

Feedback Loops

An introduction to the concept.

Background

Feedback loops are an important feature of complex adaptive systems. Examples of feedback can be found in most complex systems in biology, physics, economics, social systems, and engineering. In some cases, the interaction of individual agents can create feedback loops drive the emergence of patterns at the global level.

Definitions:

Feedback is a circular process in which a system's output is returned or "fed back" into the system as input. There are two kinds of feedback: **reinforcing** (or positive) and **balancing** (or negative).

A feedback loop is a closed system that has feedback. Often, when talking about feedback in layman's terms, we use the words "positive" and "negative" to describe how we feel about an outcome, or to describe whether or not a certain outcome is desirable or not. For example, people say "my boss gave me positive feedback on a new idea". **This is not to be confused with the technical terms "positive feedback" and "negative feedback".**

In the technical definition, reinforcing or positive feedback is feedback that amplifies or accelerates a change away from a starting point or equilibrium point whereas balancing or negative feedback is feedback that dampens, slows down or corrects a change in a system that is moving away from the starting point.

Here's one way to remember it:

In reinforcing (or positive) feedback loops
"More leads to more" OR "Less leads to less"

In balancing (or negative) feedback loops
"More leads to less" OR "Less leads to more"

Some concrete examples:

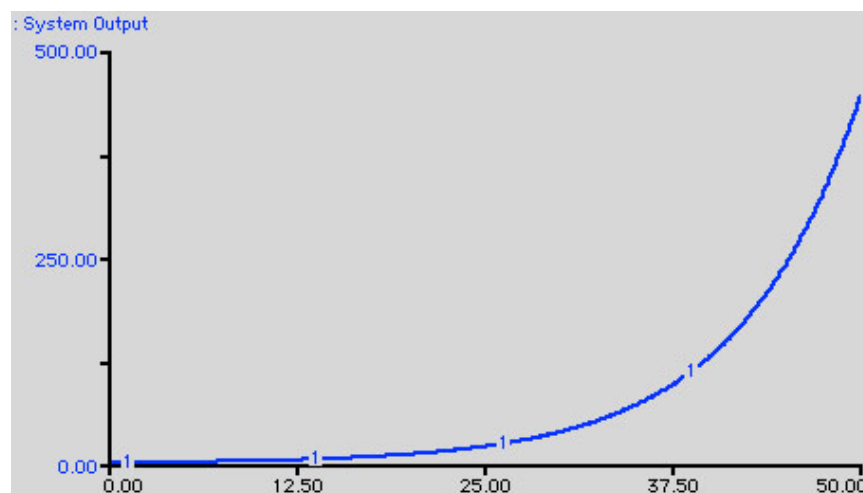
Let's look at some concrete examples with simple systems comprised of two parts.

Example 1:

A classic example of feedback is audio feedback. In this system there are two parts: a speaker and a microphone. What happens when we close the loop by turning the speaker and the microphone so they are aimed at each other? The microphone takes in some sound and sends it out louder through the speaker. Then that sound goes back in again, comes out louder, then back in again and before you know it you have a loop, a vicious circle, producing a high-pitched screeEEEEch!

