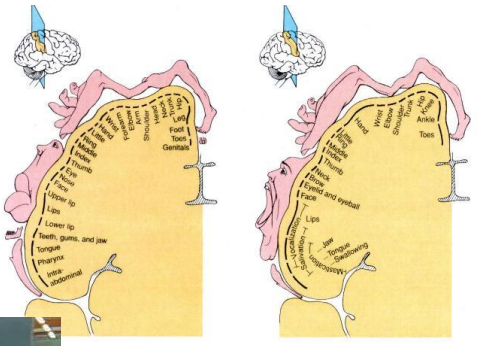
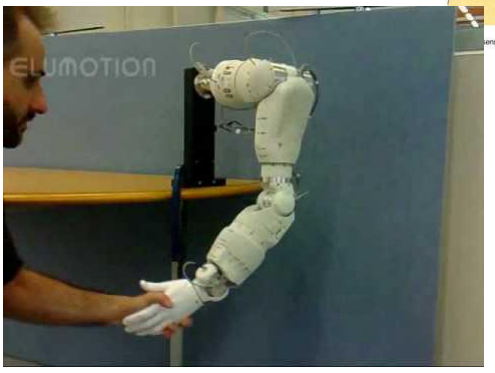
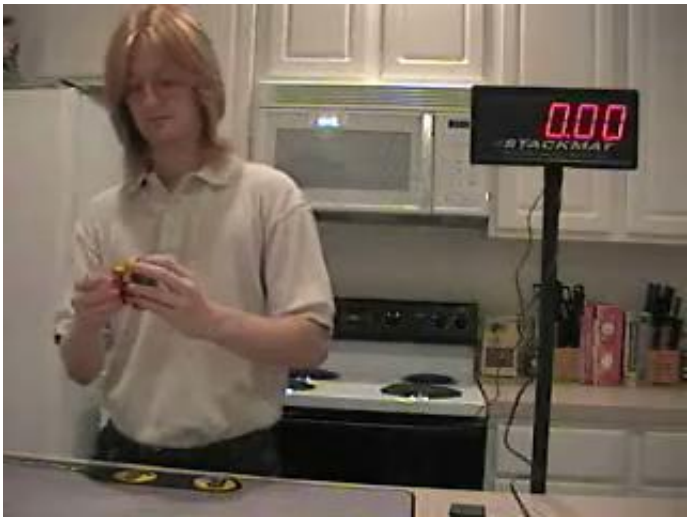


ensory cortex in right cerebral hemisphere

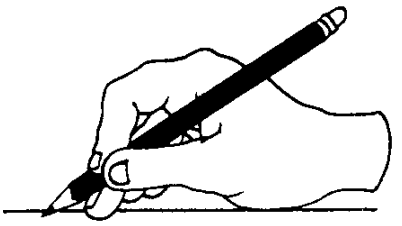
(b) Motor cortex in right cerebral hemisphere

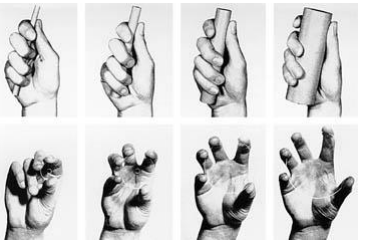




Préhension

- Precision grip
- Power grasp
- Tripod grasp
- …





Plusieurs étapes

Contexte: déplacer un objet sur une table

1. Analyser ses propriétés physiques
2. Réaliser le mouvement pour l'atteindre
3. Le saisir avec une configuration spécifique
4. Le soulever
5. Le transporter
6. Le replacer au nouvel endroit

Avant le mouvement: planification (min effort, OC, …)

Pendant: coordination des forces, marge de sécurité, glissement, expériences précédentes…

Après: correction, feedback

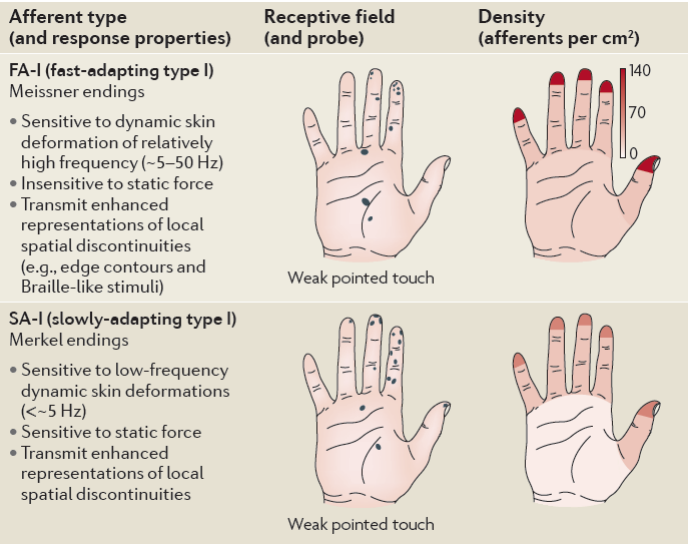
Les armes physiologiques

Avant l'action, **on dispose d'informations** sur la tâche à réaliser via:
- Vision
- Expériences précédentes
- Proprioception
- Autres…

Pendant l'action, ces canaux sensoriels restent actifs mais on a en plus le canal **haptique** (sens du toucher, du grec "*aptomai*" qui signifie "je touche")

