

Cybernetic Theory of Craniofacial Growth

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DEPT. OF ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

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What is cybernetics?

- Was first introduced by the mathematician Wiener, as the science of communication and control in the animal and the machine
- Cybernetics is a theory of the communication and control of regulatory feedback. The term cybernetics stems from the Greek Κυβερνήτης (kubernites - meaning steersman, governor, pilot, or rudder; the same root as government).Cybernetics is

- the discipline that studies communication and control in living beings or machines.
- Medical Cybernetics covers an emerging working program for the application of systems- and communications-theory, connectionism and decision theory on biomedical research and health related questions
 - Biomedical cybernetics deals with investigating signal processing, decision making and control structures in living organisms

INTRODUCTION

- Given by Petrovic(1972,1982)
- He was the first to promulgate a cybernetic model for the physiologic phenomenon involved in facial growth and method of operation of orthodontic and functional appliances. Cybernetic theory help clinicians to rigorously address the study of communication, control mechanisms, and organization in both living and technological systems.
- Modern orthodontist must become acquainted with the cybernetic language, because cybernetic thinking is the route to data processing and computerizing for 21st century.
- Cybernetics based on communication and information theory-particularly on feedback control systems-provides useful research approach.
- Cybernetics has got new and beneficial concepts(eg.negative feedback,positive feedback,self regulation,reference point,open and closed loop,regulation versus servosystem and circuit analysis)for biologic and biomedical sciences.
- This approach lies on linear differential equations.
- Cybernetics is infact a major breakthrough in the decision making process and problem solving in scientific and clinical orthodontics and dentofacial orthopaedics.
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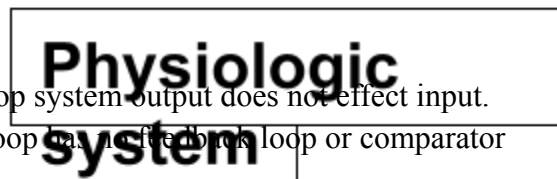
CYBERNETIC APPROACH

- System operates through signals that transmit information.
- Signal may be physical, chemical, or electromagnetic in nature.
- Any cybernetic system, when provided an input it processes such an input and provides an output.

- The out put is related to input by a *transfer function*.
- This is similar to feeding numbers into a computer, and obtaining the sum or product of the numbers.
- The calculations performed by the computer, correspond to the “TRANSFER FUNCTION”
- Inputs and outputs are generally denoted by arrows.
- Physiologic system under investigation is represented by black box.