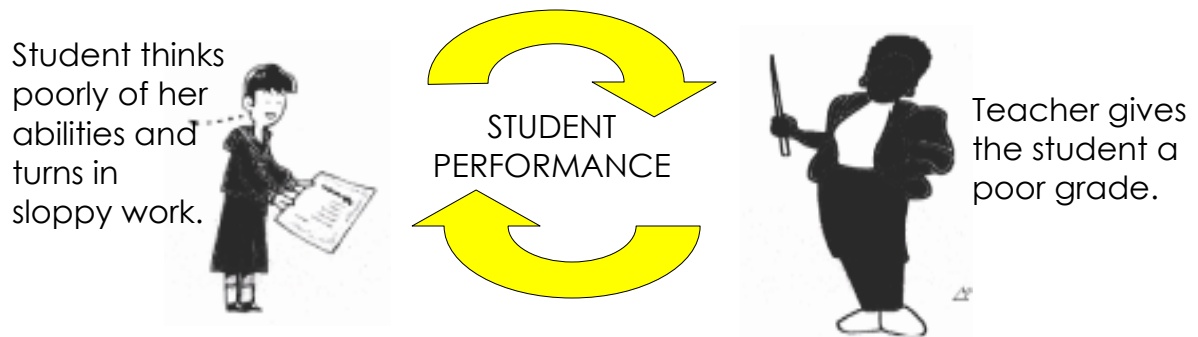


This is an example of positive feedback (though we may think of the outcome as negative to our ears!) Luckily, eventually one of the mechanical parts will fail which breaks the loop. In this example "more (louder sound) leads to more (louder sound)". A graph of the amplitude of the sound might look like this.

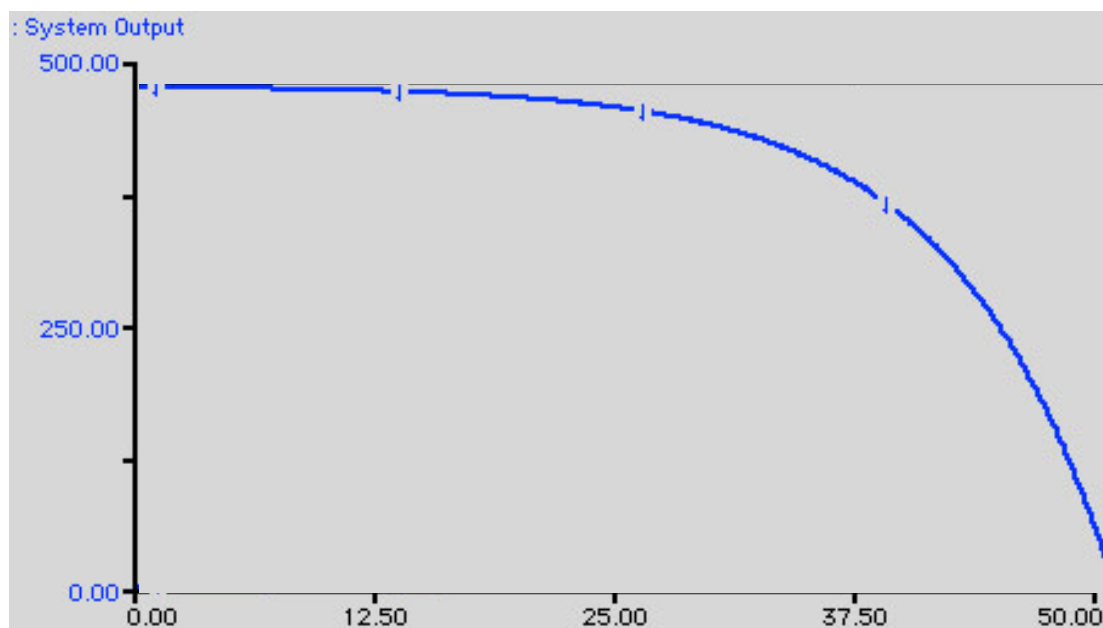


Example 2:

Here's another example, a system made up of a teacher and a student. In this hypothetical situation, let's say the student turns in some sloppy work. The teacher takes a look at the work and gives the student a bad grade. In response, the student thinks poorly of him/herself and puts in even less effort on the next assignment. Is this an example of "positive" or "negative" feedback? Remember that in reinforcing (or positive) feedback loops "More leads to more" OR "Less leads to less" while in balancing (or negative) feedback loops "More leads to less" OR "Less leads to more".

