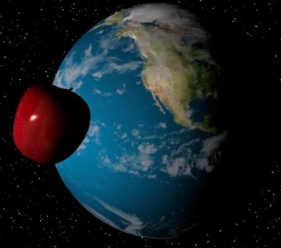


Visuo-vestibular compensation after somatosensory loss in the perception of external and self orientation

Lionel Bringoux

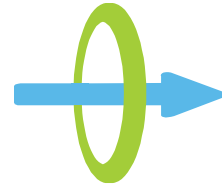
lionel.bringoux@univ-amu.fr



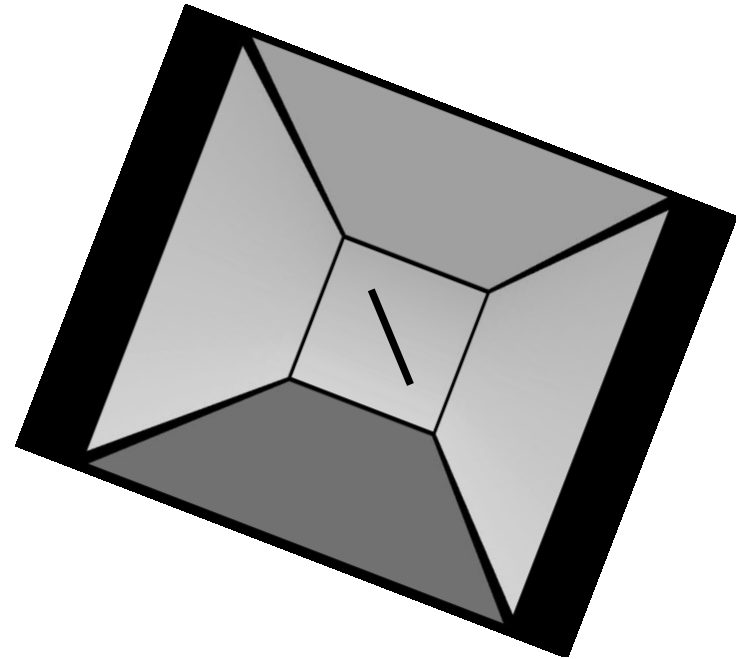
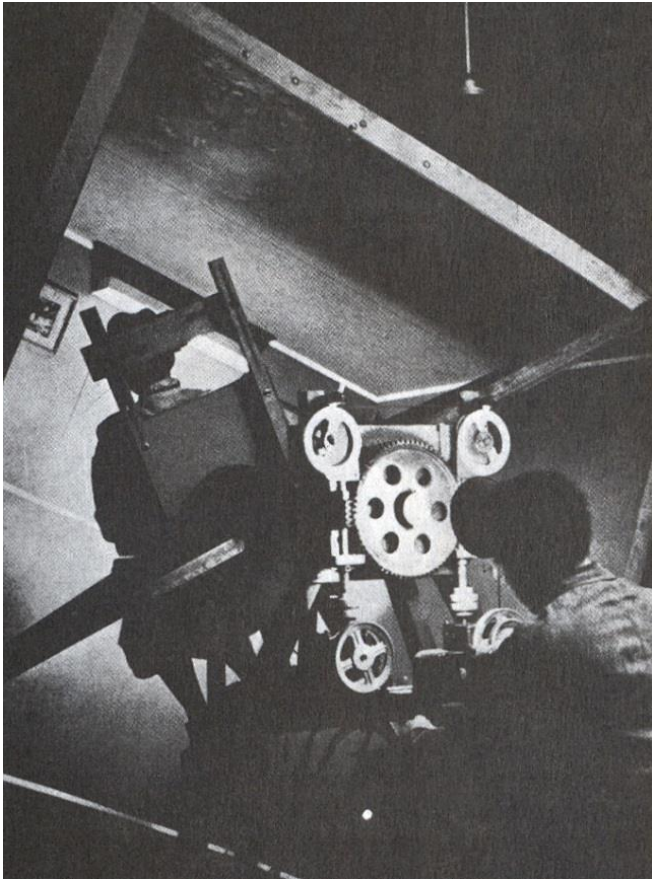
Institute of Movement Sciences
Aix-Marseille University / CNRS

New perspectives on embodiment and self-location / Marseille / Nov 9th 2016

Visual influence



Spatial orientation



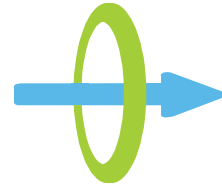
Asch & Witkin (1948) : Visual field dependence

FD

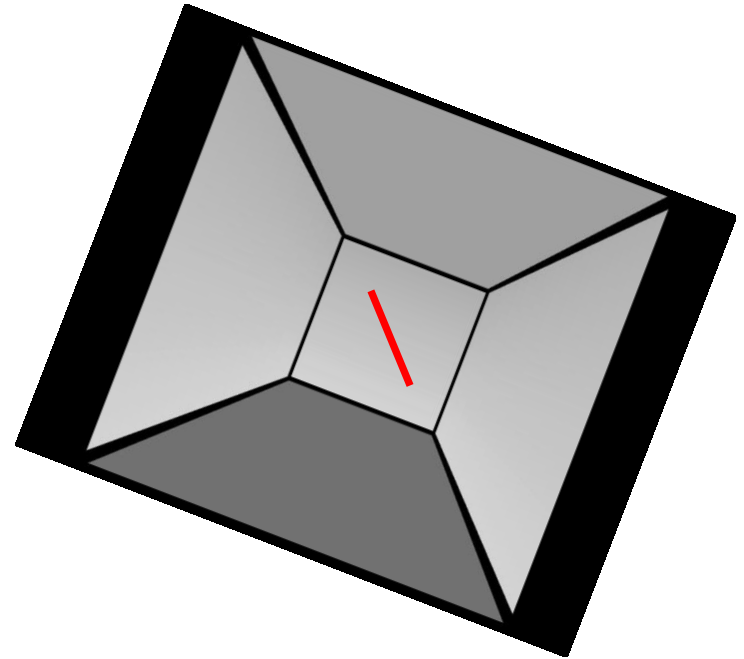
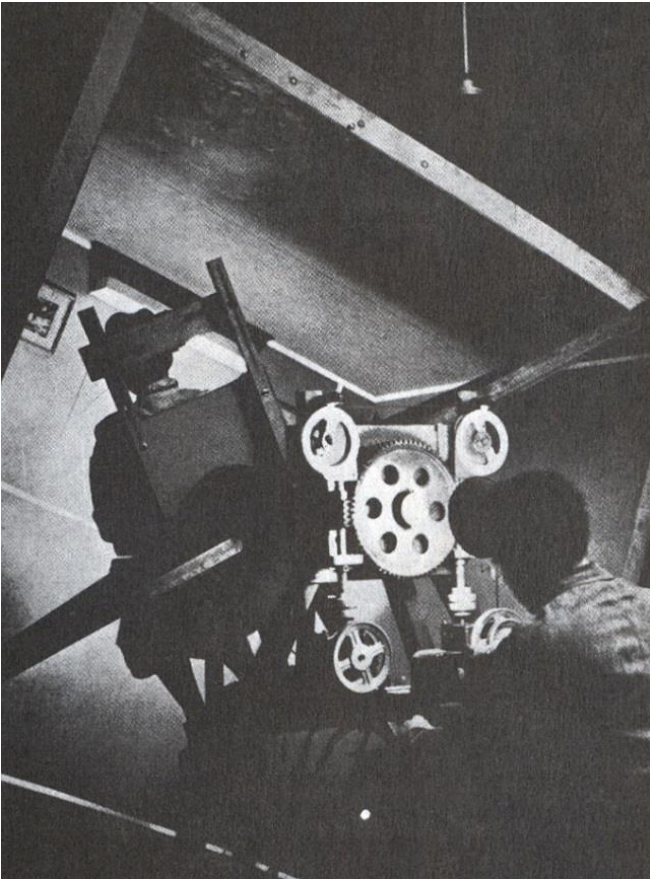
VS

FI

Visual influence



Spatial orientation



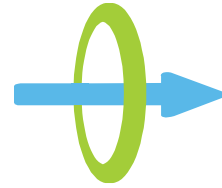
Asch & Witkin (1948) : Visual field dependence

FD

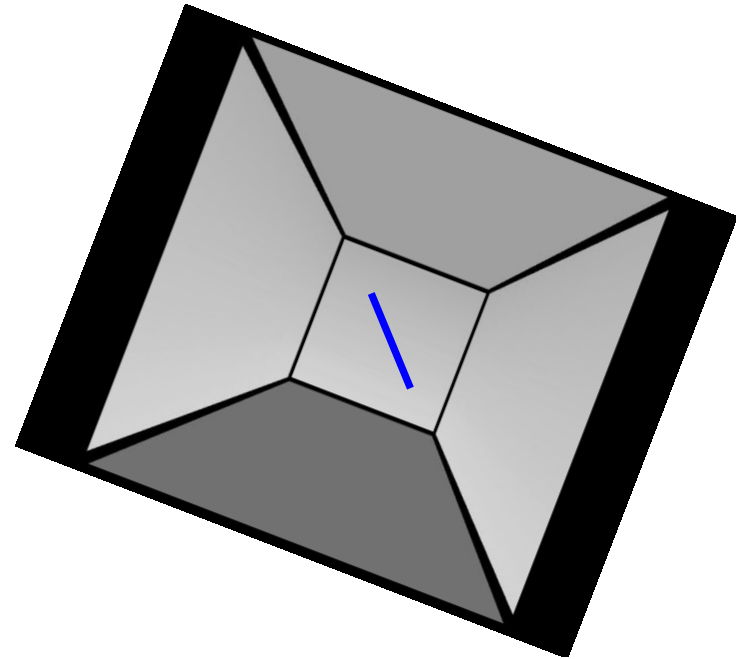
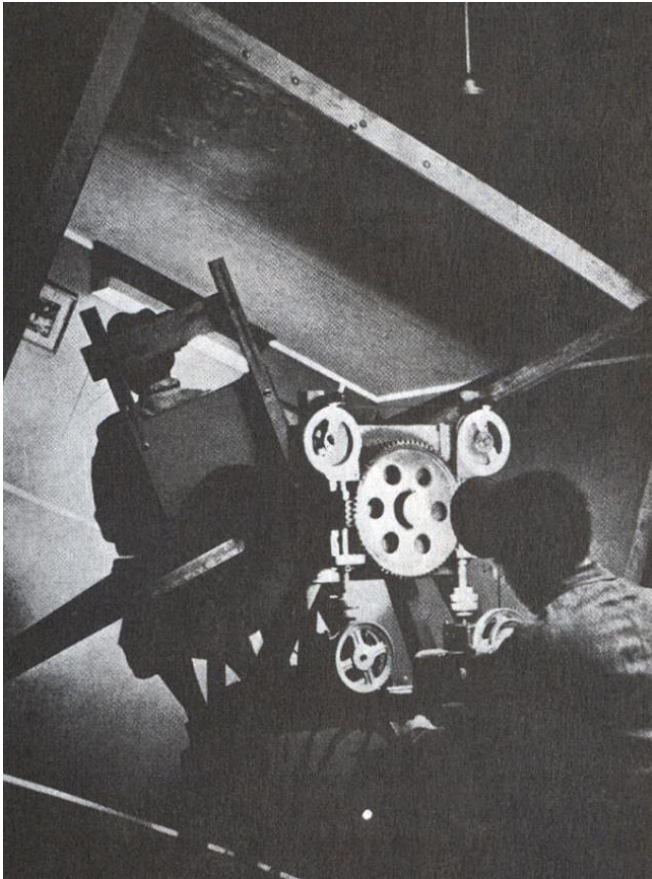
VS

