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WHAT IF VISION FAILS?

How the brain manipulates pilots‘ cues

(processing of sensor conflicts)

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What are the Human Sensor Systems?

Classical answer: 5

sight – hearing - smell – taste – touch

Any other important human sensor systems?

equilibrium – proprioception – thermoreception – pain sensors (notiception)

Numerous further physiological sensor systems like:

Pressure sensors (blood), complex „chemical“ sensoring of hormone concentration in physiological closed and open loop self regulating circuits

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Sensor systems important for flying and common conflicts

Most important sensor systems for flying are:

Vision, vestibular system, proprioceptive system

There is a potential of sensor conflicts:

Response time the of vestibular organs on accelerations are very fast (faster than central vision) due to incompressibility of the endolymphe contained in the semicircular canals and the otolith organs.

Each super-threshold acceleration/deceleration signaled to the brain is followed by „false signals“ of about 1 – 3 sec. until the endolymphe comes to a rest again

Typical sensor conflict between vestibular cues and vision:

Latency and „false cues“

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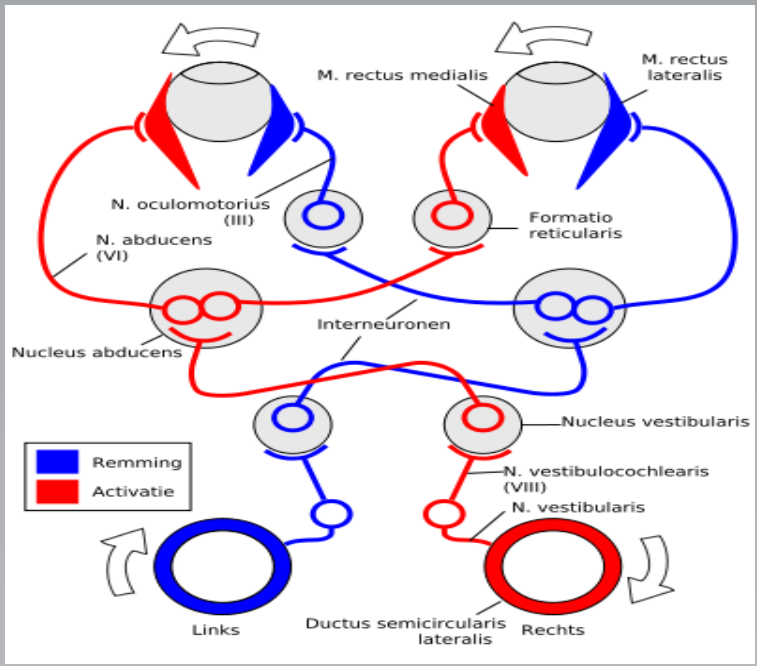
Vestibulo-Ocular Reflex (VOR)



Vestibulo-ocular Reflex (VOR)

Any **head movement** or perceived angular or linear **acceleration** causes an involuntary **eye movement** in the **opposite direction** (eyes are stabilized)

Important to note:

- Eyes are always „inertially stabilized" according to perceived vestibular sensations
- VOR during flight is disturbing and fatiguing in turbulent air as unvoluntary (fast) eye movements must be compensated by (slow) direct eye movem.
- In turbulent air eyes tend to loose their focus (difficult to scan instruments or read checklist, approach chart, etc.)

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What in case of signal conflicts?

Most sensor conflicts can be managed by our brain by genetic disposition and by training:

Motor skills like „fly aircraft“, „biking“, „slacklining“, etc. are acquired in a three phases learning process:

1. cognitive phase, 2. associative phase, 3. autonomous phase

During the learning process the passive multi-sensory motion memory turns into the active „multi sensory mental motion model“ (mental model)

The mental model is capable of suppressing and/or inducing vestibular and proprioceptive cues on a subconscious level by taking vision as „master“

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Development of Mental Model

Start of Basic Training **VMC**
(Cognitive Phase)

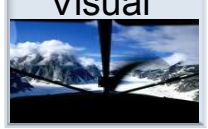
Stimulation

Vestibular Organs

Proprio-ceptors

Equilibrium Inputs

Visual



multi sensory motion memory

Storage multi-sensory cues

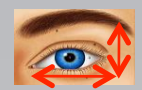
- visual and vestibular cues are saved in motion memory
- translation of raw (non-manipulated) vestibular cues into motion sensation

Visual

Spatial Orientation

Motion Sensation

VOR



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Development of Mental Model

Advanced Basic Training (Associative Phase) VMC

Stimulation

Vestibular Organs

Proprio-ceptors

Equilibrium Inputs

Visual

multi sensory motion memory

Storage cues; comparison of sensor inputs

- saving cues in motion memory
- building of millons of synapses
- partial manipulation of cues
- translation of partially manipulated vestibular cues into motion sensation

Visual

Spatial Orientation

Motion Sensation

VOR

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Mental Model

Experienced Pilot **VMC**
(Autonomous Phase)