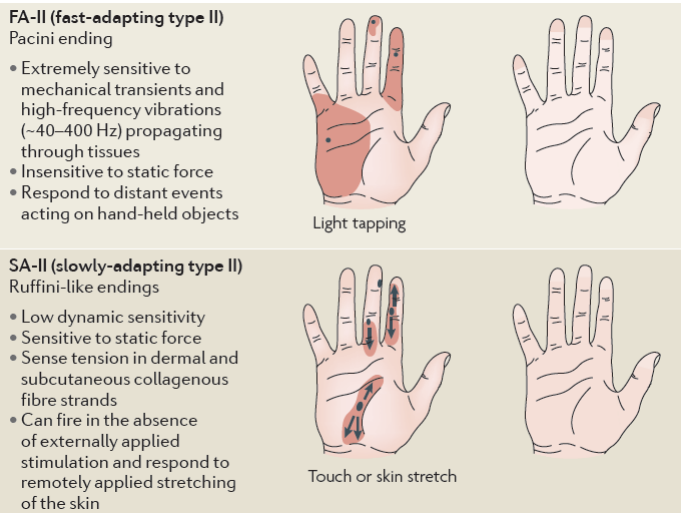
Innervations tactiles

Type I: **haute** fréquence spatiale



Innervations tactiles

Type II: **basse** fréquence spatiale



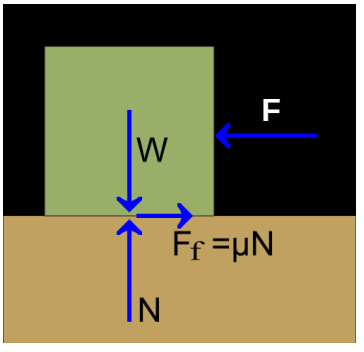
Un peu de mécanique

Les corps **élastiques** et **non élastiques**

• **Quantité de mouvement**: boules de billard ou boule de neige

$$\vec{p} = \sum m\,\vec{v}$$

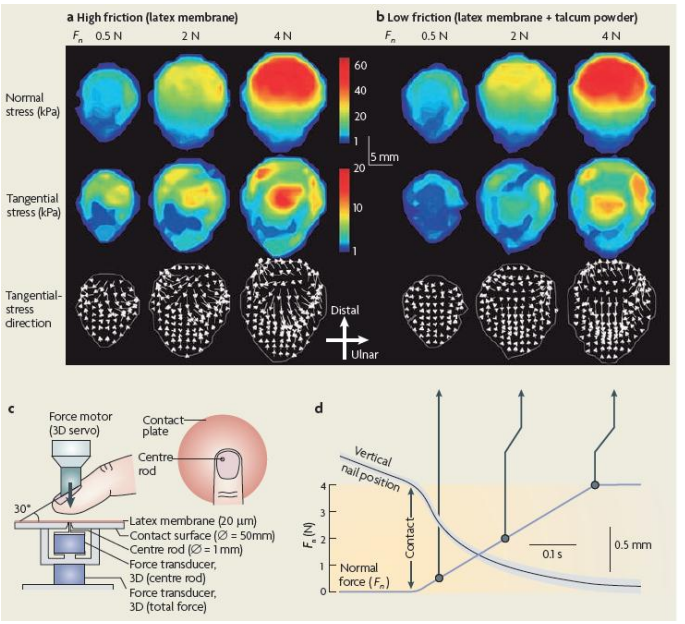
• **Friction**: livre sur une table ou … le doigt sur une surface



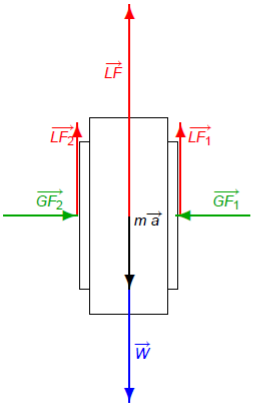
$$\vec{F}_f \leq \mu \vec{F}_n$$

Monde réel est complexe

Tribologie: Science qui étudie la friction des corps non élastiques



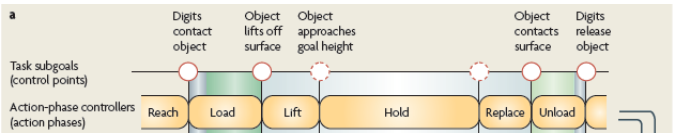
Encore un peu de mécanique

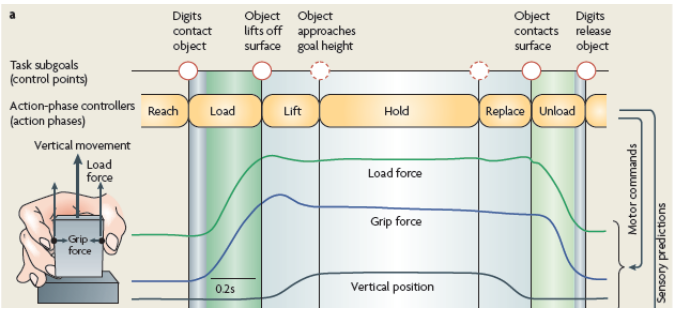


- $\overrightarrow{GF}$: Grip Force
- $\overrightarrow{LF}$: Load Force
- $\overrightarrow{W}$: Weight

Relationships

- $\|\overrightarrow{LF}\| \leq \mu \cdot \|\overrightarrow{GF}\|$
- $\overrightarrow{W} = m \cdot \vec{g}$
- $\overrightarrow{LF} = \overrightarrow{W} + m \cdot \vec{a}$


a
Digits contact object
Object lifts off surface
Object approaches goal height
Object contacts surface
Digits release object
Task subgoals (control points)
Action-phase controllers (action phases)
Reach
Load
Lift
Hold
Replace
Unload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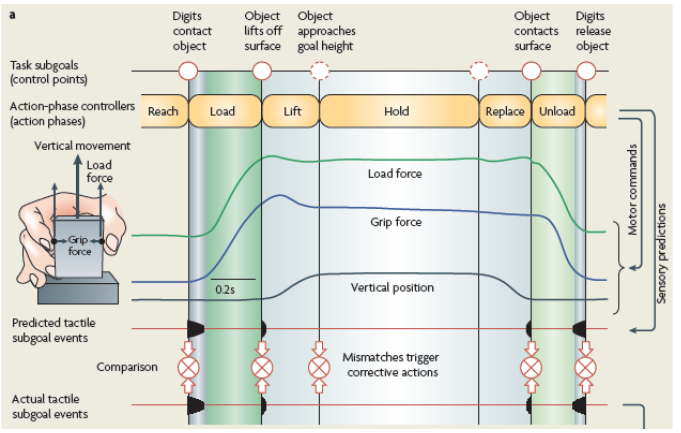
Reach
Load
Lift