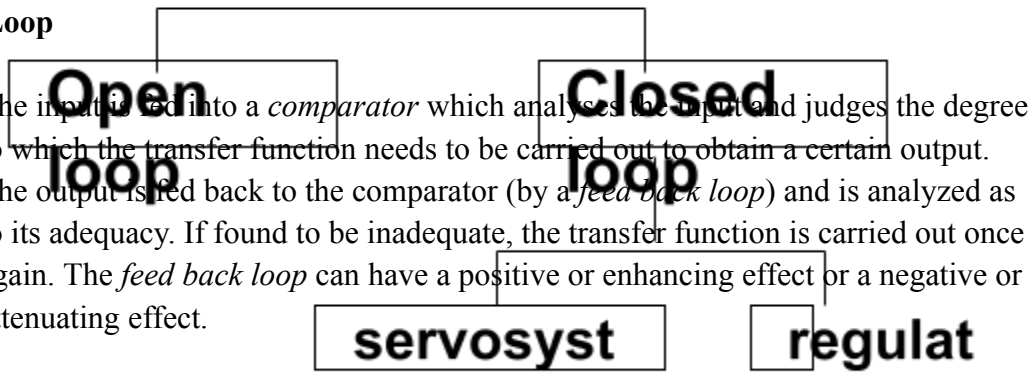
Physiologic system

Open Loop

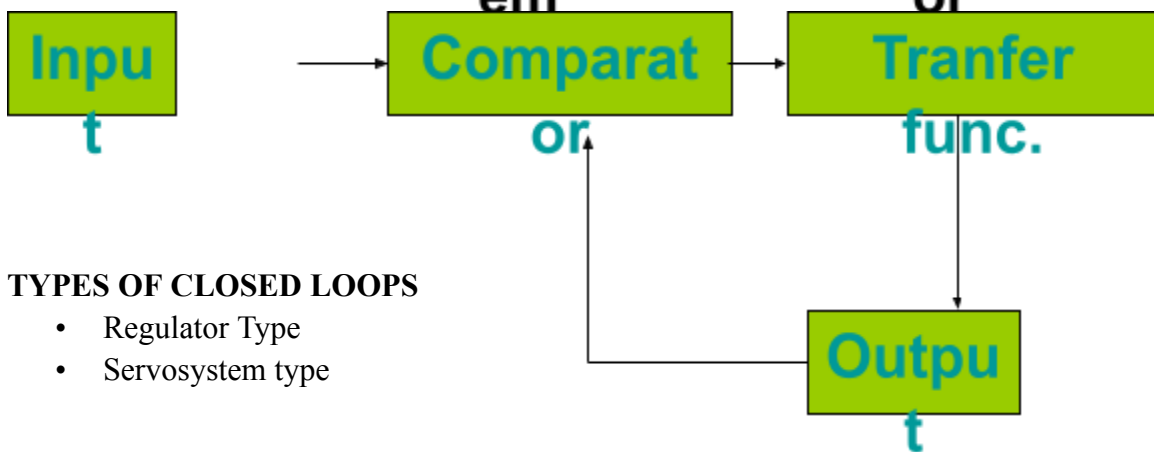


- In open loop system output does not effect input.
- An open loop has no feedback loop or comparator

Closed Loop



- The input is fed into a *comparator* which analyses the input and judges the degree to which the transfer function needs to be carried out to obtain a certain output.
- The output is fed back to the comparator (by a *feed back loop*) and is analyzed as to its adequacy. If found to be inadequate, the transfer function is carried out once again. The *feed back loop* can have a positive or enhancing effect or a negative or attenuating effect.



TYPES OF CLOSED LOOPS

- Regulator Type
- Servosystem type

□ Regulator type of closed loop is one in which the input is constant.

eg. Temperature Regulation

CLOSED LOOP

□ Servo System type of closed loop the input is constantly changing with time, and the output is constantly adjusted in accordance to that.
eg. Face as Servo System
Input-Maxillary dental arch
Output-Adjustment of the position of Mandibular dental arch in accordance to input.

Terms Used in Servo System

Command:

A signal established independent of the feedback system and is not affected by the output of the system. As the name suggests it tells system as to what should be done.

eg. secretion rates of the growth hormones

- Reference Input:

It is a signal established as a standard of comparison. Ideally it should be independent of the feedback.

Eg. The saggital position of upper dental arch.

Reference input elements:

They establish relationship between the command and the reference input i.e. the command (growth hormone) creates a reference input (saggital position of the upper dental arch) through the action of these reference input elements.

Eg. septal cartilage

- Comparator:-peripheral
-central

Peripheral Comparator:

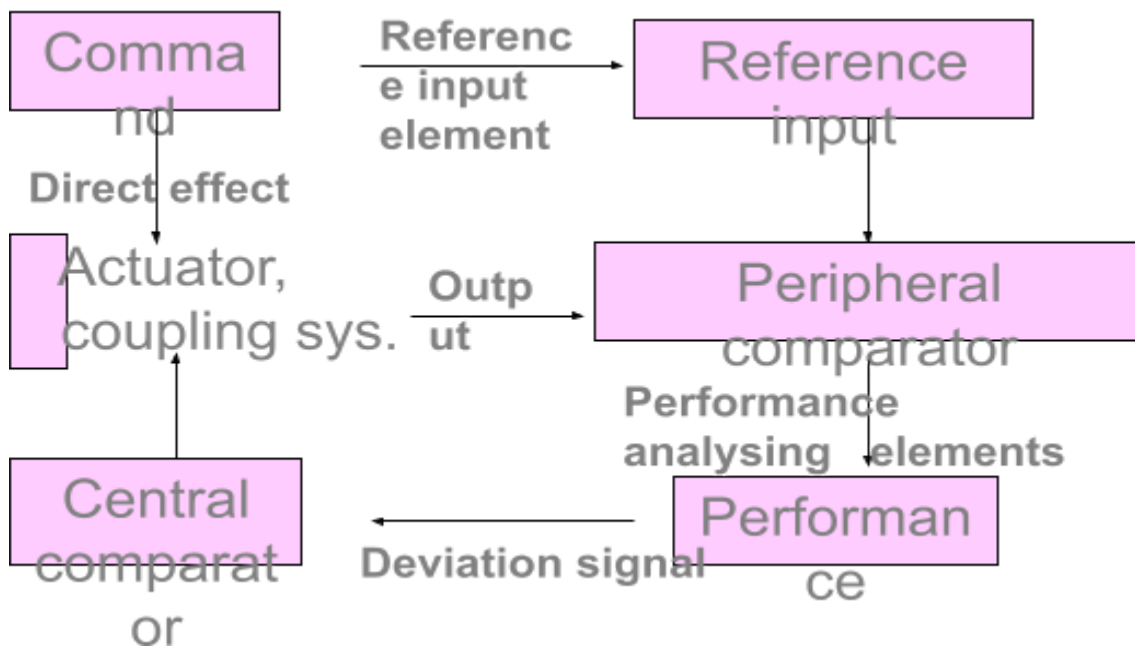
The input is fed to the comparator that analyses the input and judges the performance judging elements.

Central Comparator:

The performance judging elements then transmit a deviation signal to the central comparator which sends a signal to various components like the actuator, the coupling system and controlled system. This brings about the output.

Actuating signal:

This is the output signal of the controller e.g. Activity of LPM and retrodiscal pad.



SERVO SYSTEM THEORY

- Given by Charler, Petrovic and Stutzmann.
- They observed following dissimilarities concerning different growth cartilages when detected in organ culture (in both transplantation and in situ investigations.)
 - a) If growth results from cell division of differentiated chondroblasts like in the epiphyseal cartilages of the long bones, cartilages of the synchondroses of the cranial base, all stemming from the primary cartilagenous membrane of the organism. It appears to be subjected to extrinsic factor and more specifically to STH, sexual hormones, and thyroxine. In this case the effect of local biomechanic

factors is reduced, and the amount of growth can not be modulated by means of orthopaedic appliances.

b) If the growth results from the cell division of prechondroblasts like in condylar cartilage, coronoid, and angular cartilages of the mandible, mid palatine suture, and all secondary formation during phylogenesis (the sequence of events involved in the evolutionary development of a species) and ontogenesis (individual development of a living thing, all sequence of its transformations from birth to the end of life).

In this case the the amount of growth can be modulated by appropriate orthopaedic appliances.