Stimulation

Vestibular Organs

Proprio-ceptors

Equilibrium Inputs

Visual

mental motion model

comparison and alignment of cues with vision

- comparison of cues with vision
- suppression of false cues
- inducing of missing cues
- enables control inputs on subconscious level
- translation of adjusted and manipulated cues into motion sensation

Motion Sensation

VOR

Visual

Spatial Orientation

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Mental Model

Experienced VFR-Pilot IMC

Stimulation

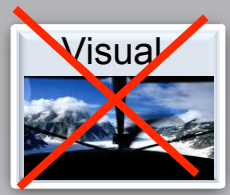
Vestibular Organs

Proprio-ceptors

Equilibrium Inputs

mental motion model

- no alignment of cues with vision
- mental model disconnect
- translation of non adjusted cues into motion sensation



Spatial Orientation

Motion Sensation

VOR

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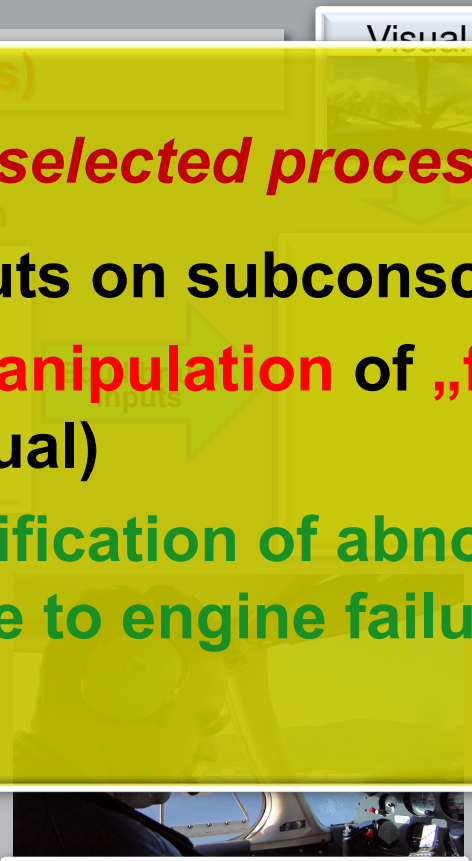
Mental Model

Summary (selected processes)

***Mental Motion Model** (selected processes)*

- **enables control inputs on subconscious level**
- **identification and manipulation of „false“ cues (alignment with visual)**
- **instantaneous identification of abnormal motion (e.g. yaw due to engine failure)**



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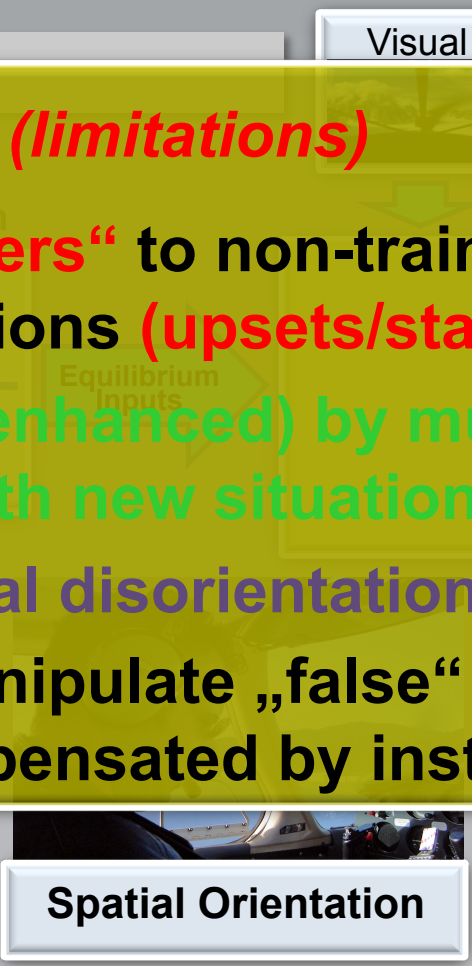
Mental Model

Mental Motion Model (limitations)

- cannot give „answers“ to non-trained/ experienced situations (upsets/stalls, etc.)
- can be upgraded (enhanced) by multi-sensory training to cope with new situations like (upsets, stalls, etc.)
- cannot avoid spatial disorientation in case of no vision (IMC)
- cannot identify/manipulate „false“ vestibular cues in case of IMC (must be compensated by instrument flying)



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What is the secret of training instrument flying?

Basics:

- The student pilot is confronted with a mixture of correct and false vestibular cues which are not manipulated by the mental model due to non visible natural horizon
- The student pilot must learn to concentrate on the artificial horizon regardless of any motion sensation
- The student pilot must learn to suppress any disturbing motion sensation not in line with the movement of the a/c (substitution of the subconscious suppression of false cues by a conscious concentration process)

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Recommendations for practical flight training

For all training elements bearing the risk of sensor conflicts between vestibul. and visual cues motion based training with „*feel true*“ motion is highly recommended for a best possible transfer of training (*enhancement of mental model*):

- **Basic instruments training (IMC/moderate turbulences)**
- **Basic hover and autorotation training (helicopter)**
- **Upset and stall/post-stall recovery training**
- **Spatial disorientation training**
- **MOFT/LOFT training missions containing elements of human performance limitations (distraction, fatigue, complacency, startle effects)**
- **MOFT/LOFT training missions containing elements of technical malfunctions (unreliable IAS, a/p malfunction, etc.)**
- **MOFT/LOFT training missions containing elements of unusual turbulences (microbursts, windshear, wake vortex turbulences)**

Situational Awareness?

