Differential Sensitivity of Manipulation and Grasp Forces to Task Requirements

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BACKGROUND
Successful dexterous manipulation requires simultaneous prevention of object slip and object pose control. However, how humans coordinate digit forces to attain these two goals is not well understood. This gap is due to (1) the use of tasks devoid of dexterity requirements and/or (2) the use of analytical techniques that cannot isolate the dual role of digit forces. Research question: Can grasp and manipulation forces be independently modulated by changing mass and torque, respectively?

INSTRUMENTATION
- Task: Grasp with thumb and index fingertip (precision grip), lift and hold an inverted T-shaped object while preventing it from slipping and tilting.

METHODS
Grasp Force ($F_G$)
\[ \vec{F}_G = G_0 \cdot G_0^T \left[ \vec{F}_C^{TH} \quad \vec{F}_C^{IN} \right]^T \]

Manipulation Force ($F_M$)
\[ \vec{F}_M = \left[ \vec{F}_C^{TH} \quad \vec{F}_C^{IN} \right]^T - \vec{F}_G \]

RESULTS
- The distinct sensitivity of $F_G$ and $F_M$ likely underscores differences in their:
  - Functional role: Object slip prevention ($F_G$) vs. object pose control ($F_M$, normal component).
  - Sensorimotor mechanisms: Feedforward ($F_G$) vs. feedback ($F_M$).
  - Tactile afferent inputs: Encoding of digit force vector direction.

REFERENCES

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