FI

Visual influence



Spatial orientation



Asch & Witkin (1948) : Visual field dependence



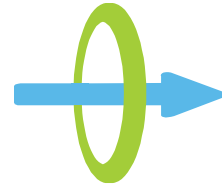
Rod and Frame Test [RFT; Oltman (1968)]

FD

VS

FI

Visual influence



Spatial orientation

Objects (external) orientation

vs

Body (self) orientation



SVV or object-tilt perception



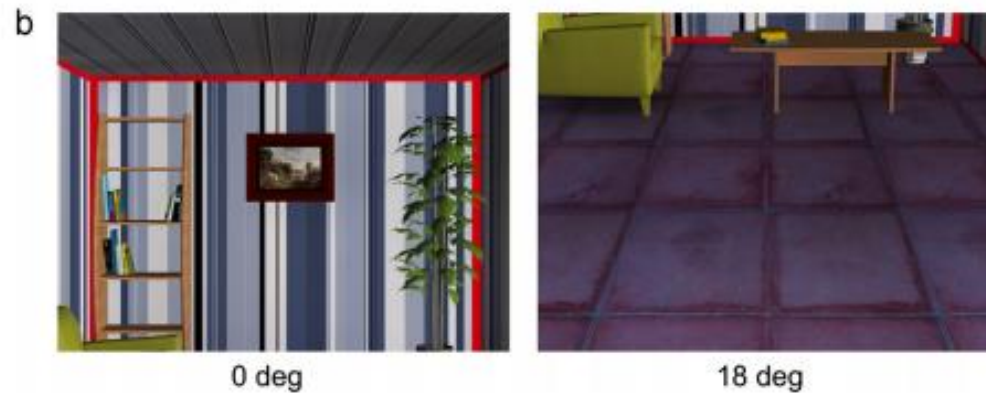
PV or self-tilt perception

Visual influence  Spatial orientation



Scotto Di Cesare et al. (2015) Gait & Posture

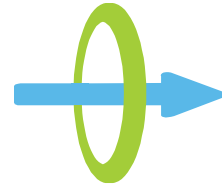
- ✓ Very slow body/scene rotations
- ✓ Self-tilt detection threshold
- ✓ 5 visuo-vestibular conditions



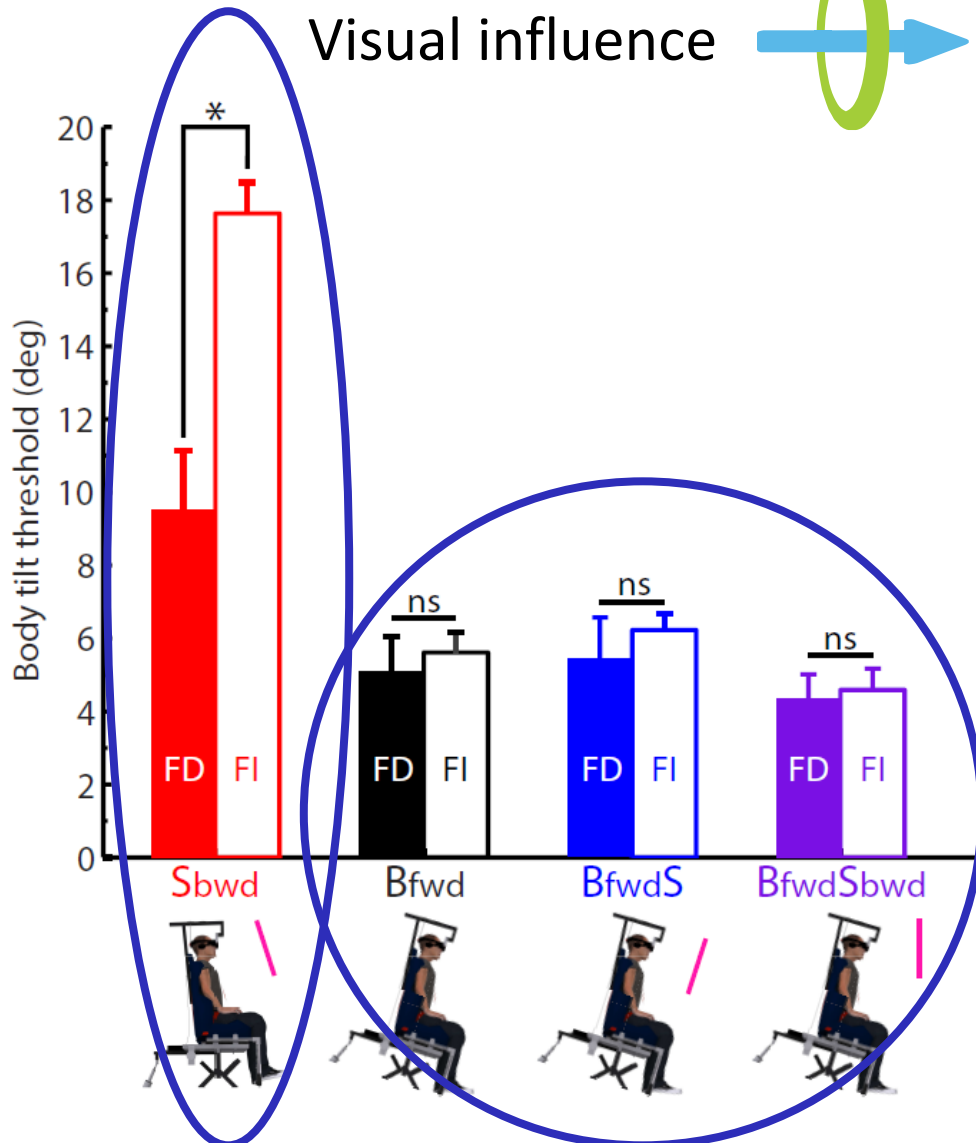
0 deg

18 deg

Visual influence



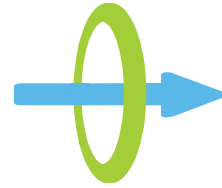
Spatial orientation



Scotto Di Cesare et al. (2015) Gait & Posture

- ✓ Very slow body/scene rotations
- ✓ Self-tilt detection threshold
- ✓ 5 visuo-vestibular conditions
- ✓ Slow changing postural cues cancel visual field dependence on self-tilt detection

Sensory impairment



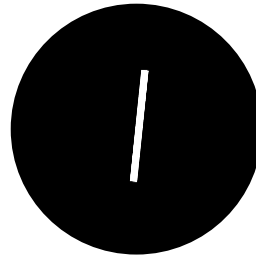
Spatial orientation

Objects (external) orientation

VS

Body (self) orientation

No visual frame



SVV



SPV

Vestibular defect

Unilateral



Tabak et al (1997)

Bilateral



Tabak et al (1997)



Bisdorff et al. (1996)



Bringoux et al. (2002)

Somatosensory defect

Hemihypoesthesia



Saeys et al (2012)

Stroke (unilateral)

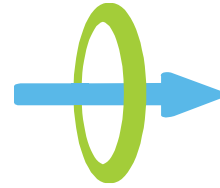


Anastasopoulos et al. (1999)... but...



Saeys et al (2012)

Sensory impairment → Spatial orientation



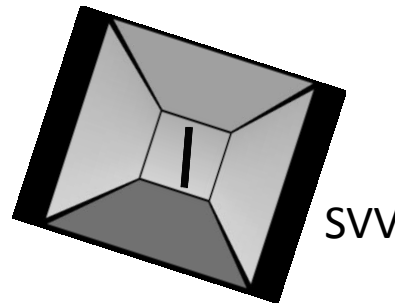
Objects (external) orientation

VS

Body (self) orientation

Tilted visual frame

Field dependence

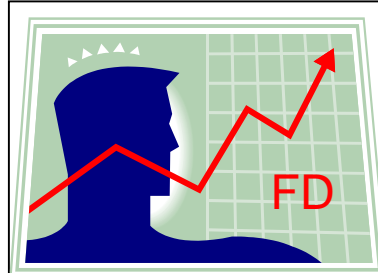


SVV



SPV

Vestibular defect
(Bilateral)



Guerraz et al (2001)
Lopez et al (2007)



Ito and Gresty (1996; 1997)

Somatosensory defect

???

???

Spatial orientation perception without somatosensory inputs

Bringoux et al. (2016) Front Hum Neurosci

Objects (external) orientation

Body (self) orientation

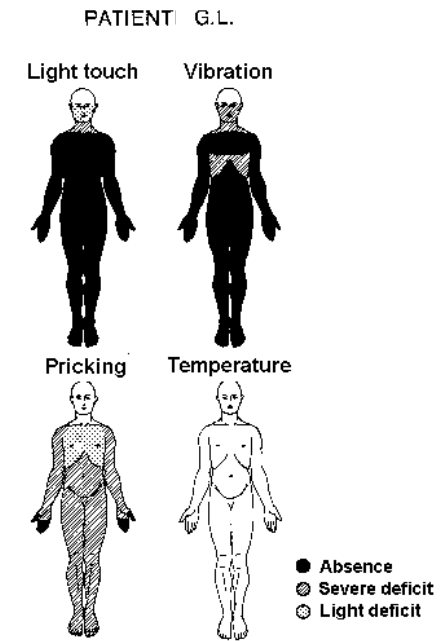
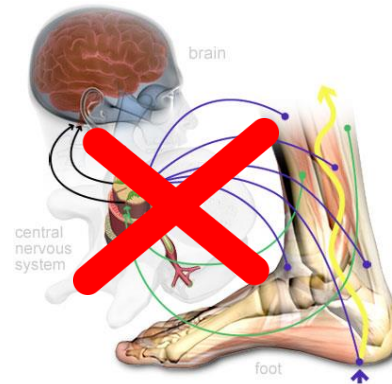
👁️👁️ Visual compensation → Field dependence?



Vestibular compensation → Graviceptive reference?

