback system then the changes might not be accurate when they are realised – leading to oscillations.

# Feedback Control

Most feedback systems keep the gain low to avoid such oscillations.

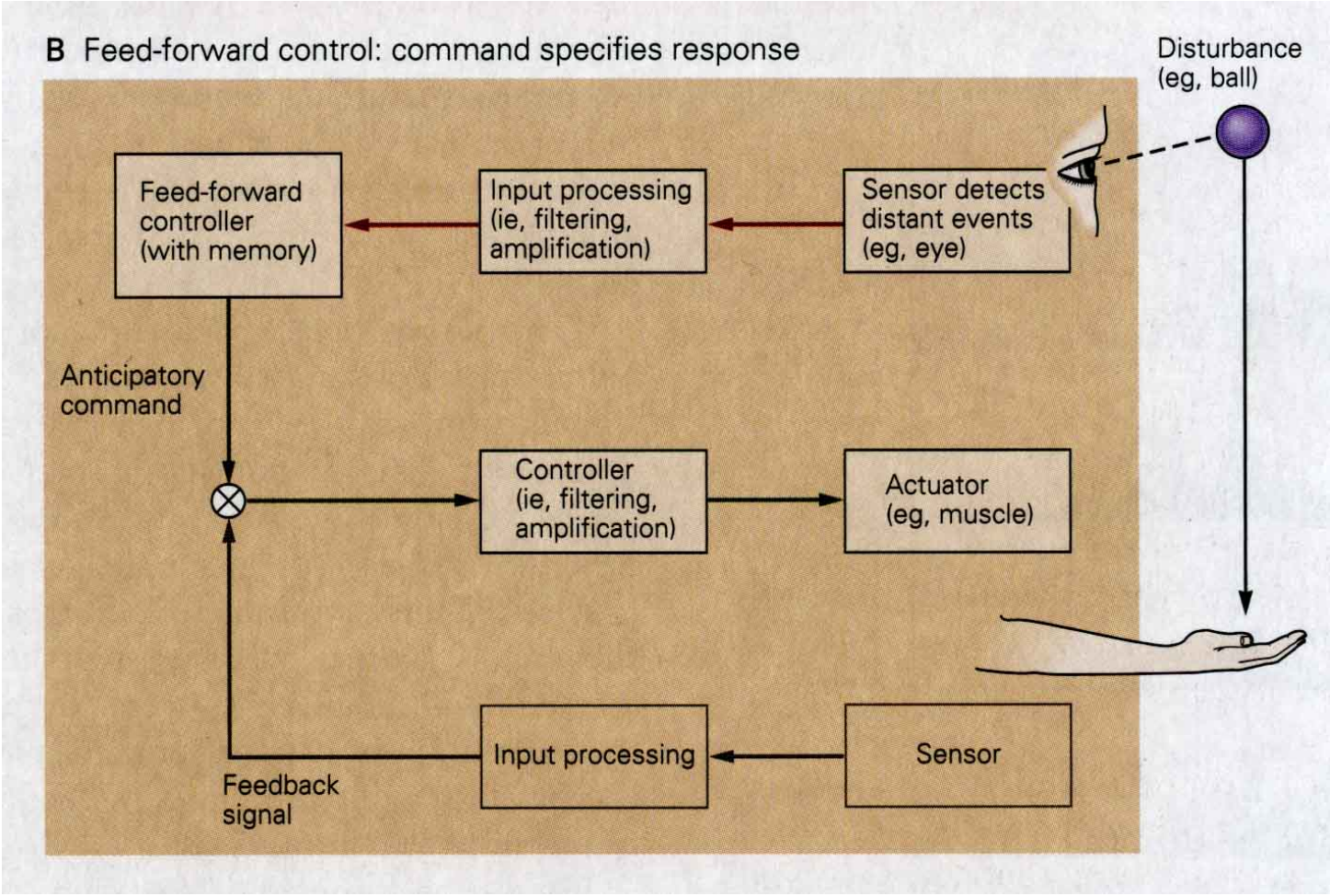
What is the downside to this?

*It takes longer to correct errors.*

Sensory feedback from the muscles and joints is particularly important in maintaining our posture and we will see examples of what occurs in patients that lack this system later in the course.