Hold
Replace
Unload
Vertical movement
Load force
Grip force
Load force
Grip force
0.2s
Vertical position
Motor commands
Sensory predictions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Load
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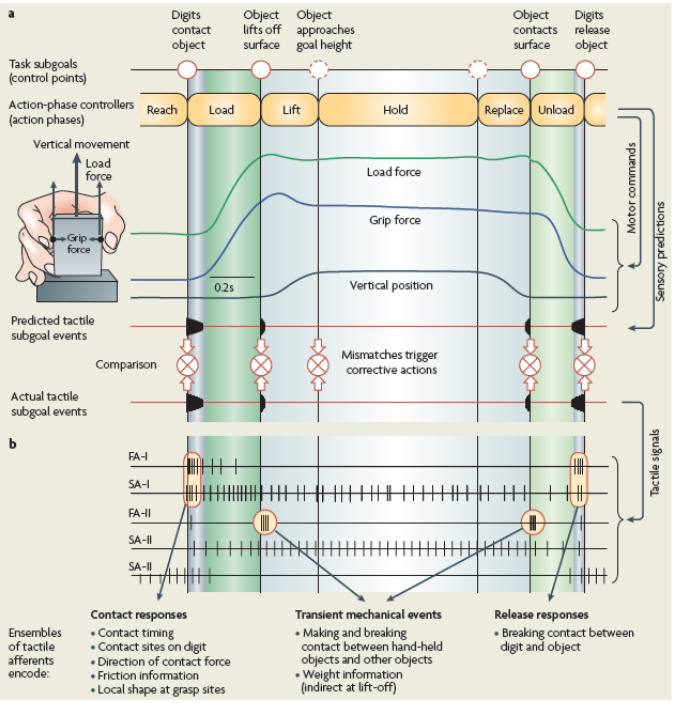
Grip force
0.2s
Load force
Grip force
Vertical position
Motor commands
Sensory predictions
Predicted tactile subgoal events
Comparison
Mismatches trigger corrective actions
Actual tactile subgoal events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Task subgoals (control points)
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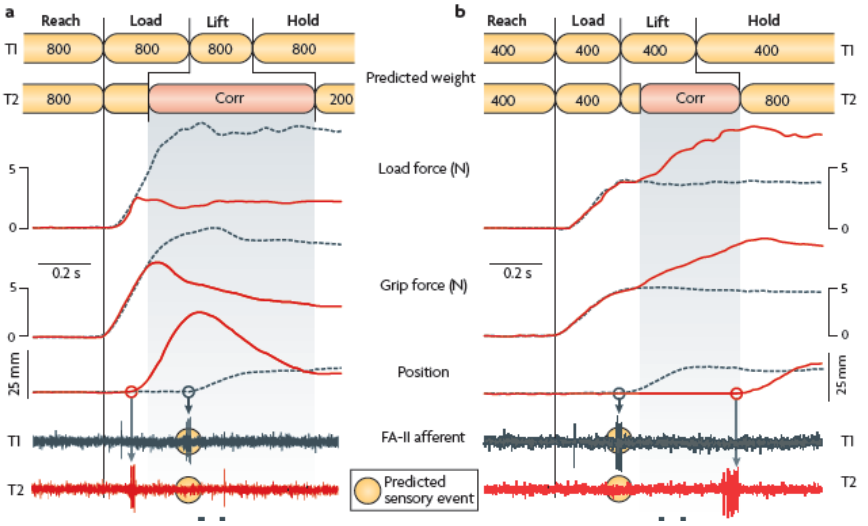
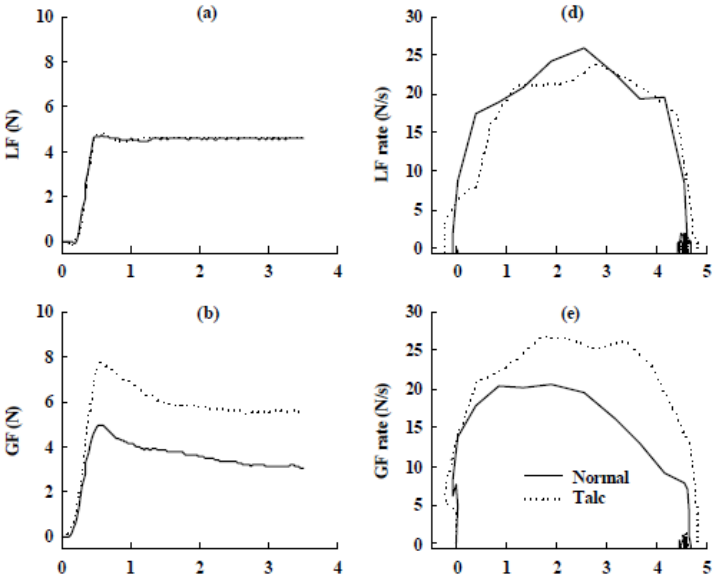
Hold
Replace
Unload
Vertical movement
Load force
Grip force
0.2s
Load force
Grip force
Vertical position
Motor commands
Sensory predictions
Predicted tactile subgoal events
Comparison
Mismatches trigger corrective actions
Actual tactile subgoal events
b
FA-I
SA-I
FA-II
SA-II
SA-II
Tactile signals
Ensembles of tactile afferents encode:
Contact responses
• Contact timing
• Contact sites on digit
• Direction of contact force
• Friction information
• Local shape at grasp sites
Transient mechanical events
• Making and breaking contact between hand-held objects and other objects
• Weight information (indirect at lift-off)
Release responses
• Breaking contact between digit and object