Many thanks for listening!

Questions?

BE AWARE OF!

Source: http://aviationhumor.net/always-trust-your-instruments/

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What are the „steps“ leading into LOC-I?

1. trigger ➔ 2. loss of s/a ➔ 3. upset/stall ➔ 4. avoidable LOC-I

In some cases the a/c is piloted directly into an upset
(severe turbulence or autoflight malfunction without disconnect)

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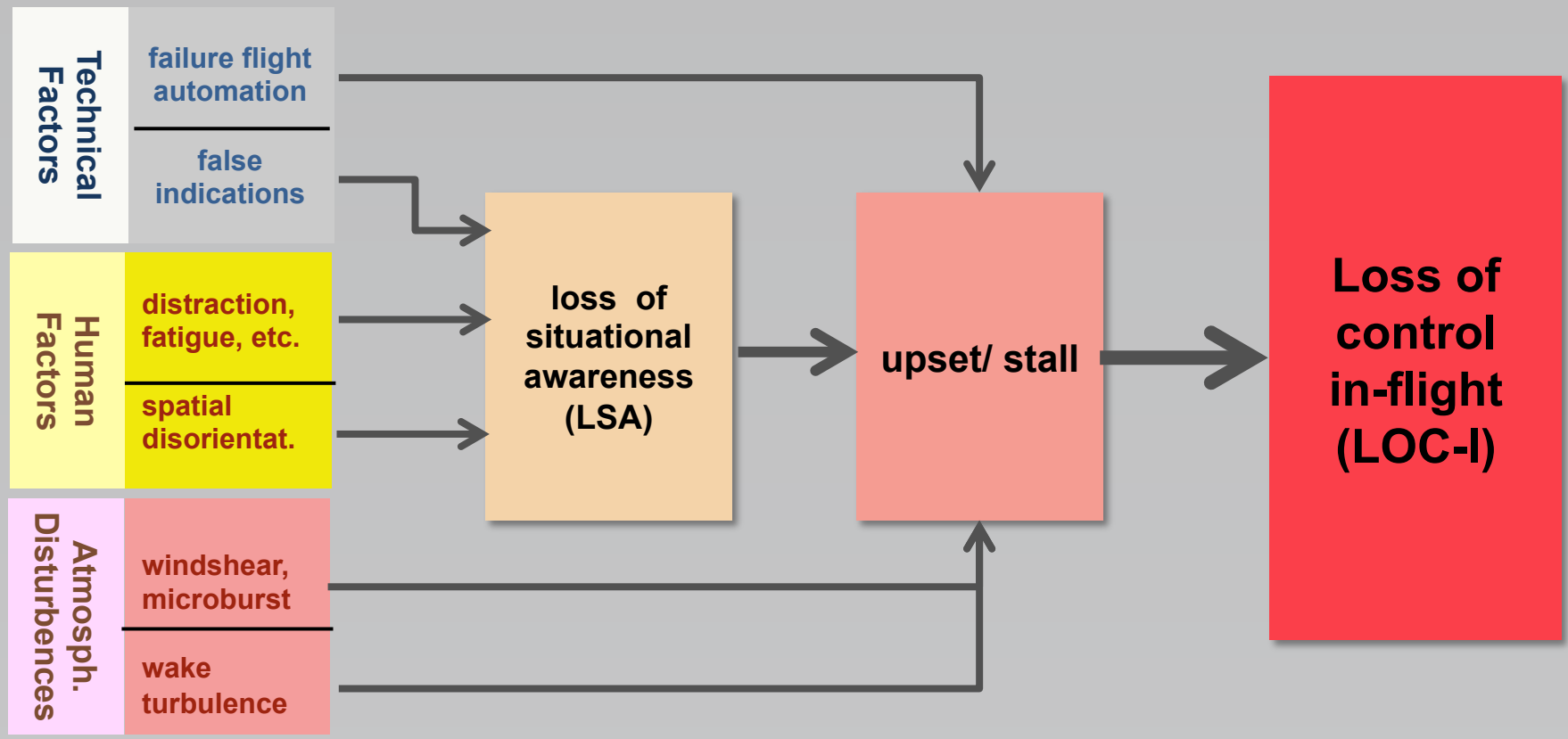
Bad chains causing LOC-I



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Significant Stress Factors, example of a complex short term psycho-physical open loop circuit controlled by hormone levels

Preparation for „fast running“ or „fight“ with quick response on possible cuts:

- increase of heartbeat
- increase of blood pressure
- increase of blood flow in the skeleton muscles
- increase of clotting ability of the blood
- increase of breathing frequency but less deep and bronchia are widened

Supporting Preparations:

- skin conductance response increased
- decreased activity of the gastrointestinal tract
- decreased immunologic tolerance

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