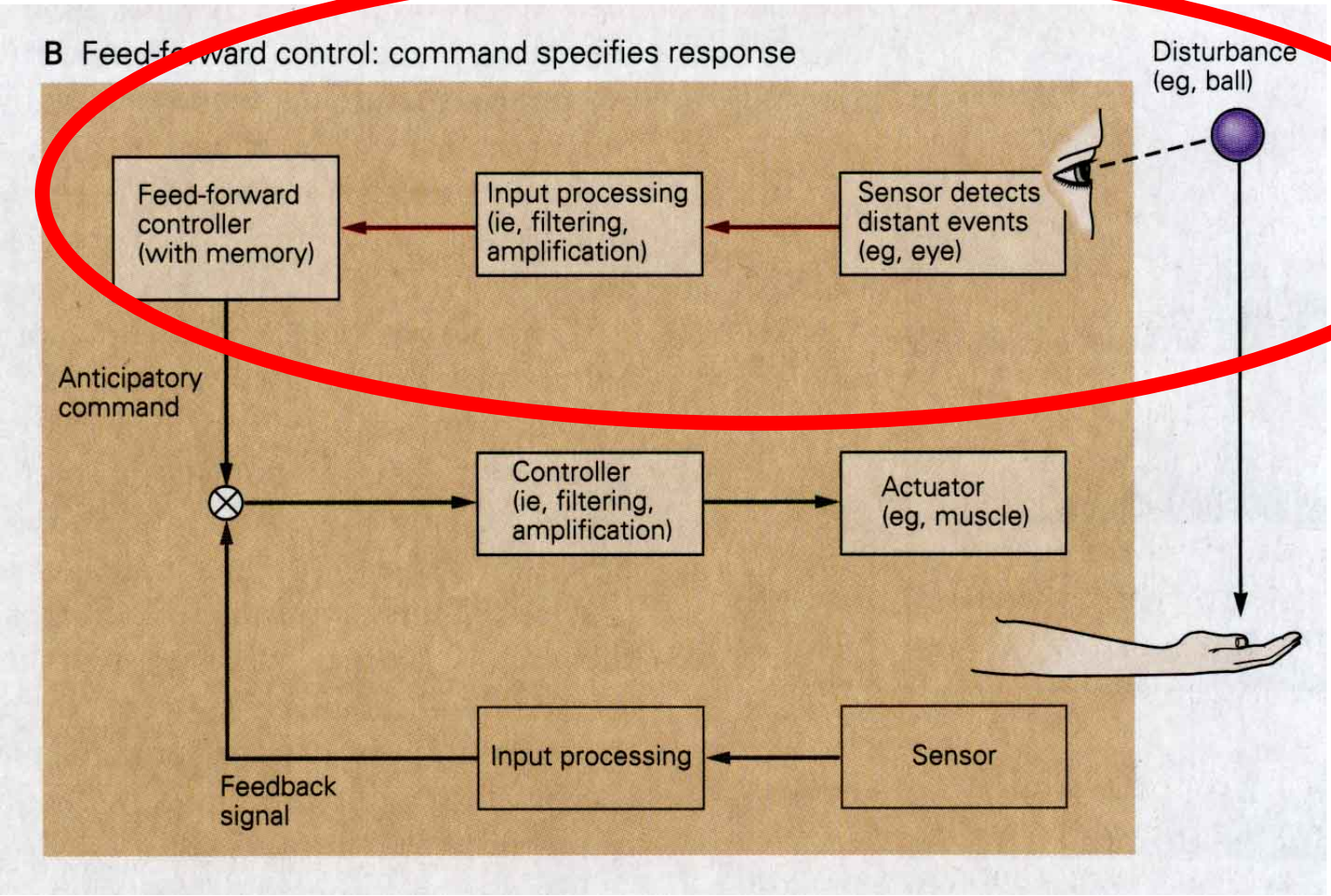
# Feedforward Control

Feedforward control acts **in advance** of certain perturbations.