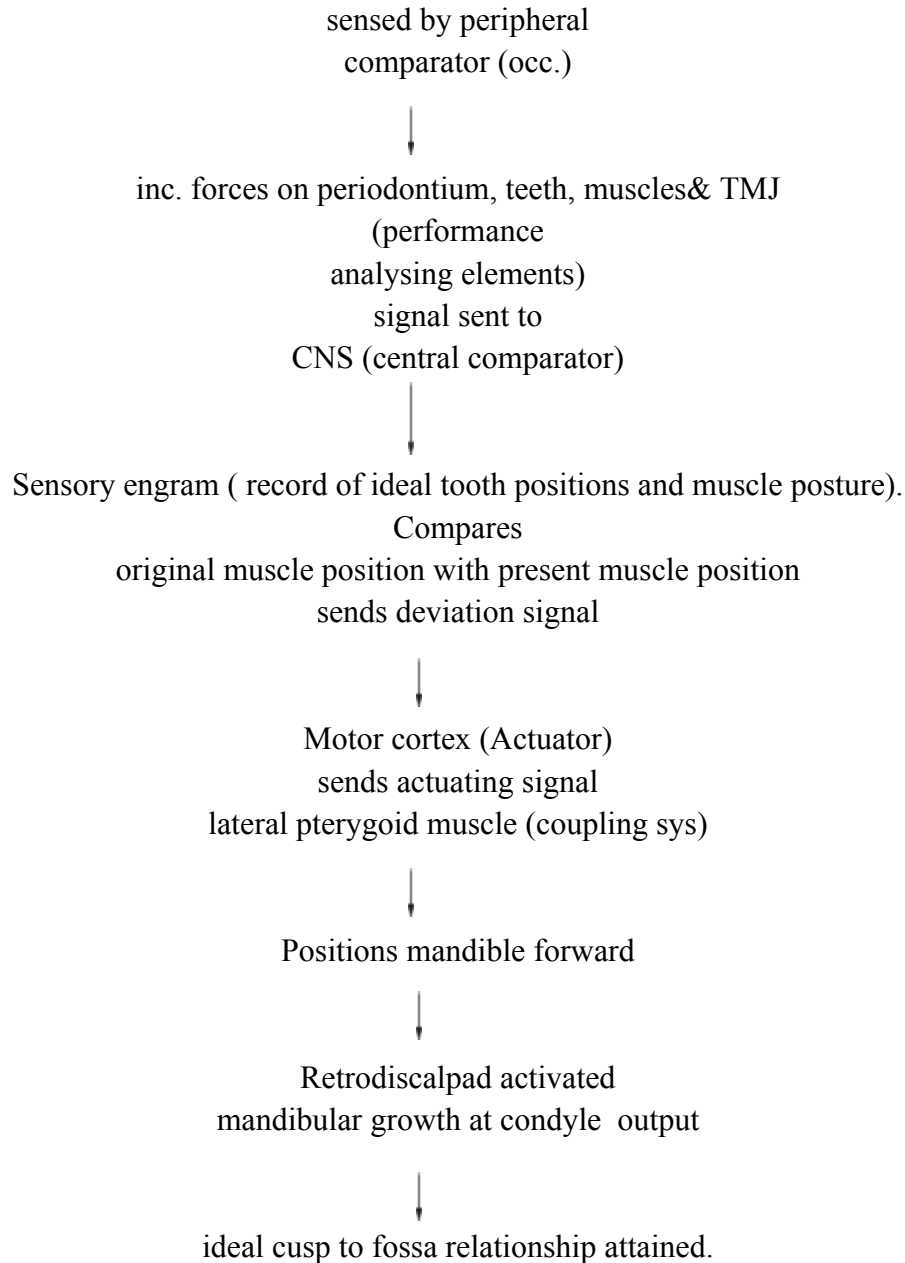
Various cybernetic terms in relation to growth of face:

- The position of dental arch forms the *reference input* of the servosystem
- The release of somatomedin represents the *command* (command to grow). The hormone itself is the *reference input element*.
- The *occlusion* between the upper and lower teeth forms the comparator.
- The CNS serves as a *central comparator* for the servosystem.
- The central comparator refers to what is known as the *sensory engram*.
- The sensory engram operates on the principle of *optimality of function*
- Any particular muscle action or mandible position that gives the minimum deviation signal is recorded in the sensory engram.

Growth of face

- The growth of the maxilla is brought about by the release of hormones (esp. STH-Somatomedin).
- These hormones have various direct and indirect effects which result in the growth of the maxilla
- Somatomedin induces growth of primary and secondary cartilages which results in an outward and forward growth of the maxilla.
- Another important action of somatomedin is the increase in the size of the tongue, which also facilitates the outward and forward growth of the maxillary dental arch
- Once the maxilla increases in length and width, the position of the maxillary dental arch is changed.

Forward & outward growth of maxilla
change in relation of teeth



Drawbacks

1)The theory places a lot of importance on the condyle as the growth centre.

- Hence if condylar cartilage is lost subsequent to a fracture, growth should seize.
- But studies done in Scandinavia show that this does not happen.

2)The author places a lot of importance on the role of hormones in controlling growth.
In all probability, they do not have such a large role to play.

3) The peripheral comparator, the occlusion, itself, is unstable. Discrepancies in the occlusion can easily be overcome by dentoalveolar changes, rather than by growth of the mandible.

4) According to the theory, an end on relation is a repeller. Still, end on relation of the molars and other teeth are often seen.

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References

1) Dentofacial orthopaedics with functional appliances-Graber, Rakosi and Petrovic.