Participants

- ✓ Somatosensory-deafferented patient (F; 65 yo)



- ✓ Age-Matched Controls (#8 [5F - 3M]; 65.2 ±4.6 yo)
- ✓ Young FD healthy subjects (#8 F; 19.6 ±1.3 yo)

Objects (external) orientation

RFT



SVV



Body (self) orientation

BTT

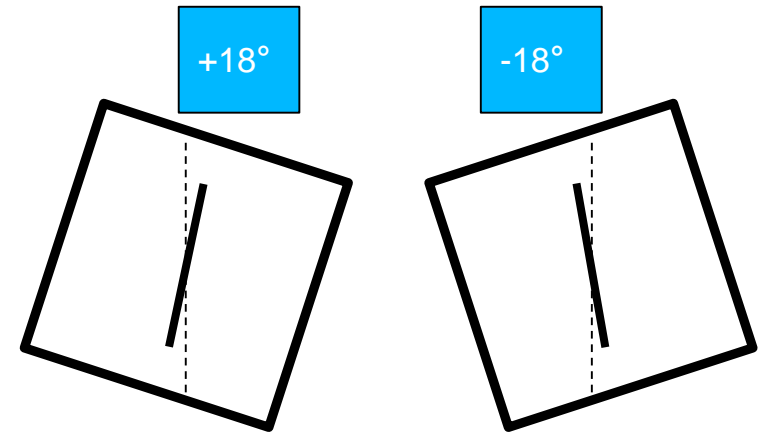
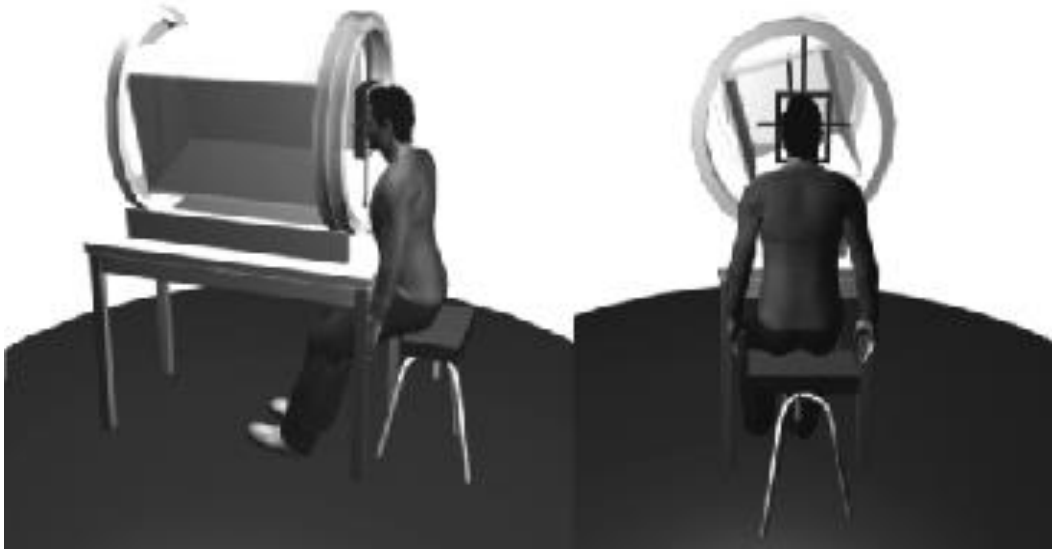


Self-tilt detection



RFT → SVV

Frame tilt	0°	±8°	±18°	±28°	±38°
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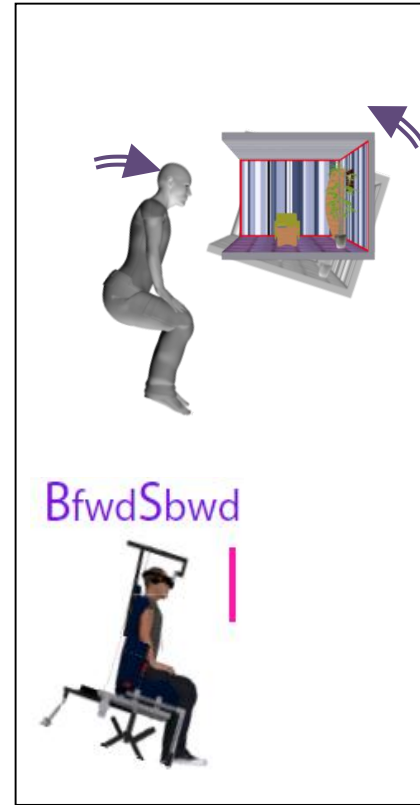
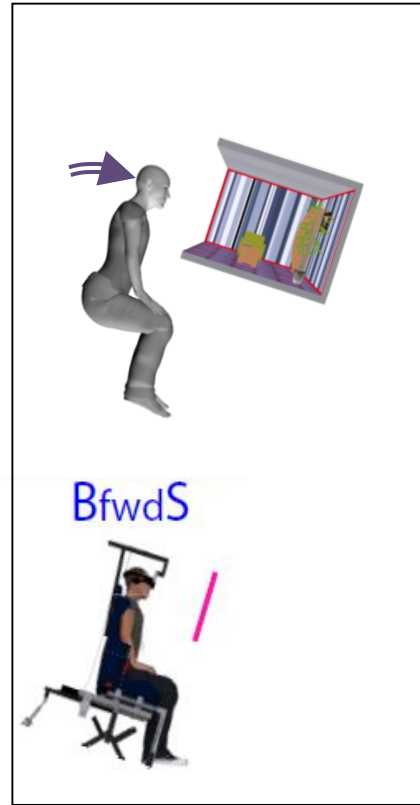
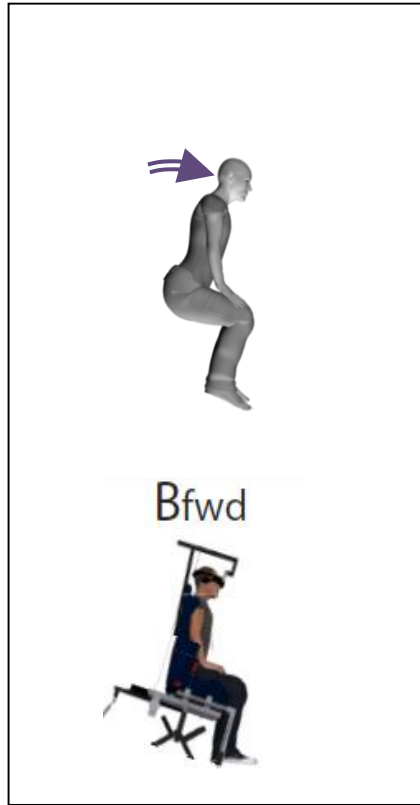
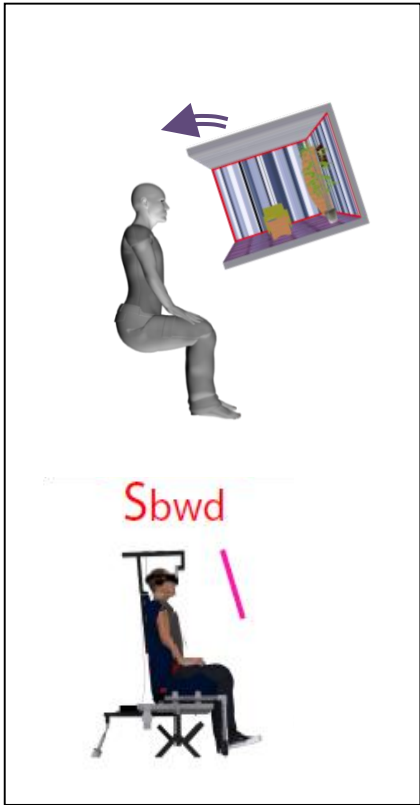


$$\text{RFT Score} = \frac{\sum \text{Dev}(R)}{Nb(R)} - \frac{\sum \text{Dev}(T)}{Nb(T)}$$

(Nyborg et Isaksen, 1974)

Mean unskewed deviation
/ gravitational vertical

Self-tilt detection



✳ Do I feel being tilted forward ?