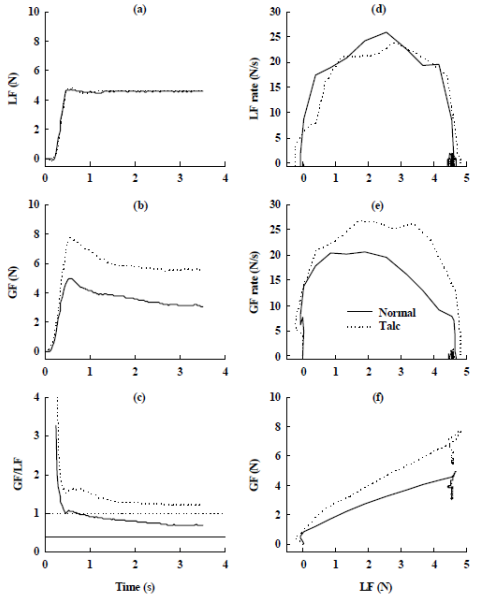
Evénements imprévisibles



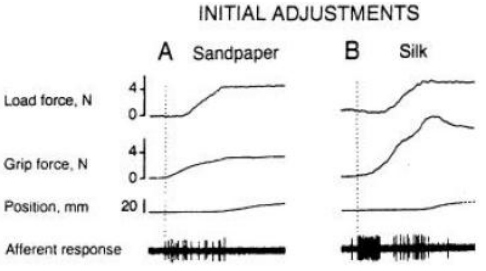
Adaptation à la friction



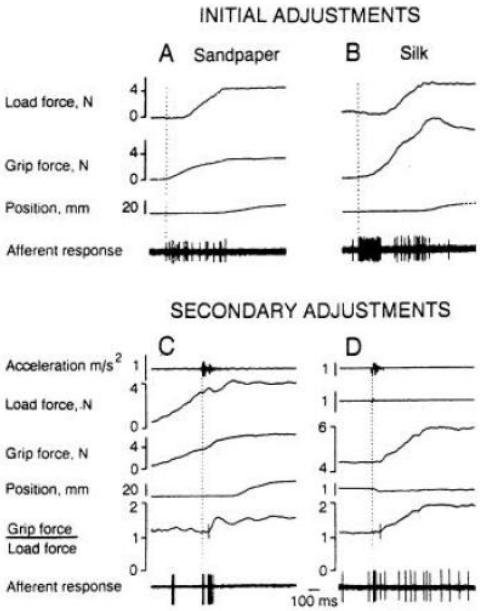
Adaptation à la friction



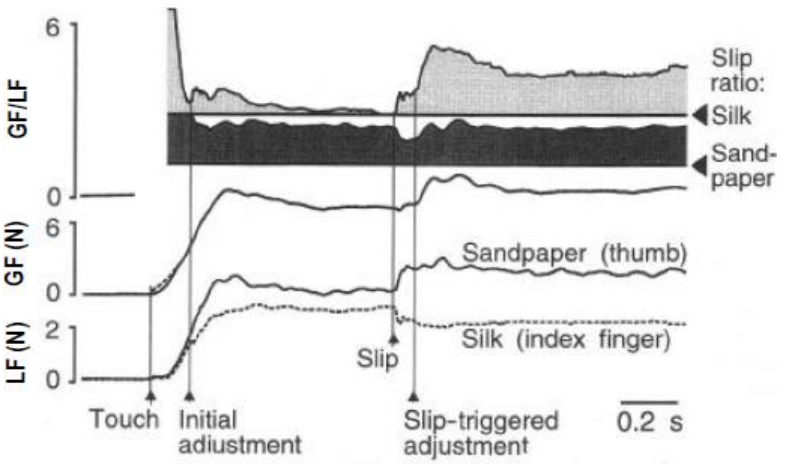
Adaptation à la friction



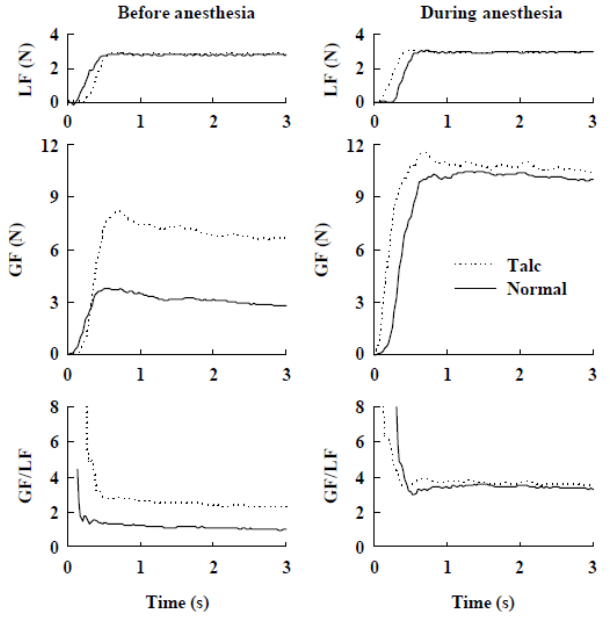
Adaptation à la friction



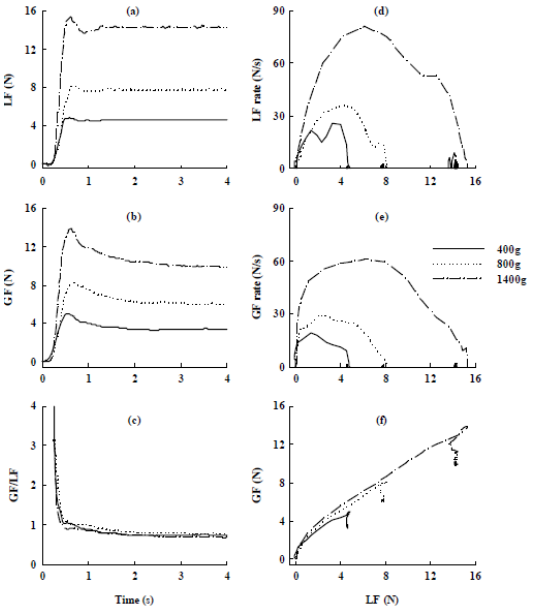
Contrôle indépendant des doigts



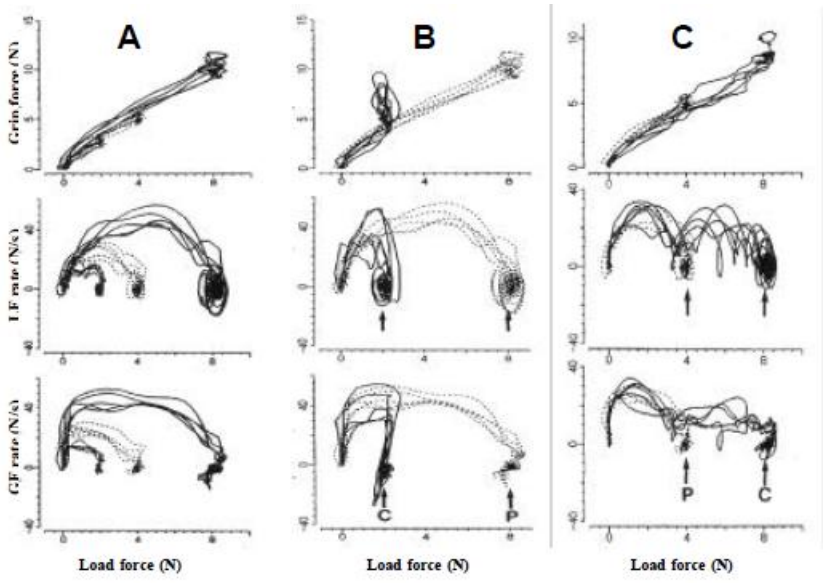
Anesthésie



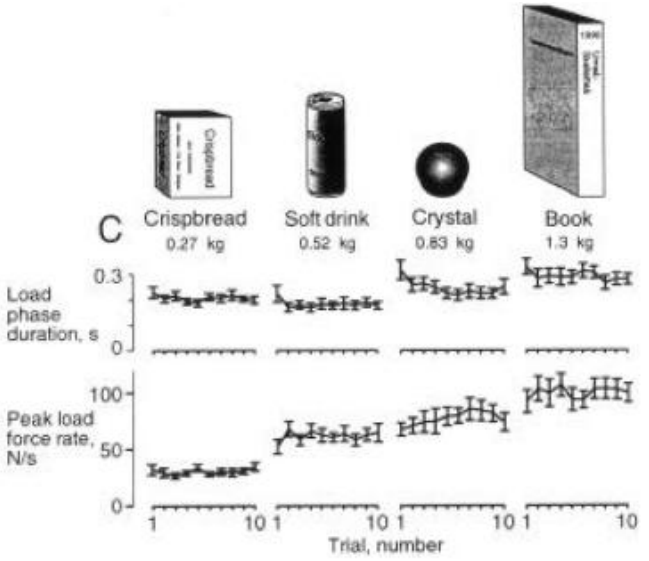
Adaptation au poids



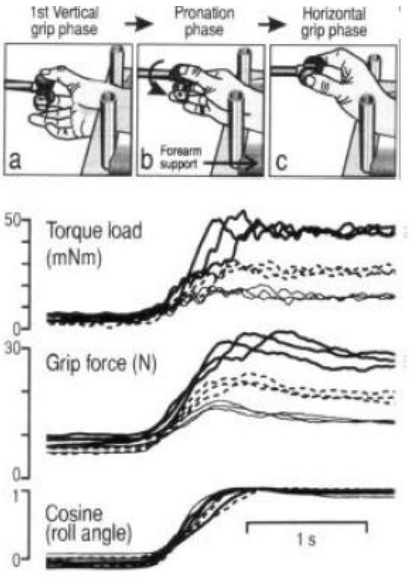
Adaptation au poids



Expérience et histoire



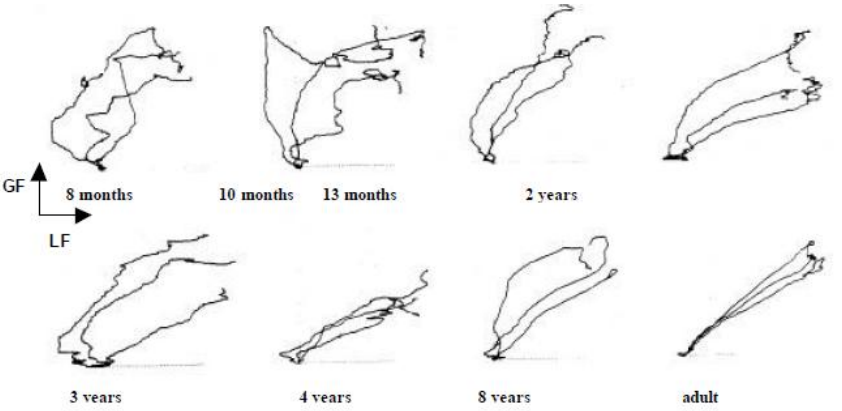
Adaptation au couple



… tout s’apprend !

adult

… tout s’apprend !

