

FEEDBACK

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Primary Disciplinary Field(s): Cybernetics, Control Theory, Psychology, Communication Theory, Biology

1. Core Definitions and Conceptual Foundation

The concept of **feedback** is foundational to systems theory, existing as the critical mechanism by which a system regulates itself, sustains an interaction, or modulates its future performance based on prior output. At its most fundamental, feedback describes a causal loop where the output of a process or system acts as new input for that system, thereby influencing subsequent operations. This process allows systems--whether mechanical, biological, or social--to achieve stability, maintain desired states, or adjust behavior dynamically in response to change. The complexity of feedback lies in its pervasive nature, applying equally to the simple regulation of a mechanical device like a thermostat, the intricate physiological balancing act of the human body, or the interpersonal dynamics of communication.

In a broad sense, feedback encompasses several distinct yet related definitions, often dictated by the disciplinary context. In general systems theory, it is defined as the process where any element of an interaction either sustains, amplifies, or modifies the interaction itself. If the interaction is reinforced, it is characterized as positive feedback; if it is dampened or corrected toward a preset standard, it is termed negative feedback. These two modes represent the dual functionality of feedback: driving change or maintaining equilibrium. The ability of a system to utilize feedback is directly correlated with its capacity for learning, adaptation, and complex functionality.

Furthermore, in human-centric fields like psychology and education, **feedback** specifically refers to the information provided to a person about their performance or behavior. This type of input, exemplified by receiving commentary on a job application or a test score, is crucial for learning and behavioral adjustment. The quality, timing, and specificity of this informational input determine its effectiveness in helping the individual bridge the gap between their current state and a desired outcome. This contrasts with purely mechanical feedback but shares the core principle of using output (performance) as input (information) to modify future behavior.

2. Historical Development and the Cybernetic Origin

While examples of systems using feedback mechanisms--such as the steam engine governor invented by James Watt in the 18th century--existed much earlier, the formal theoretical understanding of **feedback** emerged in the mid-20th century. The seminal work tying diverse regulatory phenomena together was the creation of the field of Cybernetics. Coined and largely developed by mathematician Norbert Wiener in the 1940s, Cybernetics is the interdisciplinary

study of control and communication in the animal and the machine. Wiener recognized that the principles governing the automatic guidance of a torpedo were mathematically identical to those governing voluntary human movement.

Wiener's influential 1948 book, *Cybernetics: Or Control and Communication in the Animal and the Machine*, established **feedback** as the central concept. He demonstrated how organisms and advanced machinery rely on continuous loops of information processing to counteract disturbances, maintain homeostasis, and achieve goals. This conceptual breakthrough moved scientific understanding beyond simple linear causation, introducing the idea of circular causality inherent in self-regulating systems. The Cybernetic model provided a unifying framework for understanding diverse phenomena, from nervous system disorders to automatic piloting systems, all through the lens of controlled feedback loops.

Following Wiener's work, feedback theory rapidly permeated engineering, particularly in the development of sophisticated control systems and automation. In the 1950s and 1960s, social scientists began adapting these concepts to human systems, viewing organizations and small groups as complex systems governed by communicative feedback mechanisms. This cross-disciplinary application solidified feedback's status as a universal principle of complexity and regulation, moving it from a purely mechanical term to a core explanatory concept in modern science.

3. The Feedback Loop: Mechanism and Types

The core operational characteristic of **feedback** is the loop, which involves a sequential flow: Output → Sensor → Comparator → Controller → Input modification. A system generates an output; this output is measured by a sensor; the measurement is compared to a reference standard (the setpoint); the controller determines the necessary adjustment; and the adjustment modifies the system's subsequent input or operational parameters. The efficiency and reliability of the system depend on the accuracy and speed of this continuous process.

There are two primary modes of feedback, differentiated by their effect on the system's stability: **Negative Feedback** and **Positive Feedback**. Negative feedback is generally associated with stability and regulation. In this loop, the result of the system's output is subtracted from the input, causing the system to move back toward its equilibrium state or target setpoint. For example, when body temperature rises, negative feedback mechanisms (sweating, vasodilation) are activated to decrease the temperature, thereby negating the original rise. Negative feedback loops are essential for maintaining homeostasis in biological systems and stability in engineering control systems.

Conversely, **Positive Feedback** is associated with amplification, deviation, and runaway effects. In a positive feedback loop, the output is added to the input, pushing the system further away from its

initial state. This effect is not necessarily detrimental; it is often required for rapid transitions or necessary changes. Examples include the snowball effect in economics (where success generates more success) or the physiological processes of childbirth (where contractions trigger the release of hormones that cause stronger contractions). While positive feedback drives rapid change, if unchecked, it can lead to system instability, oscillations, or collapse.

4. Feedback in Engineering and Control Systems

In engineering and control theory, **feedback** is indispensable for the design of robust, accurate, and automated systems. A control system that uses feedback is called a closed-loop system, contrasting sharply with an open-loop system, which executes commands without measuring the resulting output (like a simple timer). Closed-loop systems are inherently superior in handling disturbances, noise, and variations in load, as they constantly adjust their operation based on real-time data.