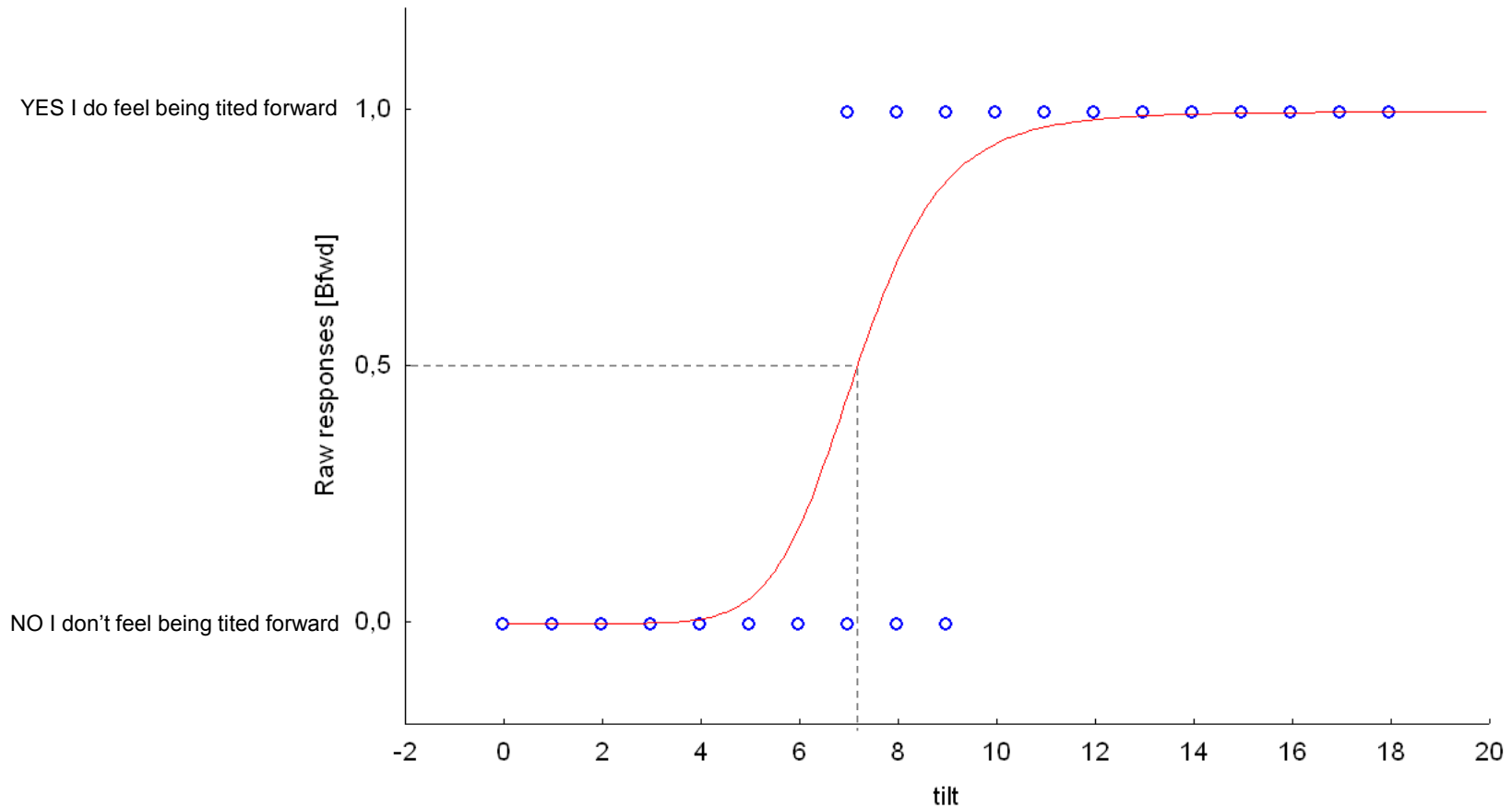
Yes

No

Self-tilt detection

Probit Model

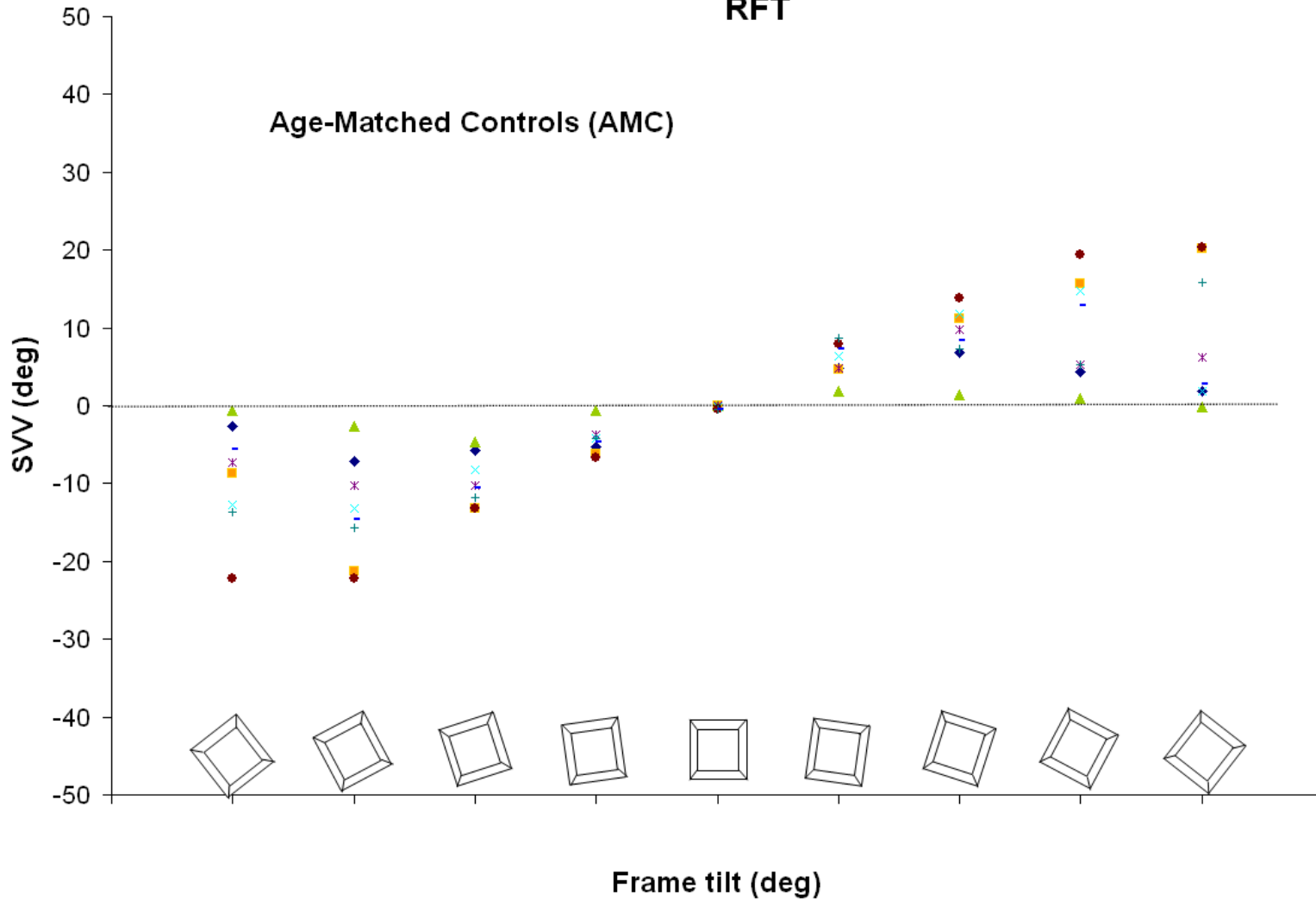
$$B_{fwd} = \frac{1}{1 + (\text{tilt}/b_1)^{b_2}}$$
$$y = \frac{1}{1 + (x/(7,20153))^{8,20939}}$$



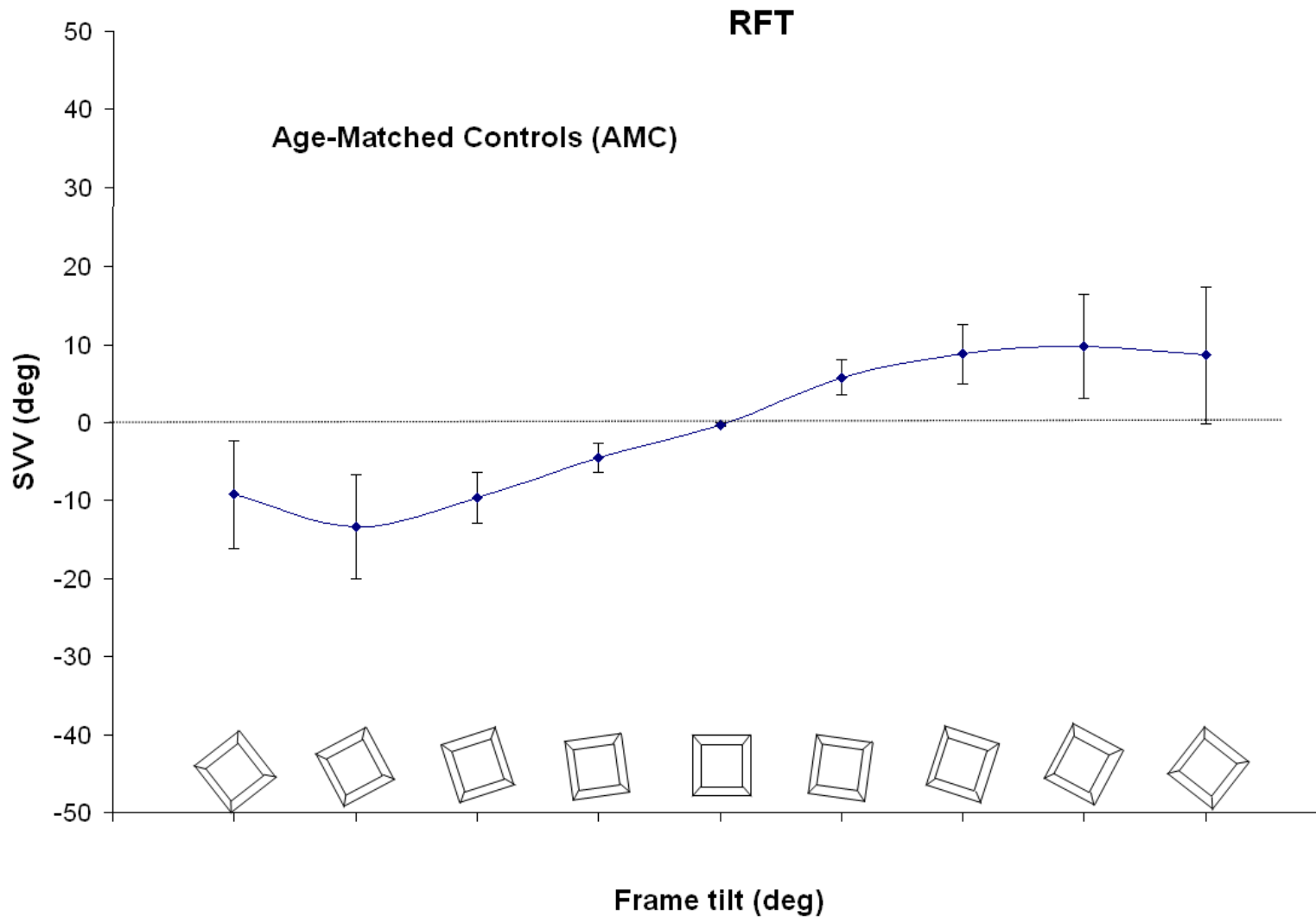
Subjective Visual Vertical

RFT

Age-Matched Controls (AMC)