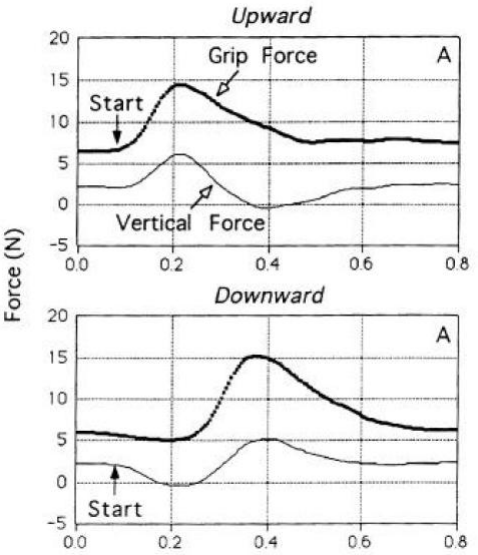


Tâches dynamiques

On ne fait pas que soulever et maintenir des objets en l’air…

- Mouvements avec des objets
- Interactions avec l’environnement
- Interactions entre les mains

Mouvements point à point



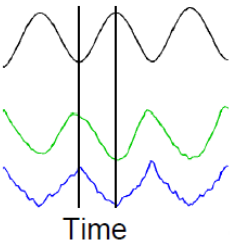
Tâches dynamiques

- GF is modulated in function of LF in a broad panel of tasks

Position

Grip force

Load force

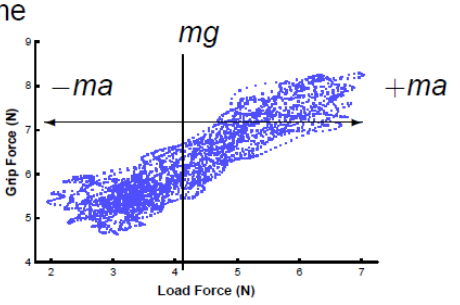


GF and LF are synchronized !

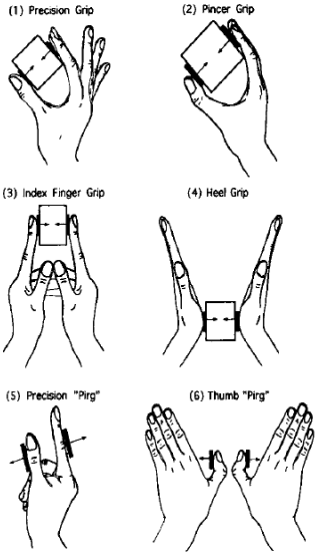
Flanagan and Wing, 1993.

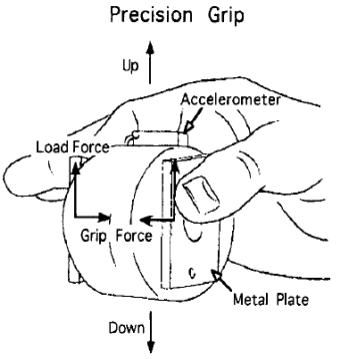
- Fluctuation of LF around object weight :