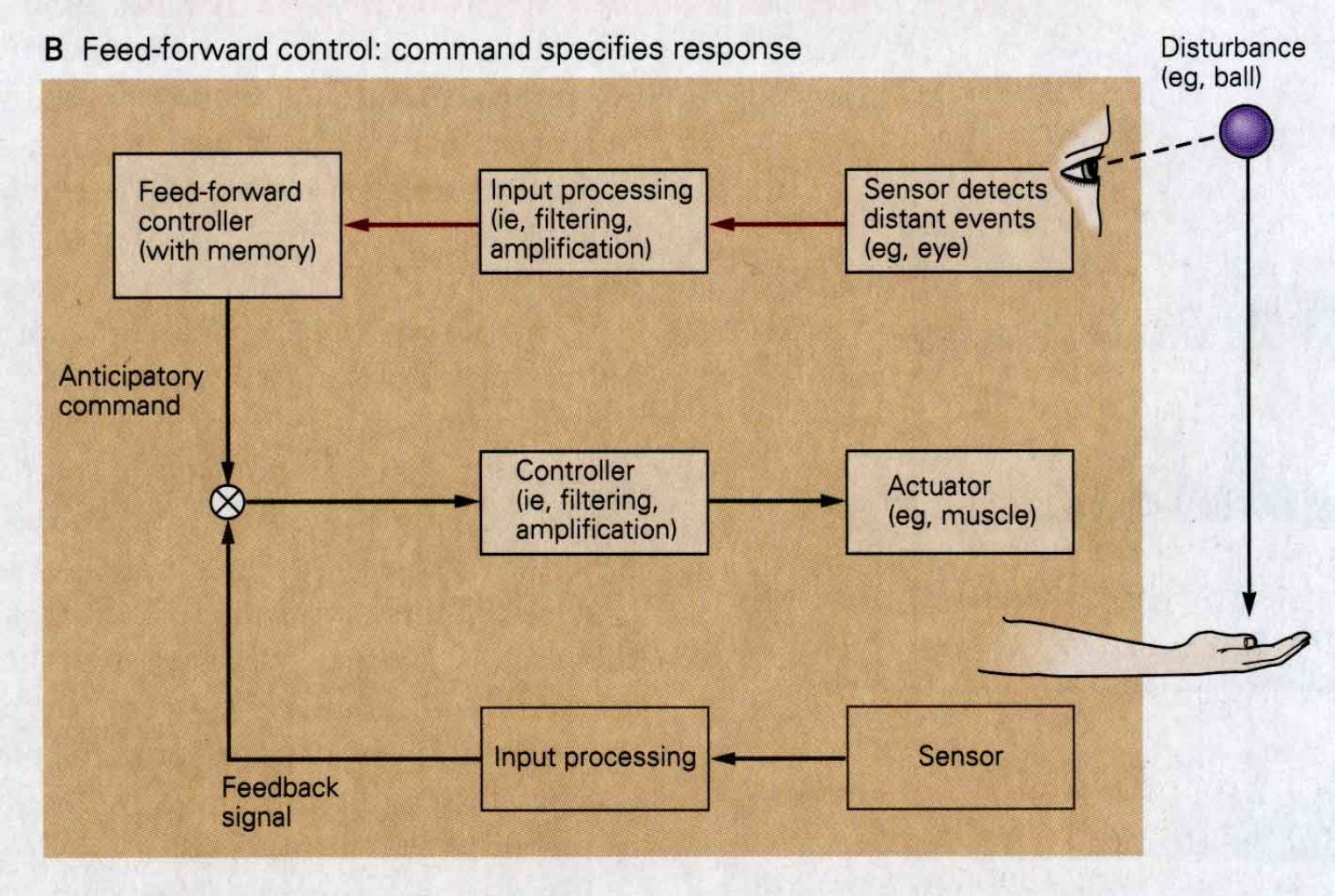

Experience is important in feedforward control.