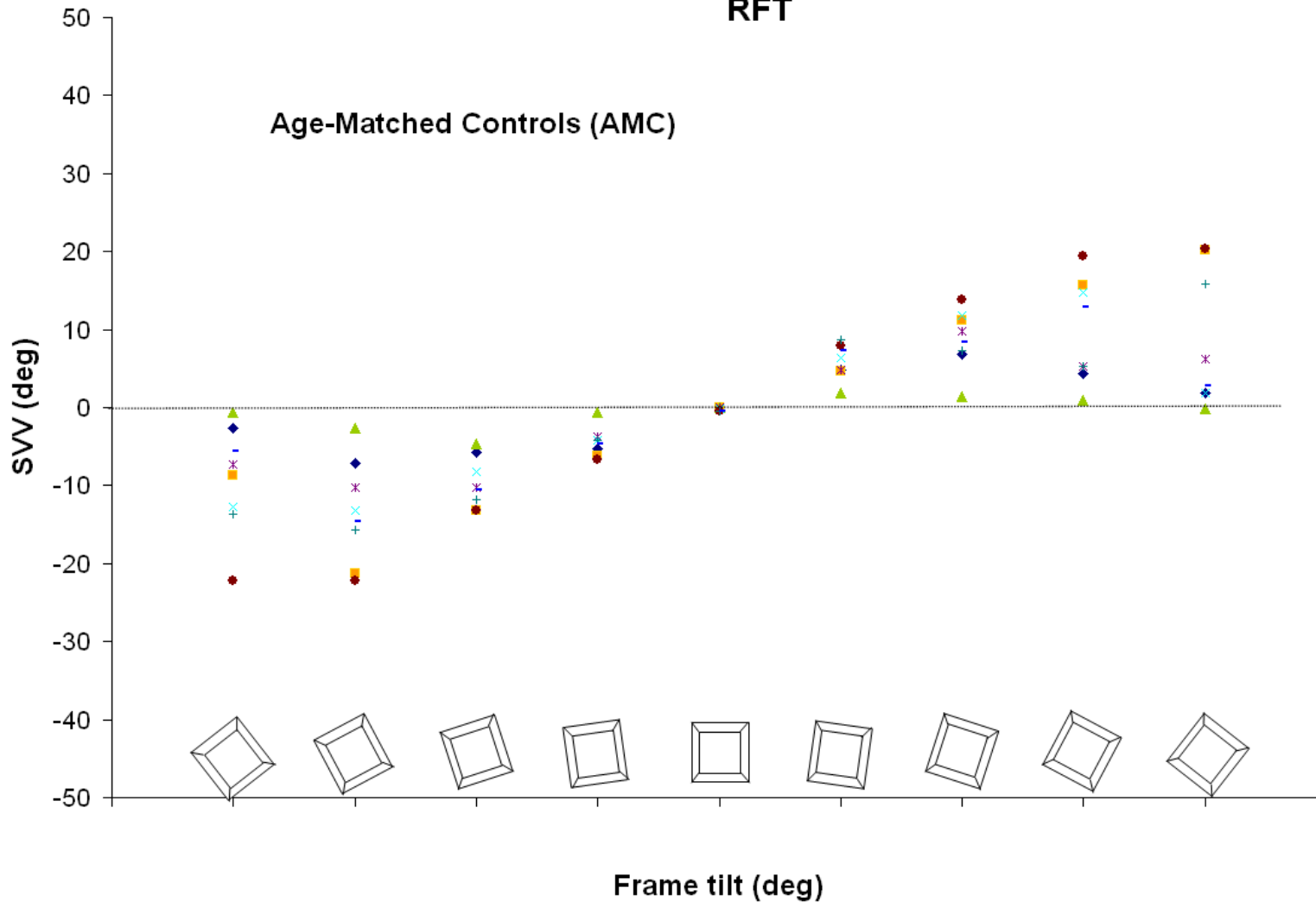
Subjective Visual Vertical



Subjective Visual Vertical

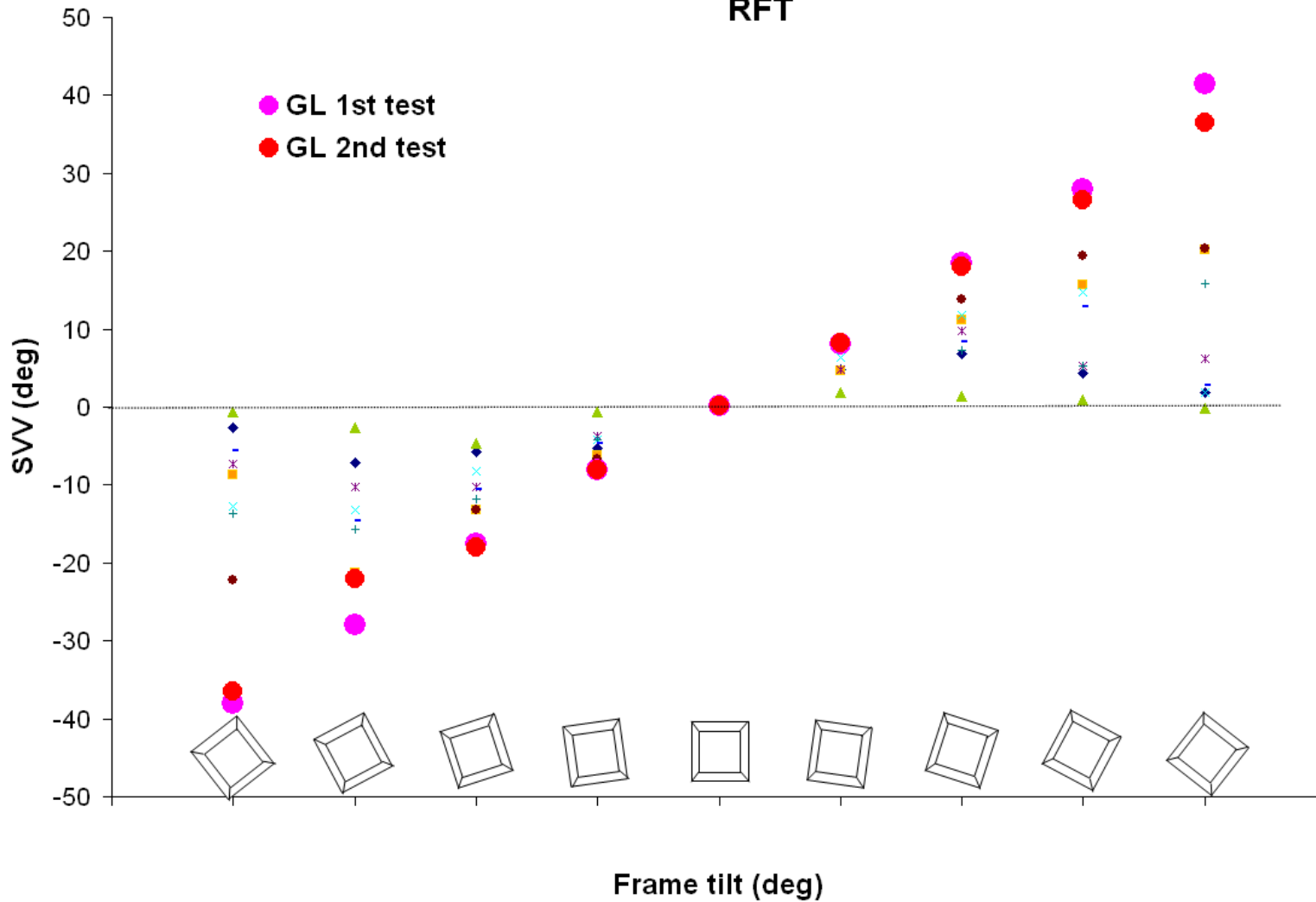
RFT

Age-Matched Controls (AMC)