$LF(t) = mg + ma(t)$

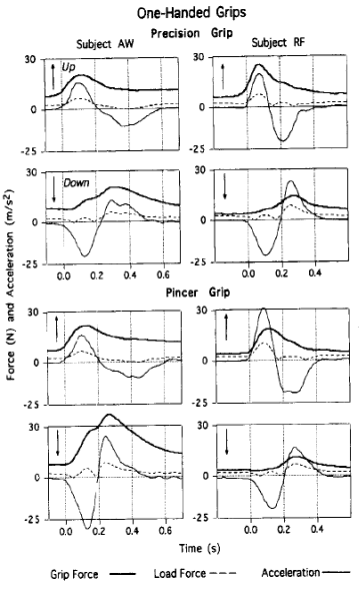


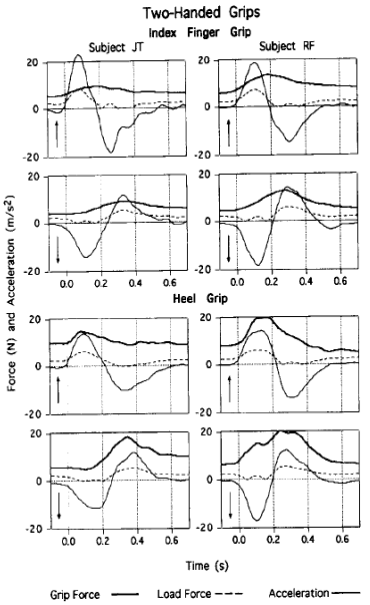
Différentes prises





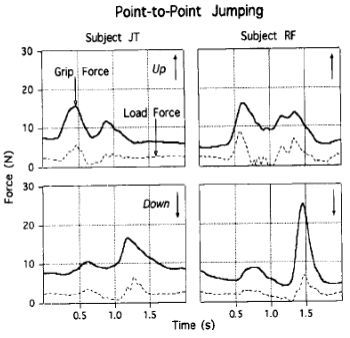
Différentes prises

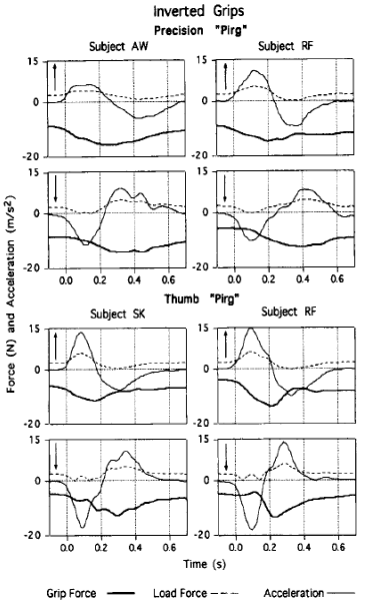




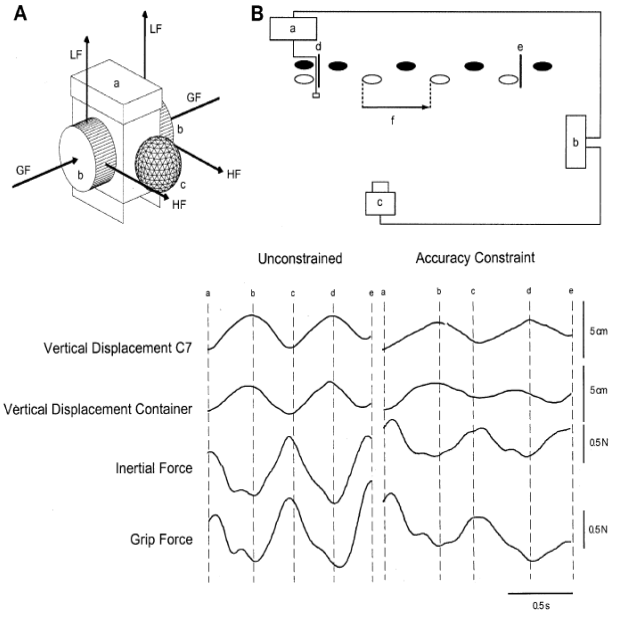
Différentes prises

GF<0 mais restent synchro

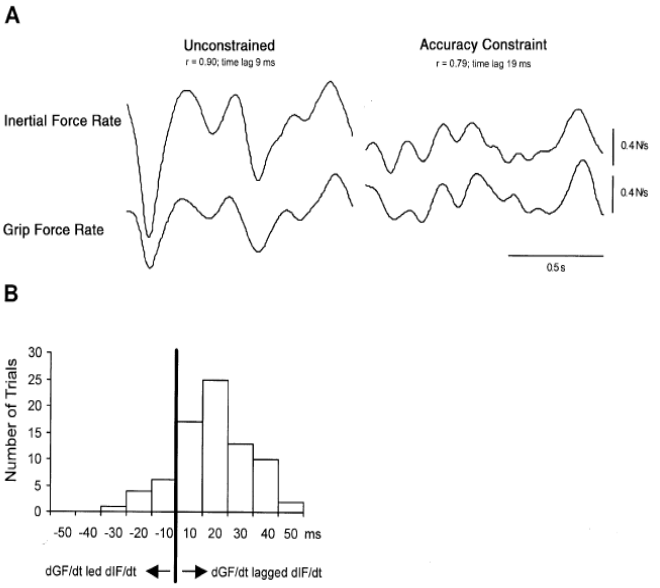




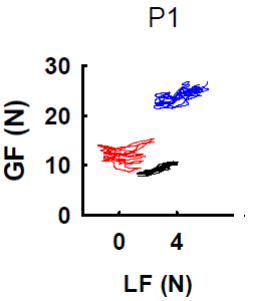
Transport et locomotion



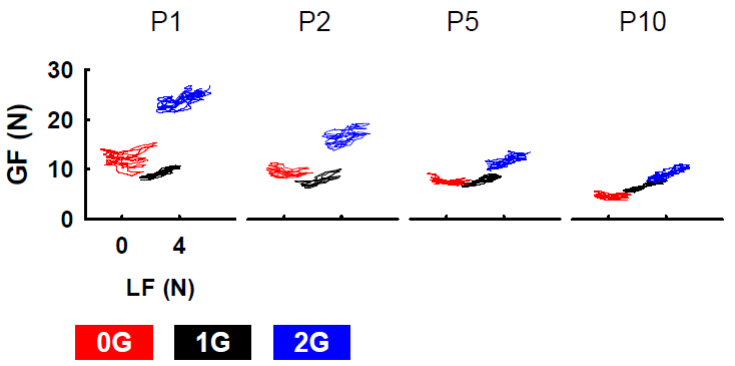
Transport et locomotion



Adaptation gravitationnelle



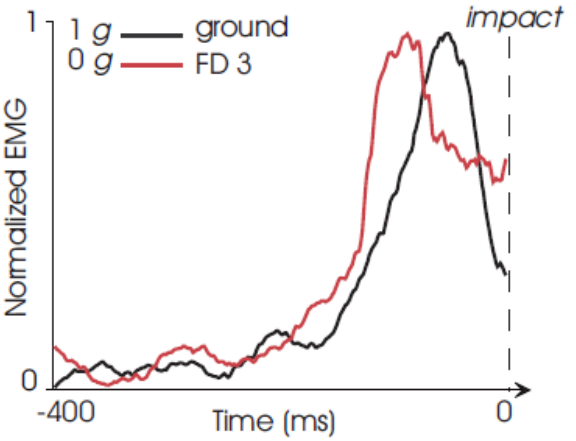
Adaptation gravitationnelle



Comment changer radicalement l'environnement ?

Altérer la gravite

- Ce changement radical s'observe par des comportements qui convergent très lentement voire pas du tout !

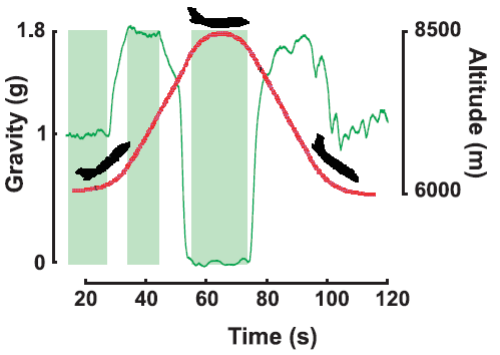


Altérer la gravite

Table A.1: Comparison between microgravity platforms.

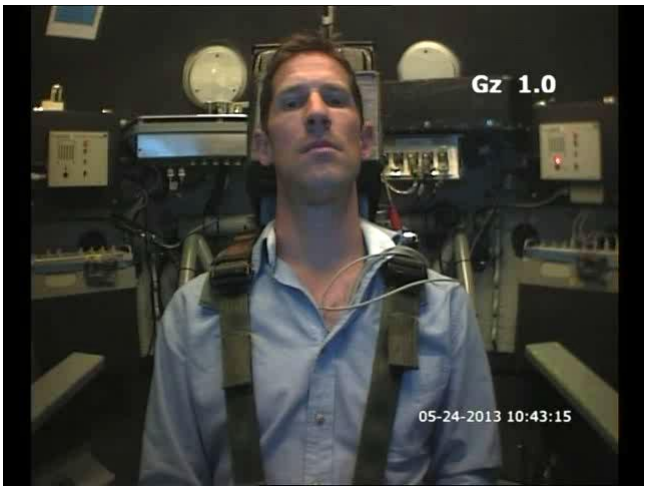
Platform	μ-g level (g)	Duration	Volume (m^3)	Control
Drop towers	10^{-3} - 10^{-6}	< 5 s	< 1	indirect
Parabolic flights	10^{-2} - 10^{-3}	20-25 s	> 10	direct
Sounding rockets	10^{-4} - 10^{-5}	5 - 13 min	< 1	indirect
Recoverable capsules	$\leq 10^{-5}$	weeks	> 1	indirect
Manned orbital platform (ISS)	10^{-2} - 10^{-5}	weeks - years	> 1	direct

Altérer la gravite

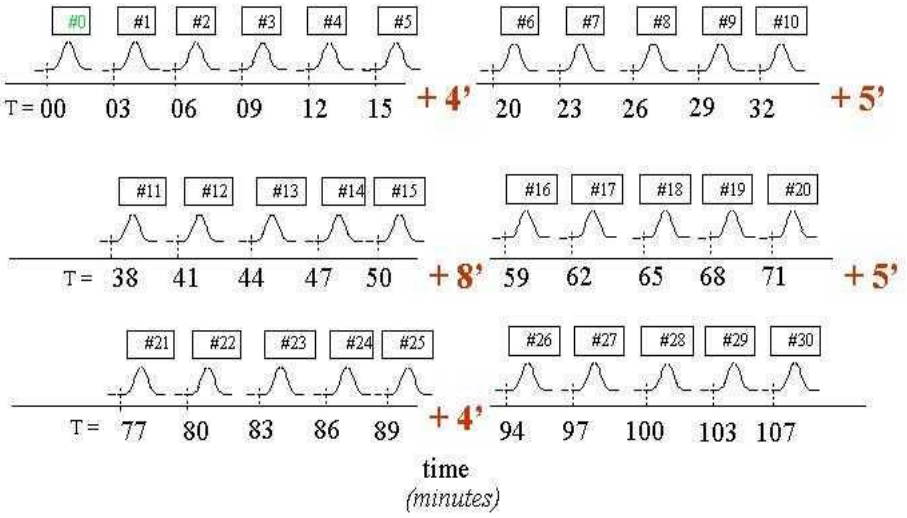



clccard


clccard



PARABOLAS SEQUENCE



Feedback et feedforward

Ces tâches apparemment réalisées sans efforts sont en fait le résultat d'un contrôle coordonné précis dans le temps et l'espace entre deux mécanismes:

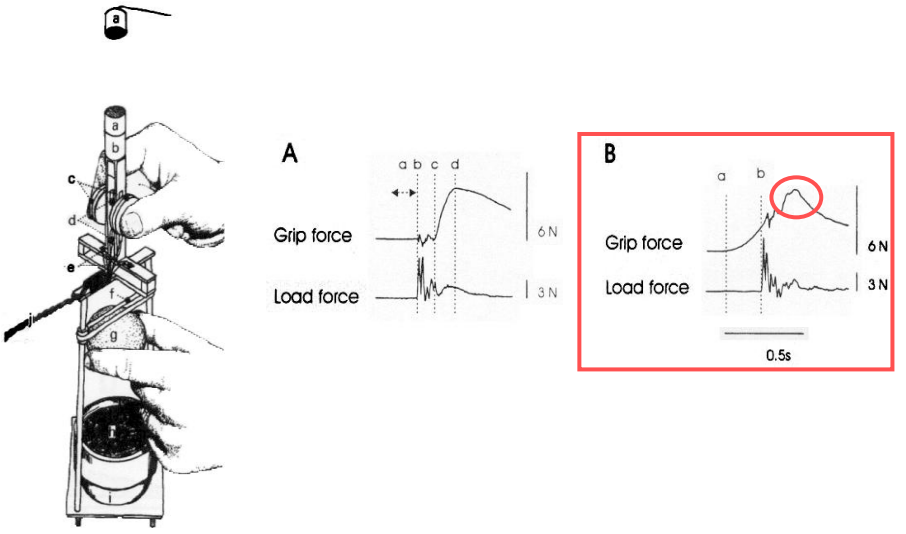
- Feedback (réflex, réactif)
- Feedforward (anticipatoire, prédictif)

Les proportions de ces mécanismes varient en Fonction de la tâche

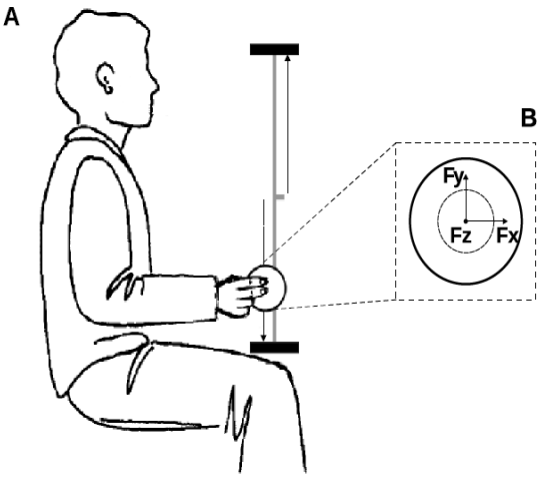
Changements rapides

de LF dans des situations courantes

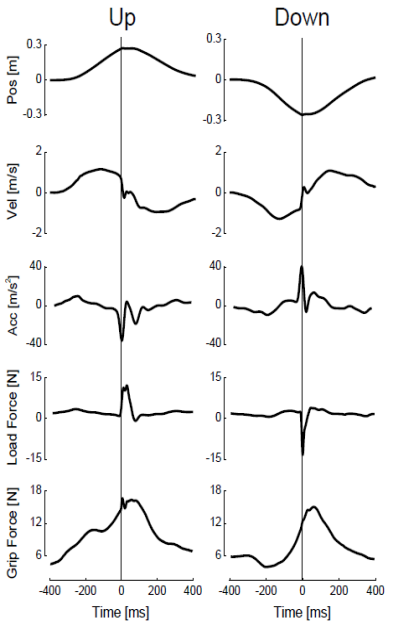
Réponse reflex

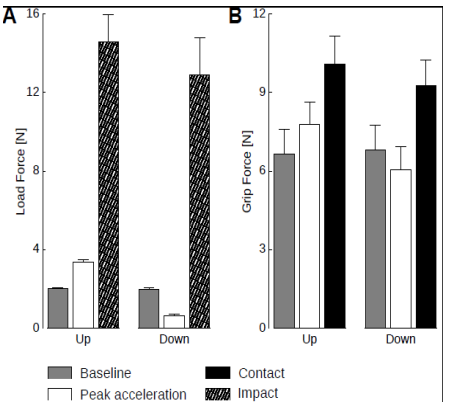


Réponse reflex ??

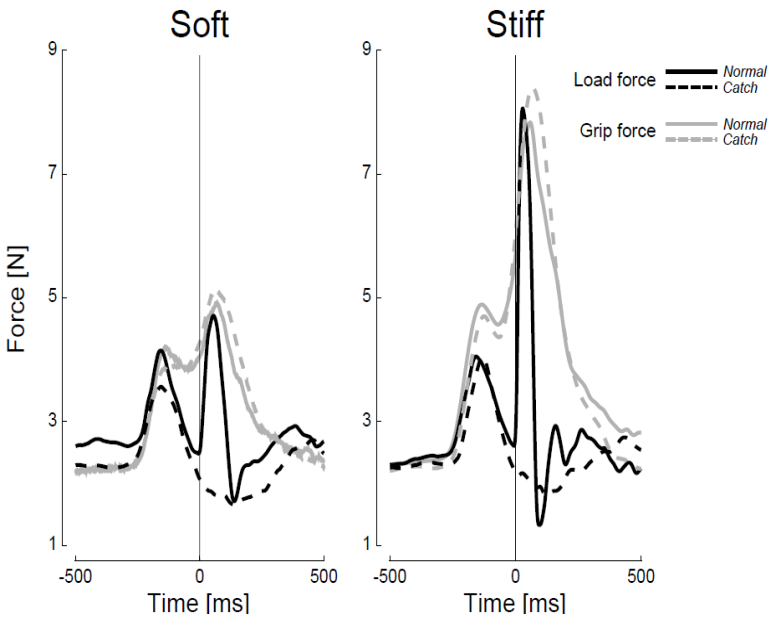


Réponse reflex ??