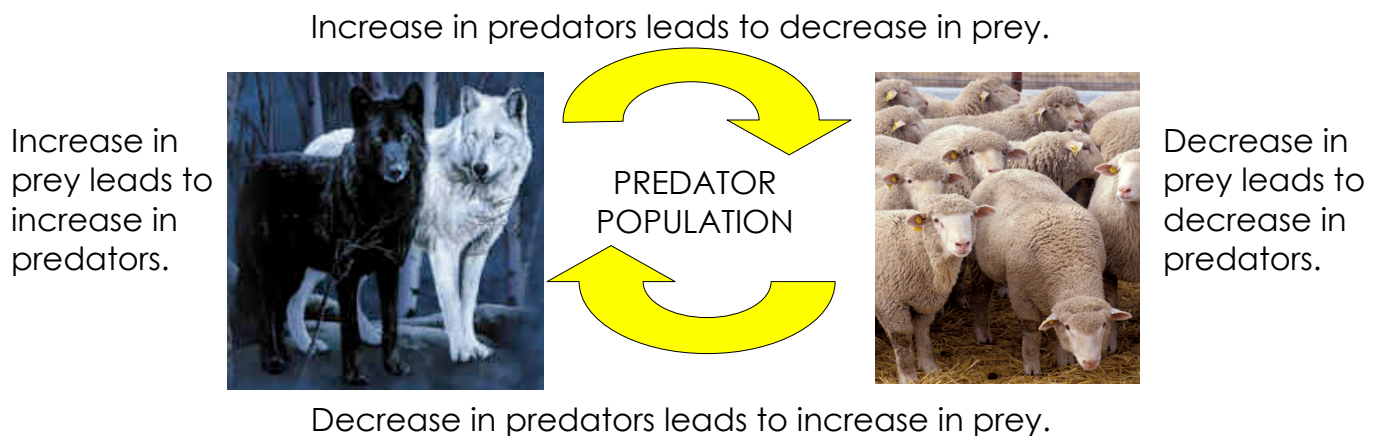


Even though the outcome is perceived as negative - the student is in a downward spiral, by definition, the feedback loop is a "**positive**" or self-reinforcing feedback loop. A graph of the student's performance might look like this. In this scenario "less (academic success) leads to less (academic success)"

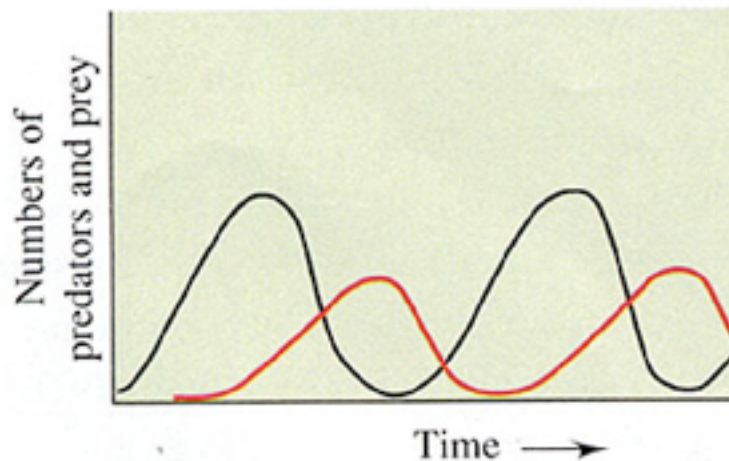


Example 3:

Let's look at a simple ecosystem with two populations: predators and prey. As the population of predators increases, the population of prey usually decreases as the predators eat more of the prey. But, at some point, the prey get scarce and some predators die of hunger. When most of the predators have died off (and a few wily prey remain) then the prey population can regenerate over time. When the prey population booms, plenty of food becomes available for the remaining predators and they thrive and reproduce. This cycle of predator and prey population variation repeats over time.



This is a classic example of “balancing” or “negative” feedback. The population of prey acts as a balancing force against the exponential growth (positive feedback) that could occur if the wolf population grew unchecked. (and visa versa.) Generally negative feedback works to re-establish equilibrium or balance in systems. In this example we see “More (predators) lead to less (prey)” and “less (predators) lead to more (prey).”



Here are some examples to discuss. Are they examples of positive or negative feedback?

Nuclear fission

Thermostat

The Swords and Shields activity

Termite forming mounds

In the real world, positive feedback loops are controlled eventually by negative feedback of some sort; a microphone will break or a resource limitation will cap runaway growth. Resource limitation may also serve to dampen a runaway positive feedback process. A variety of negative feedback controls can be used to modulate the effect of a positive feedback loop.