# Simple example of Feedforward Control



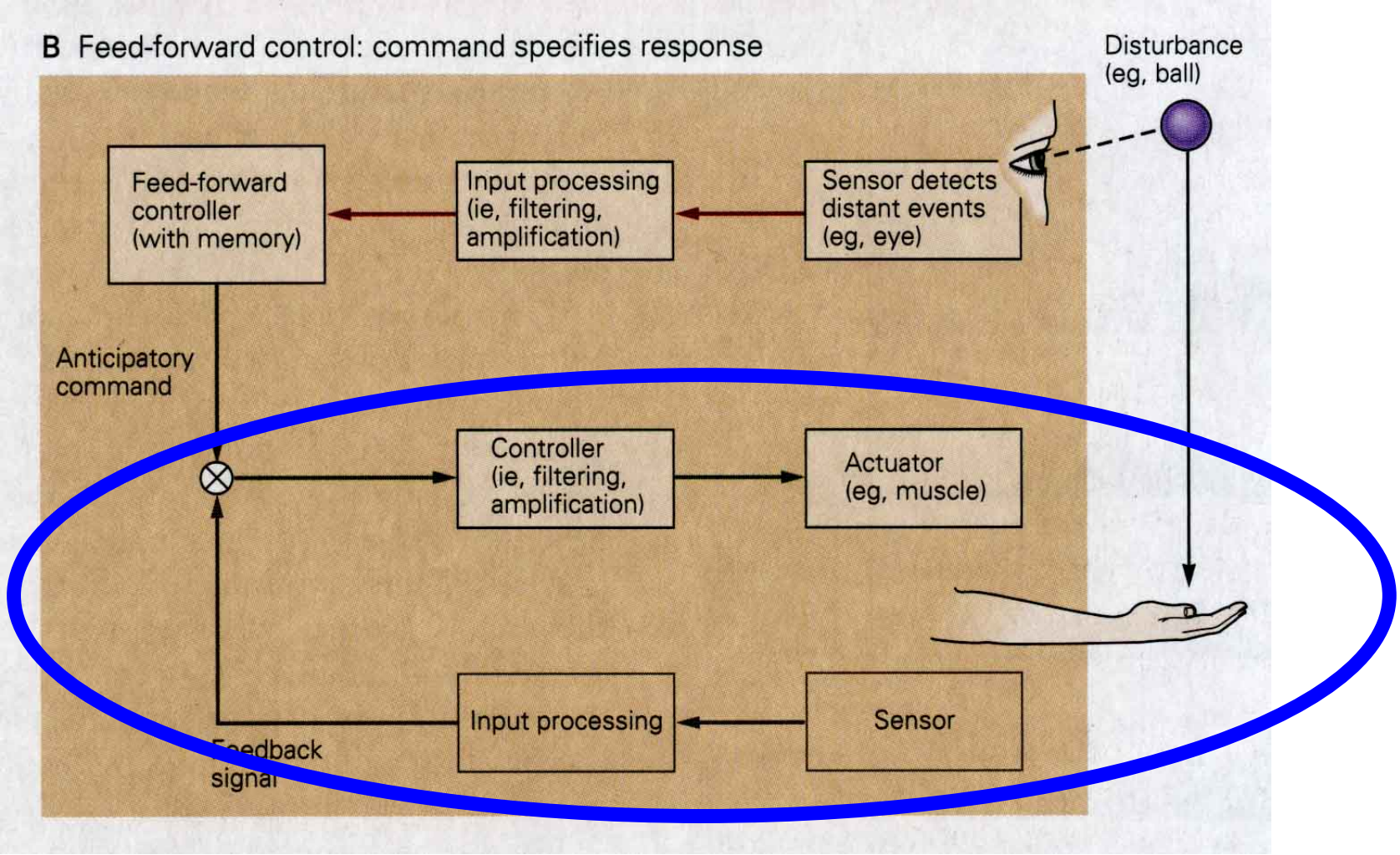

When attempting to catch a ball we use visual information to calculate the balls trajectory and calculate where we need to be to accurately catch the ball.

# Simple example of Feedforward Control




Previous experiences of catching a ball enable us to predict the time of the ball's impact and to contract the opposing arm muscles just before the ball hits.

# Simple example of Feedforward Control




Feedback from cutaneous receptors in the hand and arm muscles send feedback only after the ball has landed in your hand.

# What happens after impact?

Normally the rapid stretch of a muscle evokes a stretch reflex which controlled by spinal circuits – this protective reflex opposes the overstretching of muscles.

When you plan to catch a ball, feedforward mechanisms cause both the agonist and antagonist muscles surrounding the elbow joint to contract.

This process is learned from experience and has the outcome of stiffening the elbow joint suppressing the stretch reflex caused by the weight of the ball.

**Catching a ball illustrates the three key principles of feedforward control of a movement.**

1. Feedforward control is critical for fact movements.

2. Feedforward control relies on the nervous systems ability to predict the future based on past experiences of sensory events.

3. Feedforward and feedback mechanisms interact within the spinal cord.