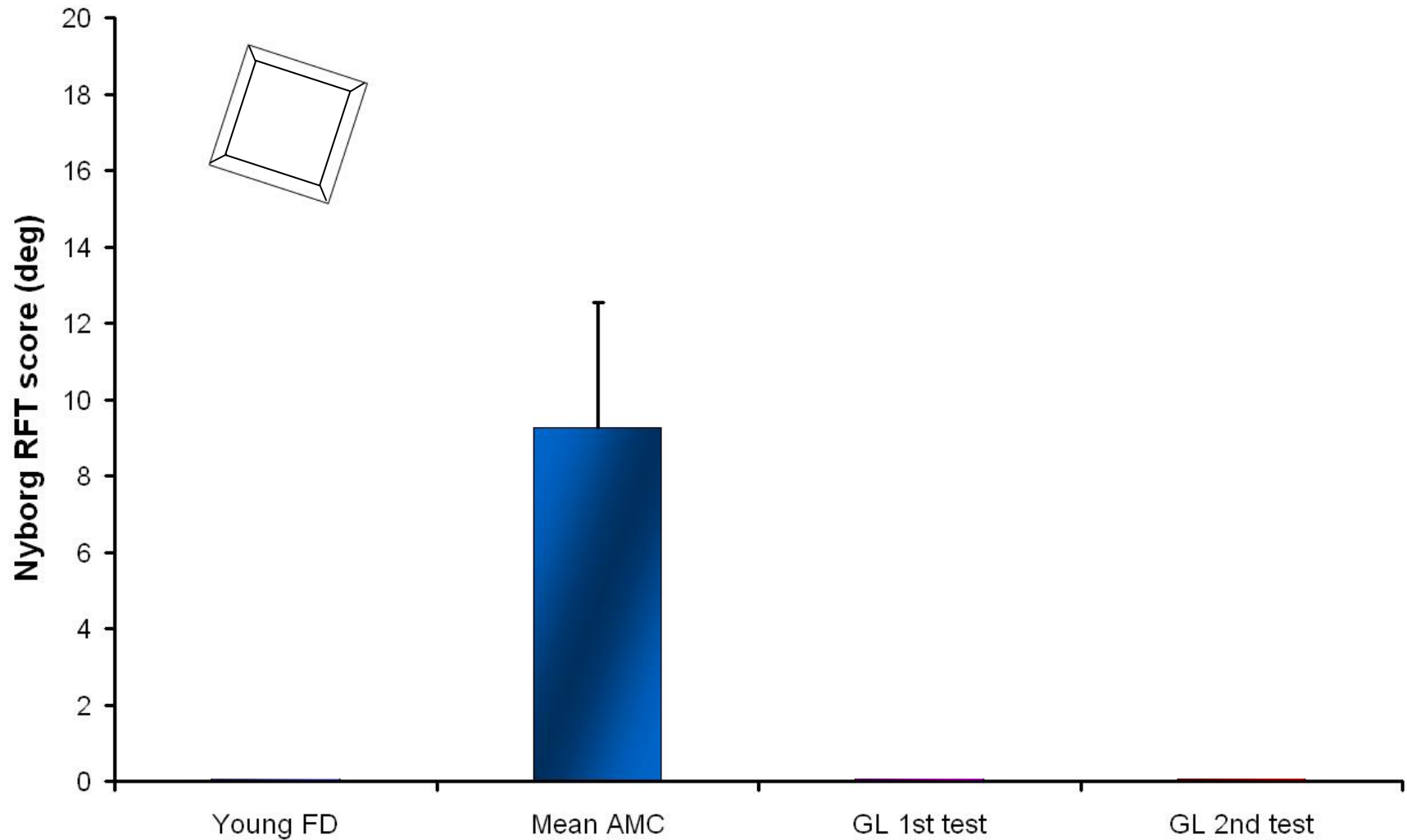


Subjective Visual Vertical

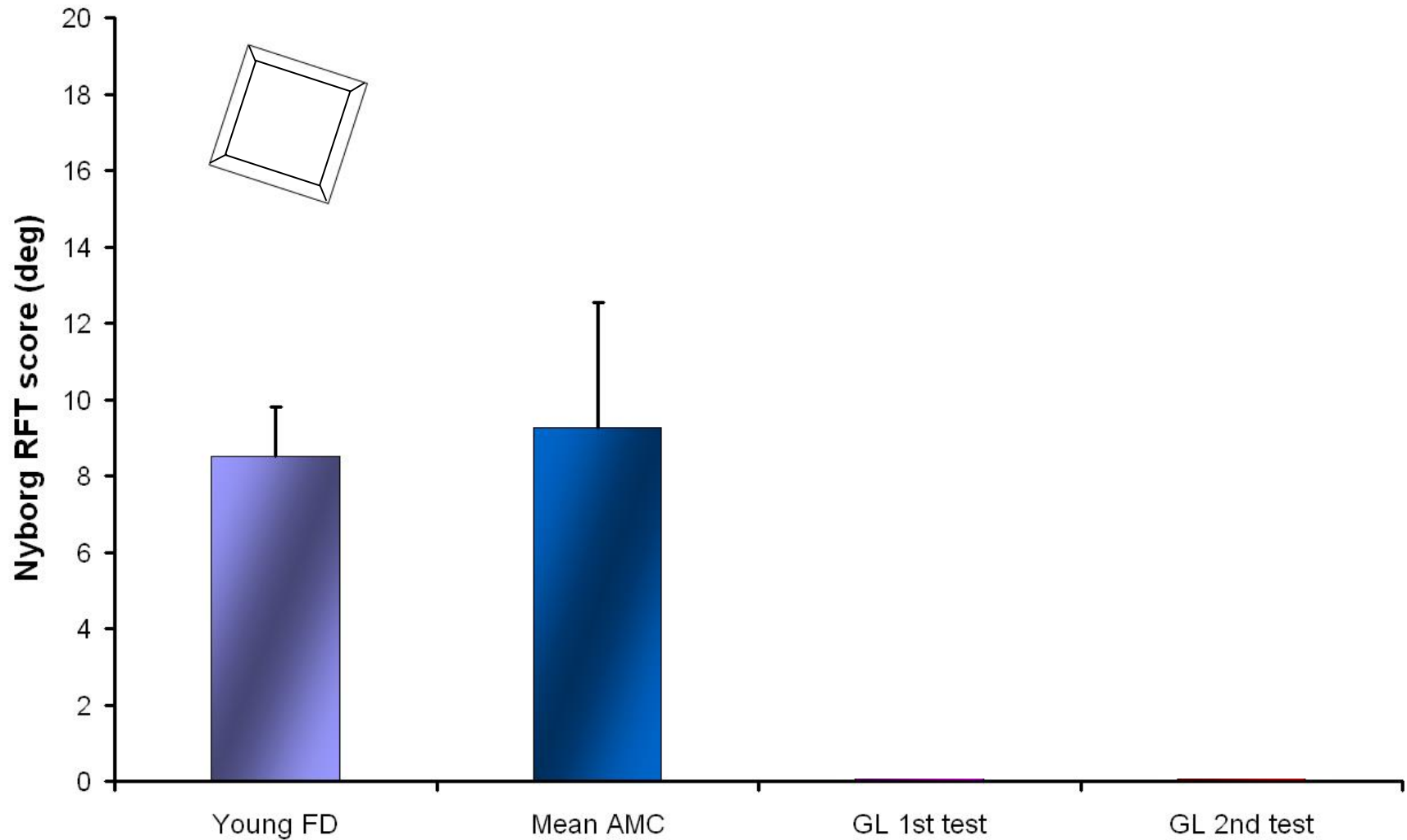
RFT

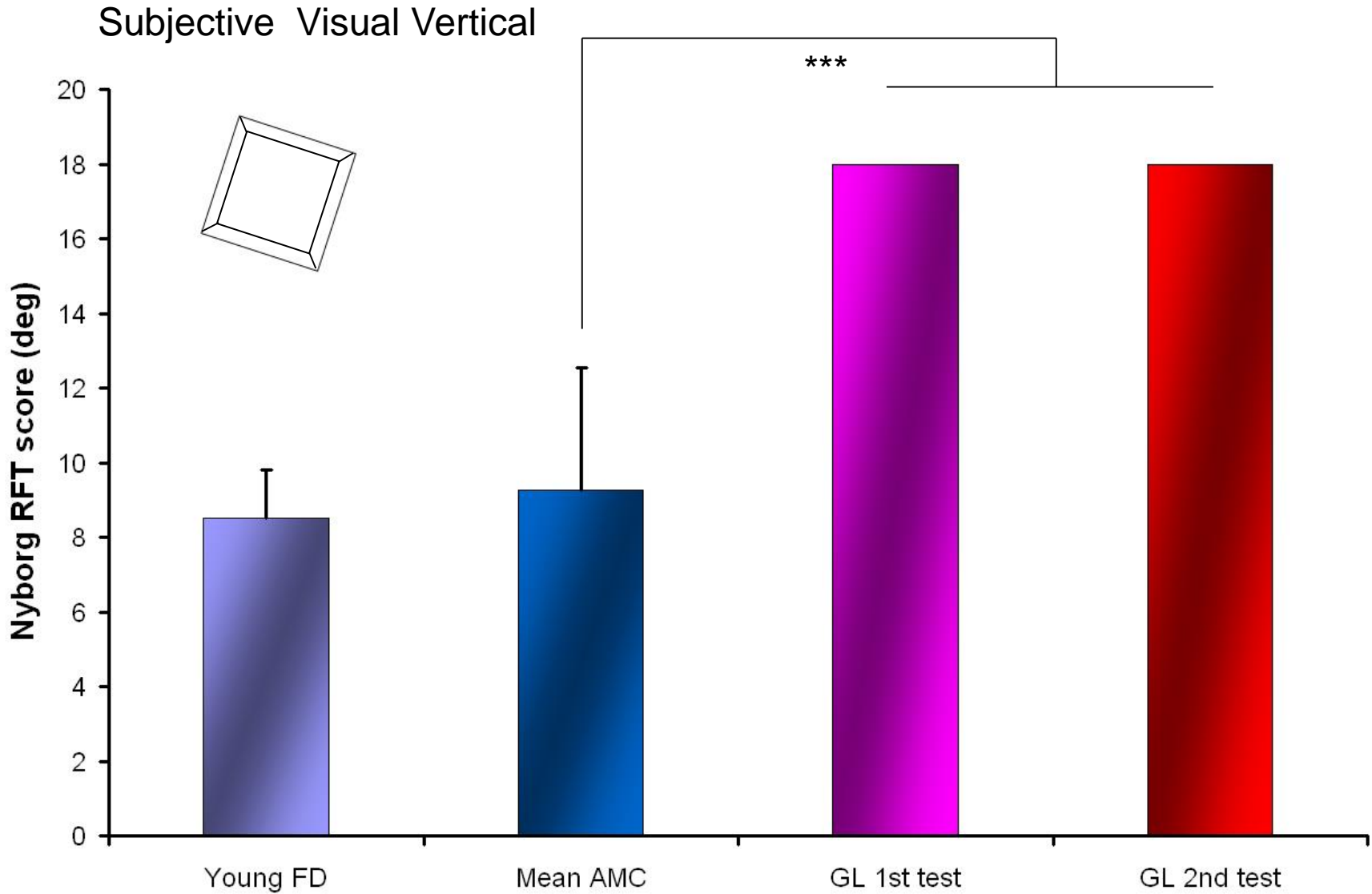


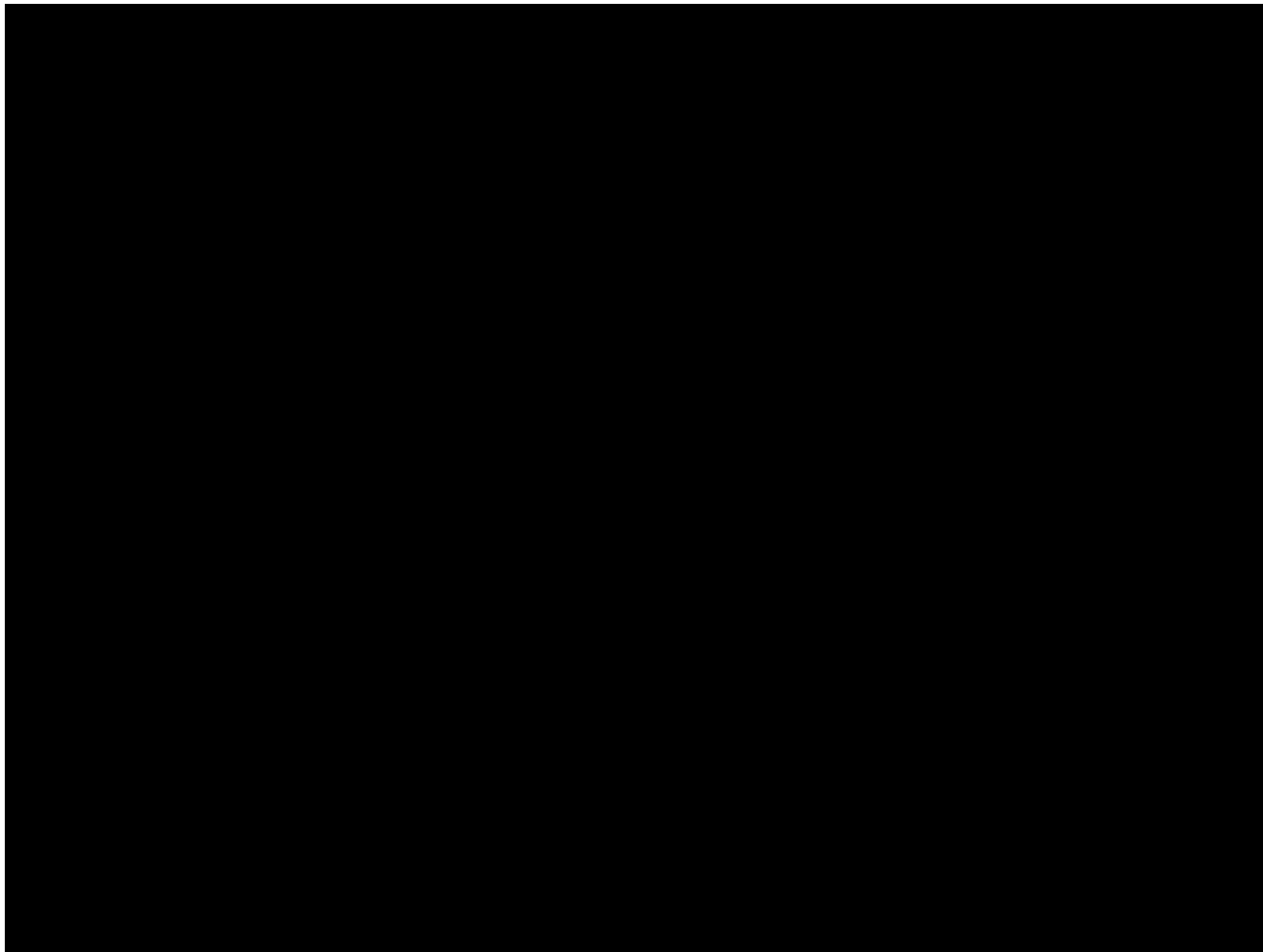
Subjective Visual Vertical



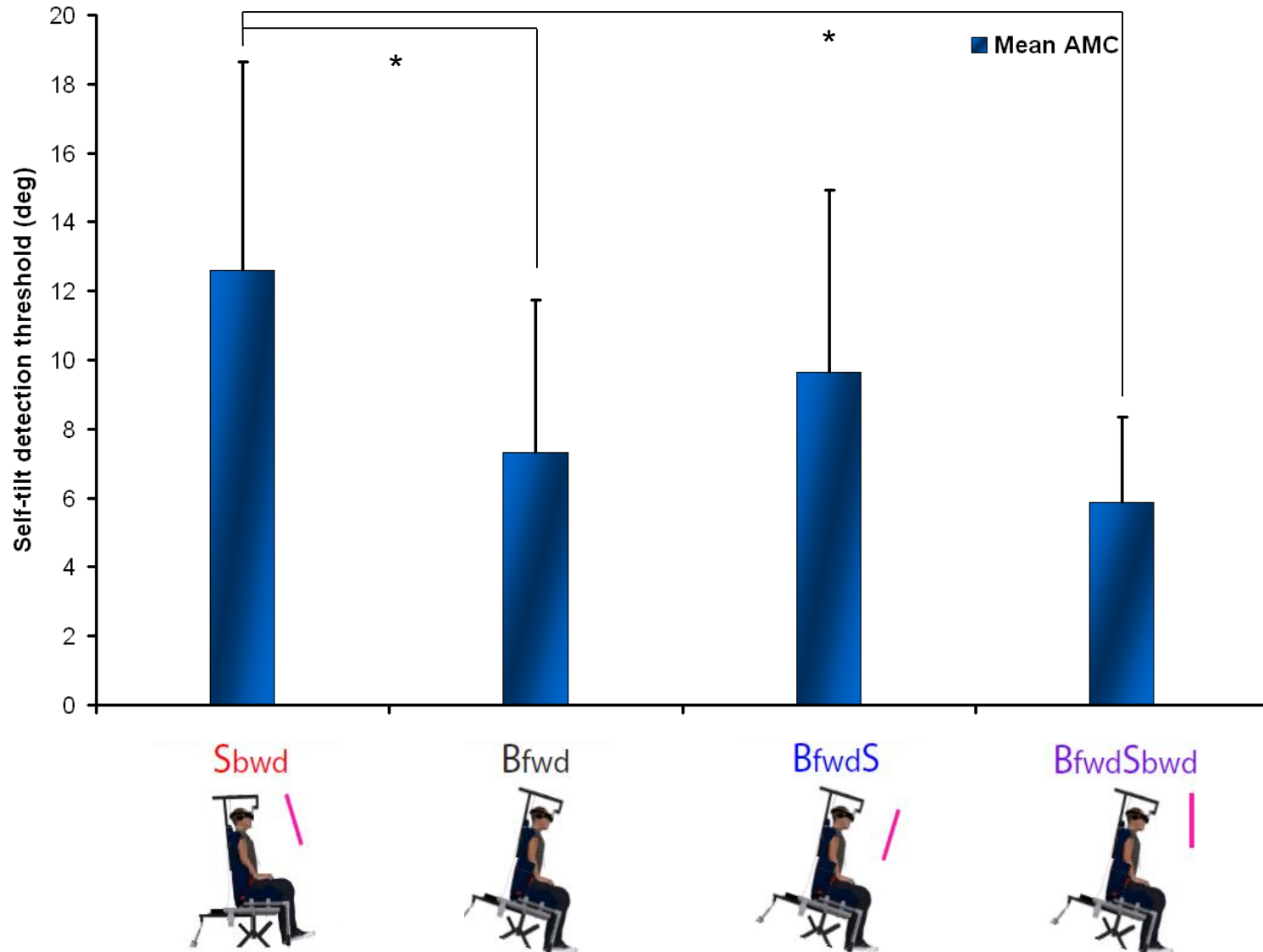