A classic example is the regulation of temperature by a thermostat. The desired temperature (the setpoint) is established. The thermostat measures the current room temperature (the output signal). When the measured temperature falls below the setpoint, a negative feedback loop activates the heating element. Once the temperature meets or exceeds the setpoint, the signal feeds back to the controller, which switches the heater off. This continuous cycle ensures that the system maintains a narrow range of variability around the setpoint, demonstrating precise control achieved through self-correction.

Furthermore, feedback is crucial in signal processing and communications. **Auditory feedback**, for instance, refers to the loop where a speaker hears their own voice, allowing for real-time modulation of volume, pitch, and speed. Delays or alterations in this loop can lead to speech impairment (delayed auditory feedback), demonstrating the continuous regulatory function of feedback even in seemingly instantaneous human processes. Control theory utilizes sophisticated mathematical models (e.g., PID controllers) to optimize these feedback mechanisms, ensuring both responsiveness and system stability in complex machinery like robotics, aerospace control, and industrial automation.

5. Feedback in Biological and Physiological Systems

Biological systems are governed entirely by intricate and overlapping feedback loops designed to maintain the delicate internal balance required for life. The overarching process is **homeostasis**, the tendency of the body to seek and maintain a stable internal environment despite external changes. Hormone regulation, blood sugar control (via insulin and glucagon), body temperature, and blood pressure are all managed through tightly regulated negative feedback mechanisms. For example, if blood glucose levels rise, pancreatic beta cells detect this rise (sensor) and release

insulin (controller), which lowers the glucose (output), thereby reducing the stimulus for insulin release (negative feedback).

A specific form of biological feedback mentioned in the source material is the process of receiving visual input or **afferent impulses from the proprioceptors**. Proprioception, often referred to as the "sixth sense," is the body's ability to sense its position, movement, and orientation without relying on visual input. Afferent nerves relay information about muscle tension, joint position, and limb movement back to the central nervous system. This continuous sensory feedback loop is essential for coordinated movement, balance, and motor control, allowing individuals to perform complex physical tasks without conscious visual monitoring.

Relatedly, **biofeedback** is a therapeutic technique that leverages physiological feedback to allow individuals to gain conscious control over involuntary bodily processes. Through specialized monitoring equipment, typically unconscious physiological data (like heart rate variability, muscle tension, or skin temperature) is converted into a measurable signal (visual or auditory) that the patient can observe. By receiving this real-time feedback, the patient can learn self-regulation techniques to voluntarily modify these processes, demonstrating the profound capacity of the human mind to utilize sensory input to achieve physiological stability.

6. Feedback in Psychology and Communication Theory

In psychology and communication, **feedback** serves as the indispensable link between behavior and consequence, essential for learning, social interaction, and performance improvement. In organizational and educational settings, feedback involves the information given to a person about their performance or behavior, assessing whether the action was successful, requires modification, or met the expected standards. This type of feedback is crucial for skill acquisition and achieving goals, as noted in the example: "Joe received feedback about his job application."

Within social psychology, **social feedback** refers to the verbal and non-verbal cues received during interpersonal interactions that inform an individual about the effect of their behavior on others. A smile, a frown, a verbal affirmation, or a sigh all constitute social feedback, influencing the continuation or cessation of the current behavior. Effective communication relies on the continuous exchange of feedback, ensuring that the message sent is interpreted as intended by the receiver. Deficiencies in interpreting or providing social feedback can lead to misunderstandings and social friction.

The quality of psychological feedback is paramount. Effective feedback must be specific, actionable, and timely, focusing on the behavior rather than the inherent characteristics of the individual. Poorly delivered or generalized feedback can lead to defensiveness, decreased motivation, or a failure to correct performance gaps. Therefore, the study of feedback in psychology focuses not just on its existence, but on the cognitive processing and behavioral

integration of the received information, transforming raw output data into meaningful input for self-improvement and behavioral change.

7. Related Concepts and Distinctions

To fully understand **feedback**, it is necessary to compare it with the related and sometimes contrasting concept of **feed forward**. While feedback involves making adjustments based on past results (output information), feed forward involves making adjustments based on anticipated future disturbances or predictions (input information). A classic example of feed forward is adjusting the heating system in anticipation of a forecasted severe temperature drop, rather than waiting for the internal temperature to drop first.

Feed forward mechanisms are often used to improve the performance of systems that suffer from significant time delays in their feedback loops. By predicting the necessary adjustment, the system can act preemptively, avoiding the oscillation or overshoot common in heavily delayed feedback systems. In human behavior, preparation, planning, and goal setting are forms of feed forward control, where actions are initiated based on future targets rather than correction of immediate past errors.

Despite their differences, feedback and feed forward are often used in conjunction to create highly robust control architectures. A comprehensive system leverages feed forward to handle predictable variations and uses the corrective power of feedback to manage unpredictable noise and disturbances, ensuring both speed and accuracy. The interplay between these two control modes represents a highly sophisticated level of system management found in advanced robotics, complex economic models, and sophisticated human cognition.

Further Reading

[Feedback \(General Systems Theory\)](#)

[Cybernetics](#)

[Control Theory](#)

[Homeostasis in Biological Systems](#)

[Proprioception](#)