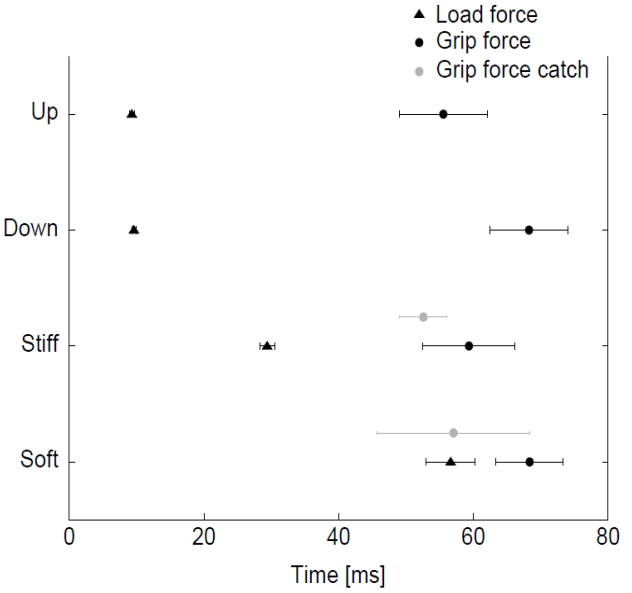




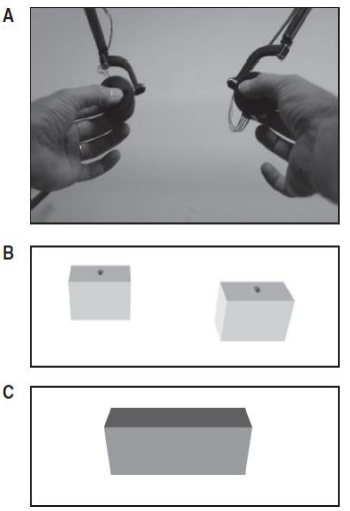
Réponse reflex ??



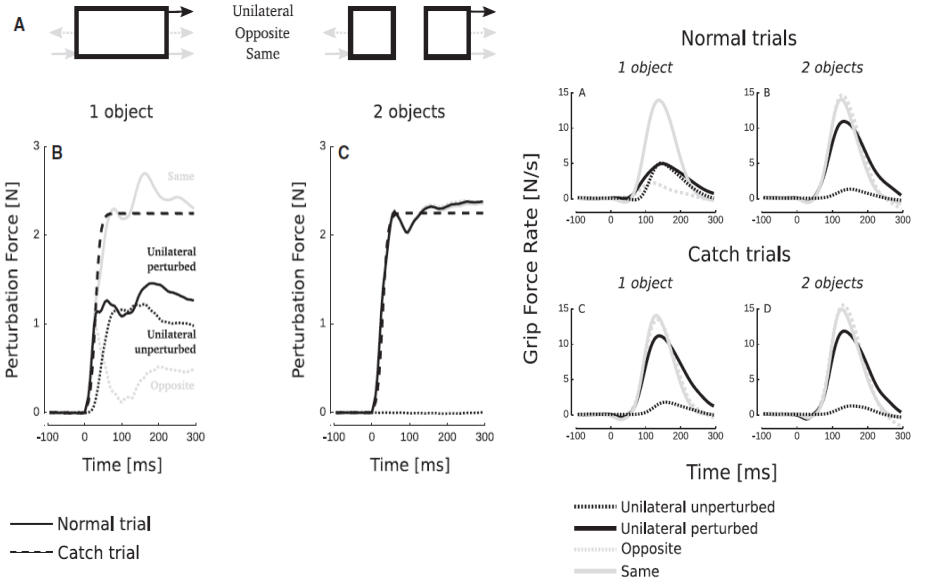
Réponse reflex ??



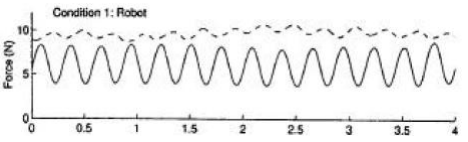
Manipulation bimanuelle



Manipulation bimanuelle



Prédiction de la GF



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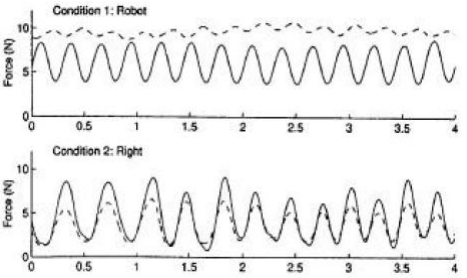

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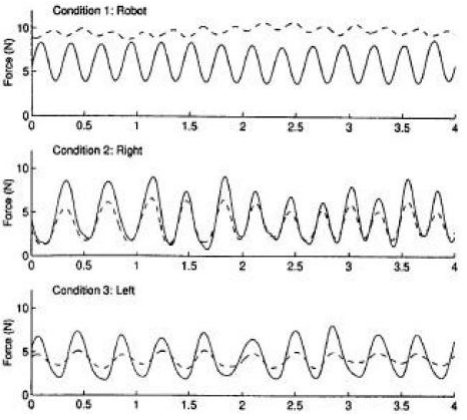

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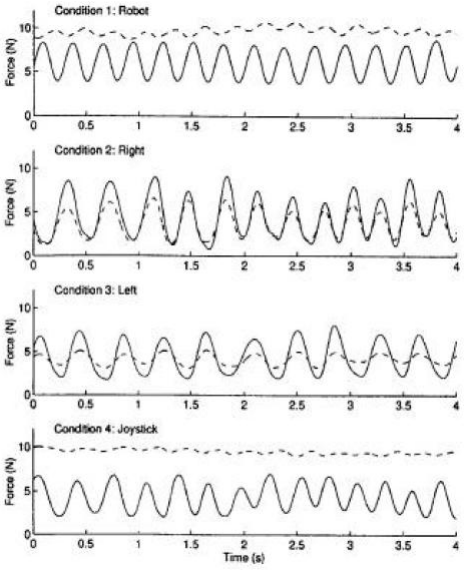
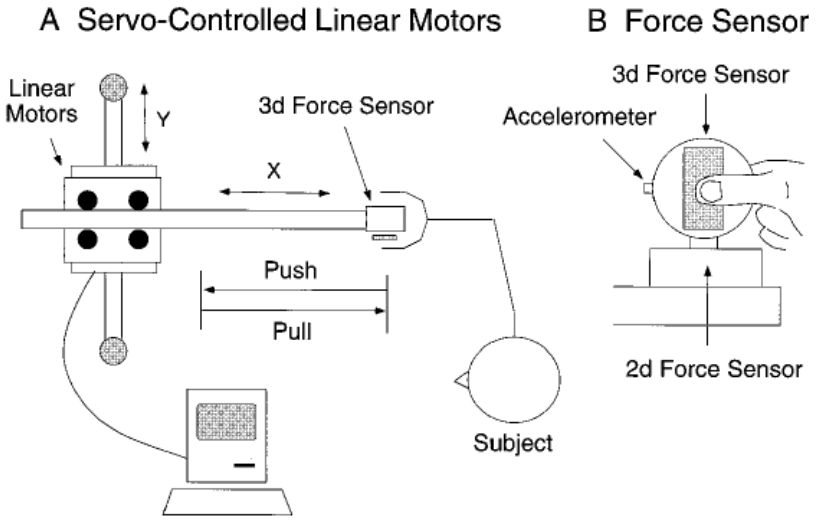


Modèle interne



Modèle interne