Subjective Visual Vertical



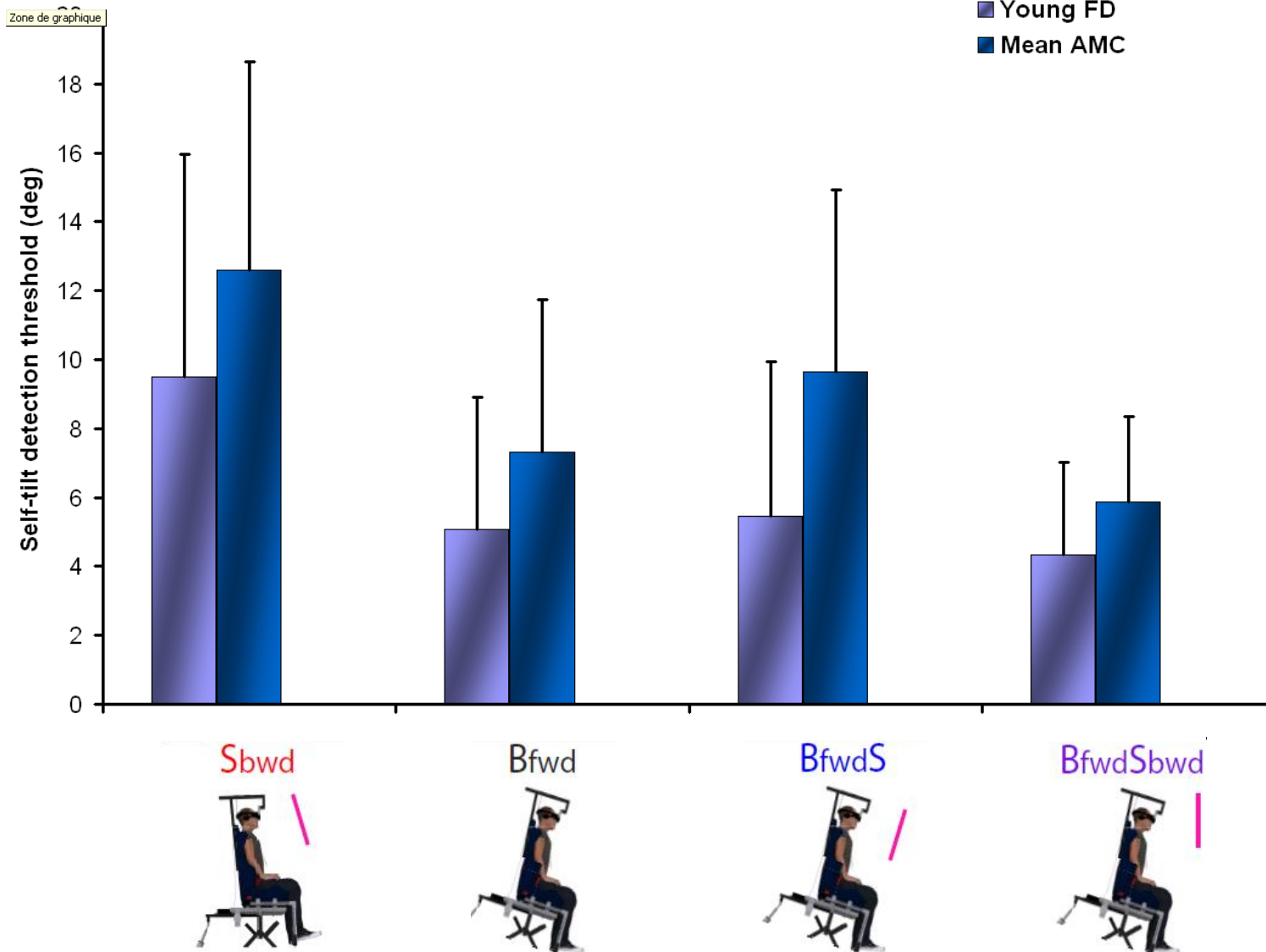




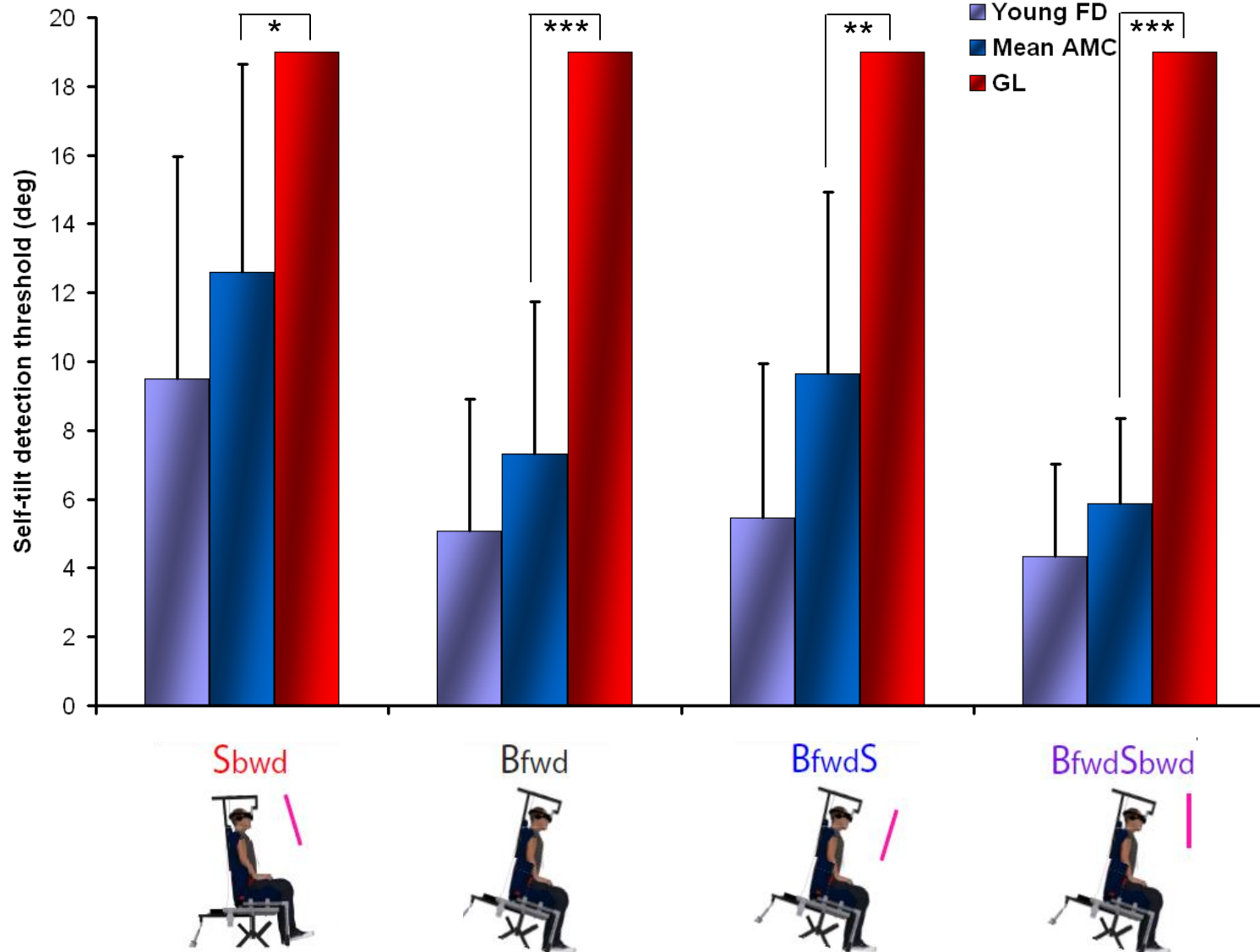
Self-tilt detection

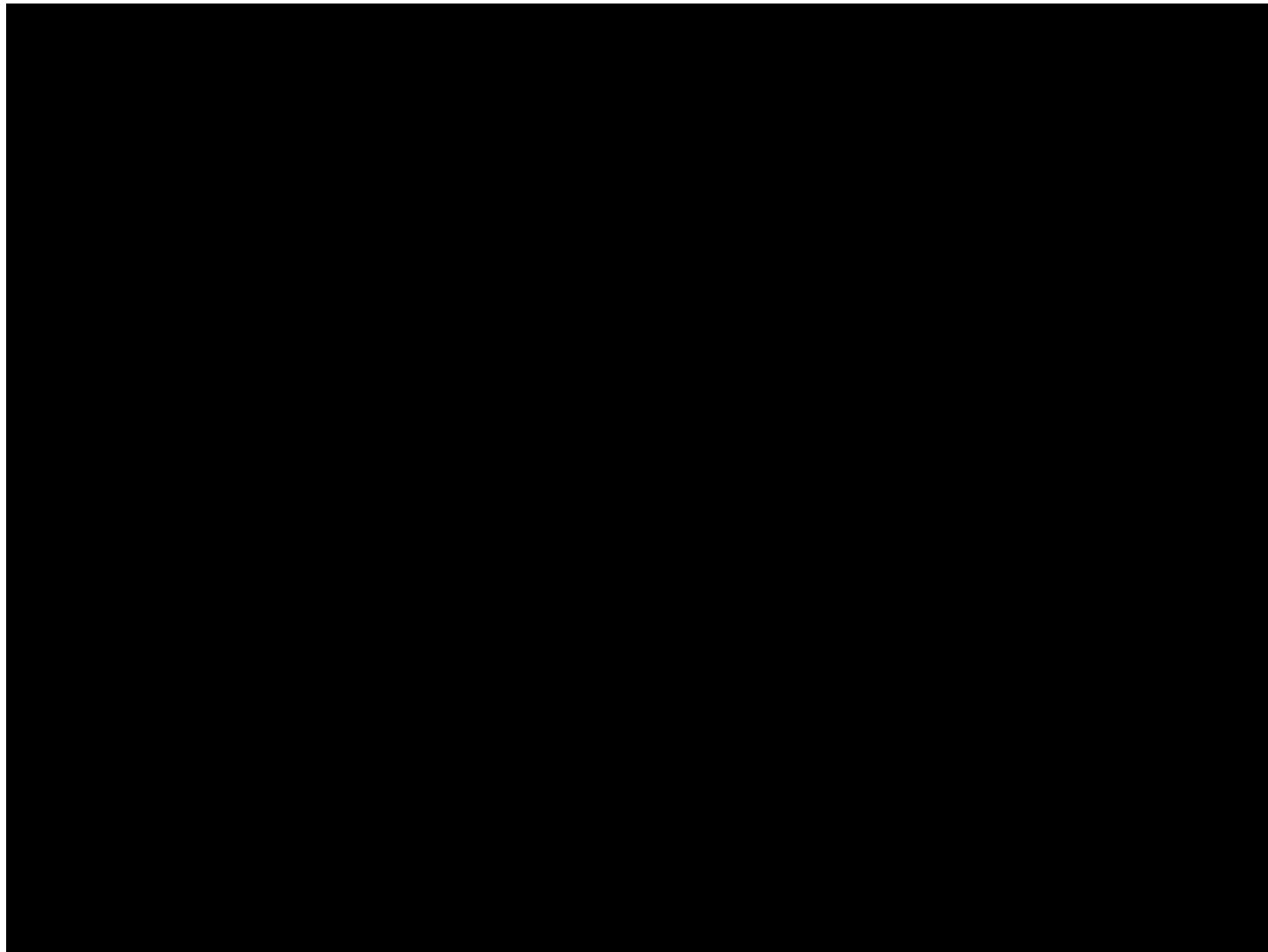


Self-tilt detection



Self-tilt detection





Sensory substitution?

- ✚ Visual capture... Not in any case!
- ✚ Graviceptive role of unrefreshed otolith inputs? (*Bringoux et al., 2003*)



Sensory substitution?

- ✚ Visual capture... Not in any case!
- ✚ Graviceptive role of unrefreshed otolith inputs? (*Bringoux et al., 2003*)

Reference frame selection?

- ✚ Distinction between external and self orientation perception (*Bronstein, 1999*)
- ✚ Allocentric vs (egocentric?) spatial reference frames (*Blouin et al., 1993*)

↑ **Idiotropic** (*Mittelstaedt, 1986*)

« *Prior for upright* » orientation (*De Vrijer et al., 2008; MacNeilage, et al., 2008*)

Thank you!



Cécile Scotto Di Cesare



Liliane Borel



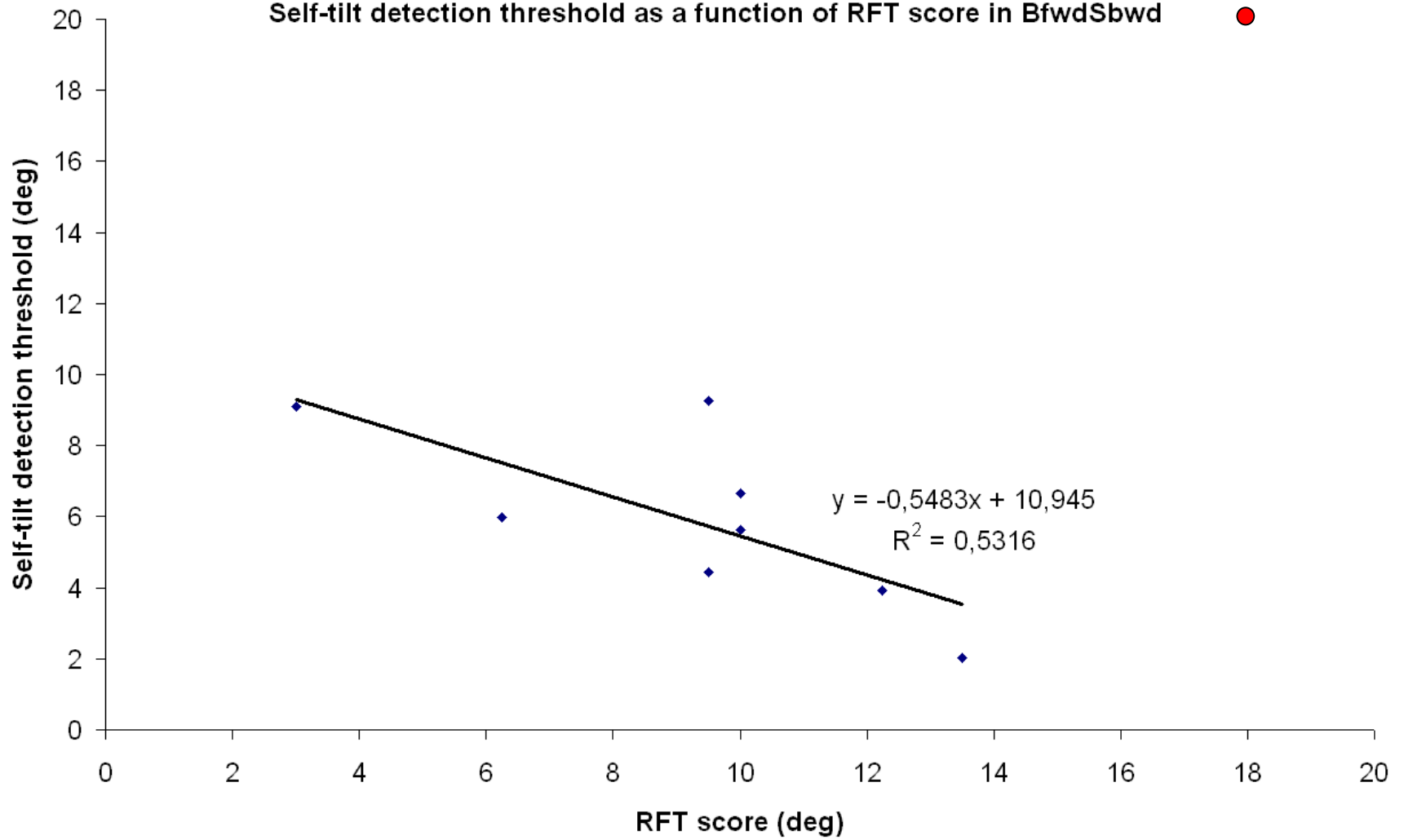
Thomas Macaluso

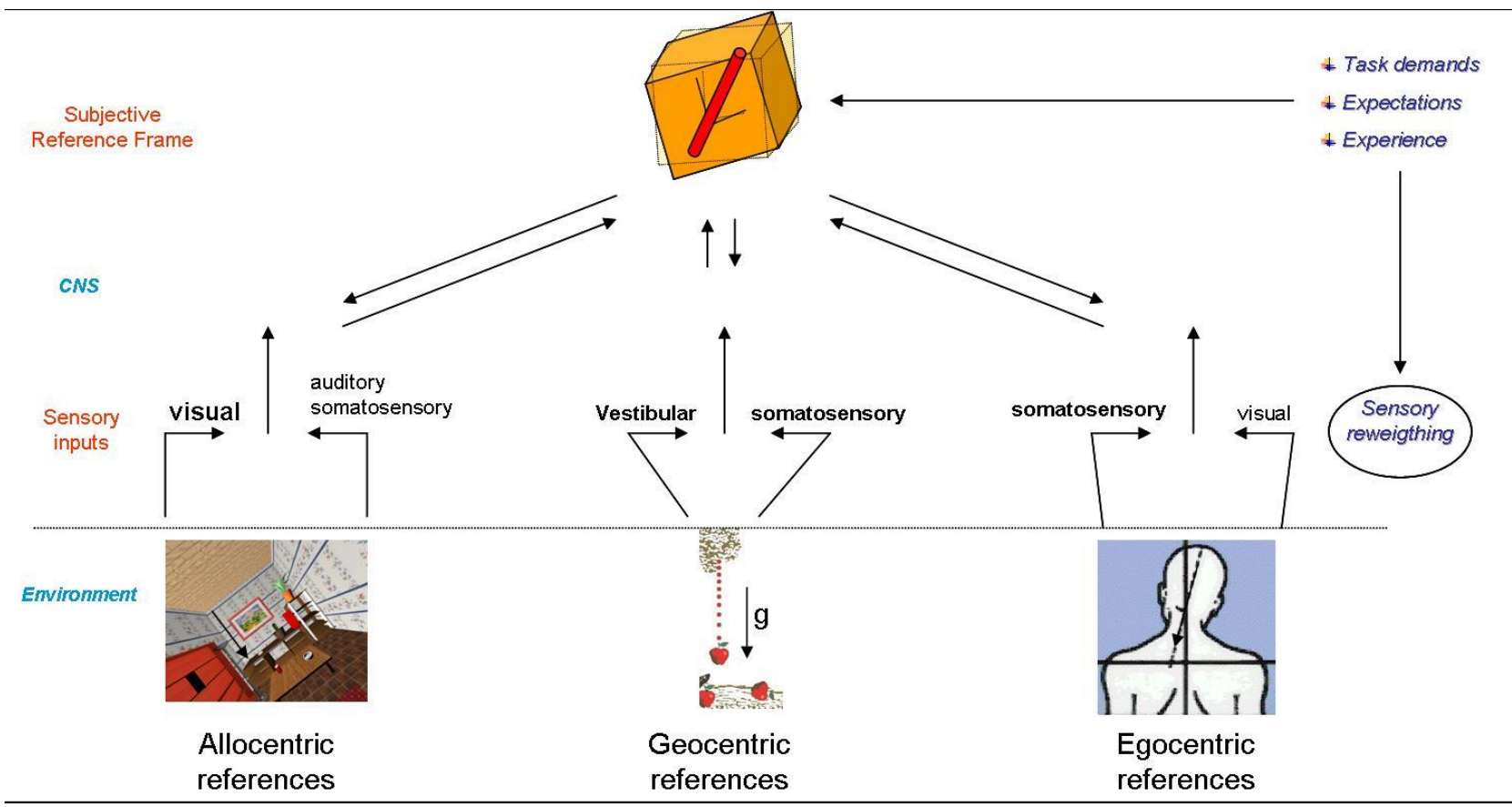


Fabrice Sarlegna

EXTRA SLIDES

Self-tilt detection threshold as a function of RFT score in BfwdSbwd





Somatosensory loss Perceptual consequences

Pending questions...

- ✚ Sensory substitution / recalibration?
- ✚ Perceptual / cognitive strategies?
- ✚ An insight into "normal" functioning?

Adapted behaviour

VS

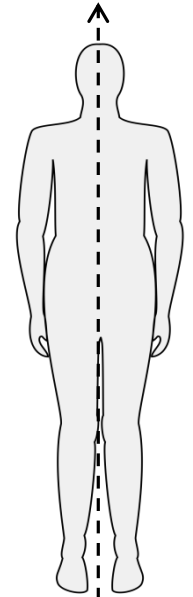
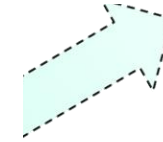
Impaired behaviour

Specific role of
somatosensory
inputs?



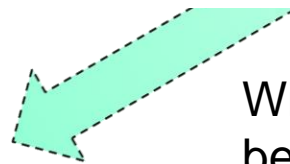
How can self-orientation perception be egocentric?

This sounds quiet paradoxical as you may judge your body orientation with respect to your own body configuration!

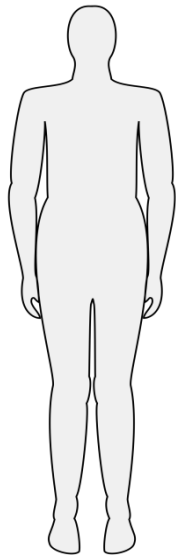


Reference

Actually, the body Z-axis may constitute a strong reference for verticality, as much as other sensory cues for orientation are fuzzy or ambiguous



Without any reliable exafference, no reason to feel being tilted, the body itself becomes the last cue for orientation



Judgment tool

