

Trade-offs between force and accuracy in human hammering performance

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Hammering as a way to study trade-offs between force and accuracy

Many functional tasks require either fine motor skill or high force

Human hammering requires both a high degree of accuracy and force

When target is large; both criteria can be fulfilled

When target is small;

Alternatives

- Reduction in accuracy, but not force**
- Reduction in force, but not accuracy**
- Reduction in both**
- Reduction in neither**

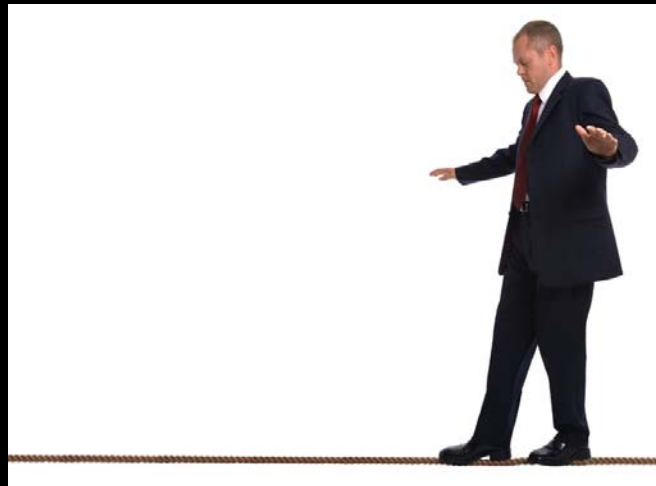


Biomechanical alternatives:

Sprinting on a wide track: High power



Walking on a tightrope: High accuracy



But consider a mix of these extremes



Sprinting on a line: What is compromised first?

Questions

(1) Does altering target size affect accuracy, force (velocity and acceleration), both, or neither?

Specific hypotheses

- Reduction in accuracy, but not force
- Reduction in force, but not accuracy
- Reduction in both
- Reduction in neither

(2) Do women and men differ in how they respond to different target Sizes?



Methods:

5 Women, 5 Men (college and graduate students and one professor)

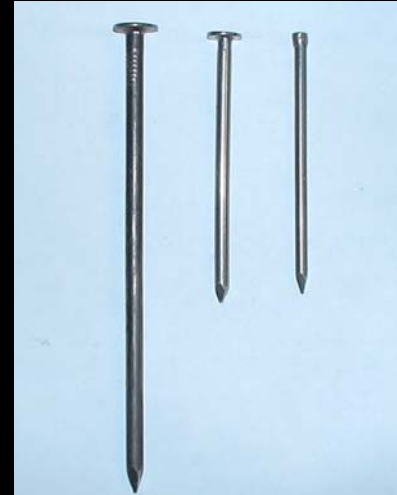
5 trials per treatment

3 Nail sizes:

Small: 5 cm long; 0.31 cm diameter

Medium: 5 cm long; 0.63 cm diameter

Large: 7 cm long; 0.94 cm diameter



Nails were pre-hammered 0.6 cm into into a large wooden board

Trials filmed with a single high-speed Redlake digital camera at 500 f/s

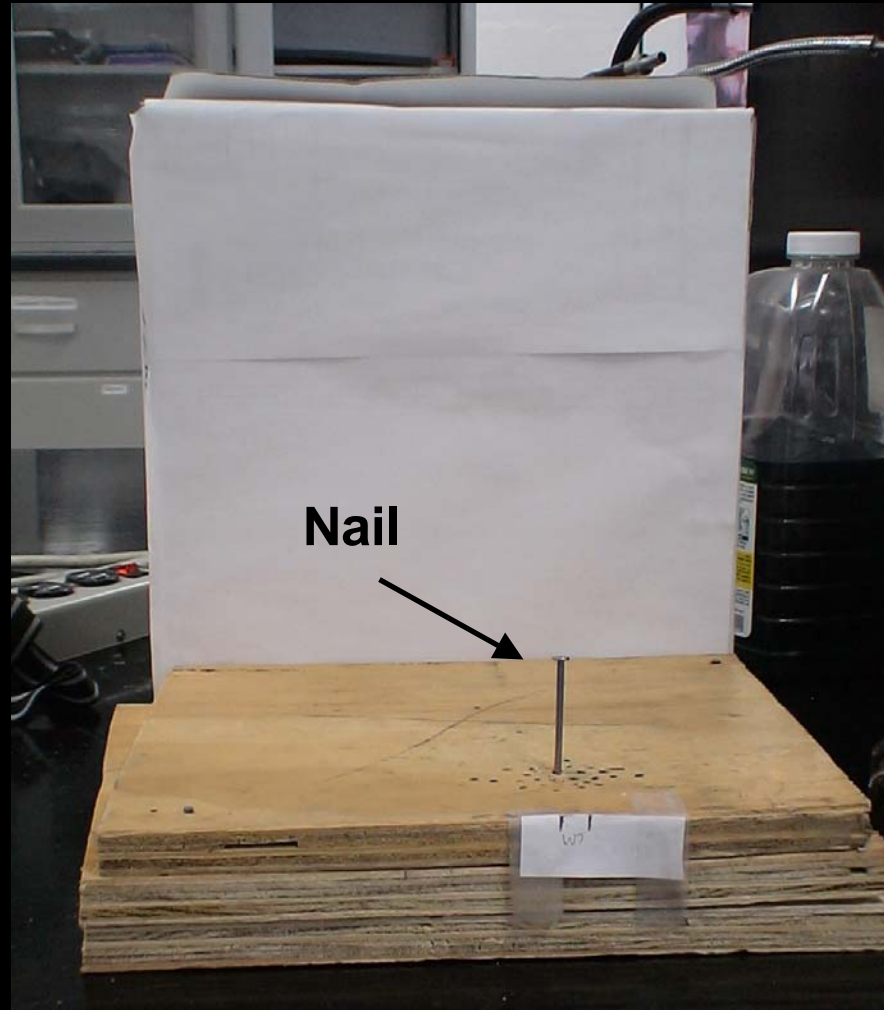
Digitized the tip of the hammer and calculated:

Peak velocity

Peak acceleration

Accuracy (hit, partial hit, or miss)

Experimental setup



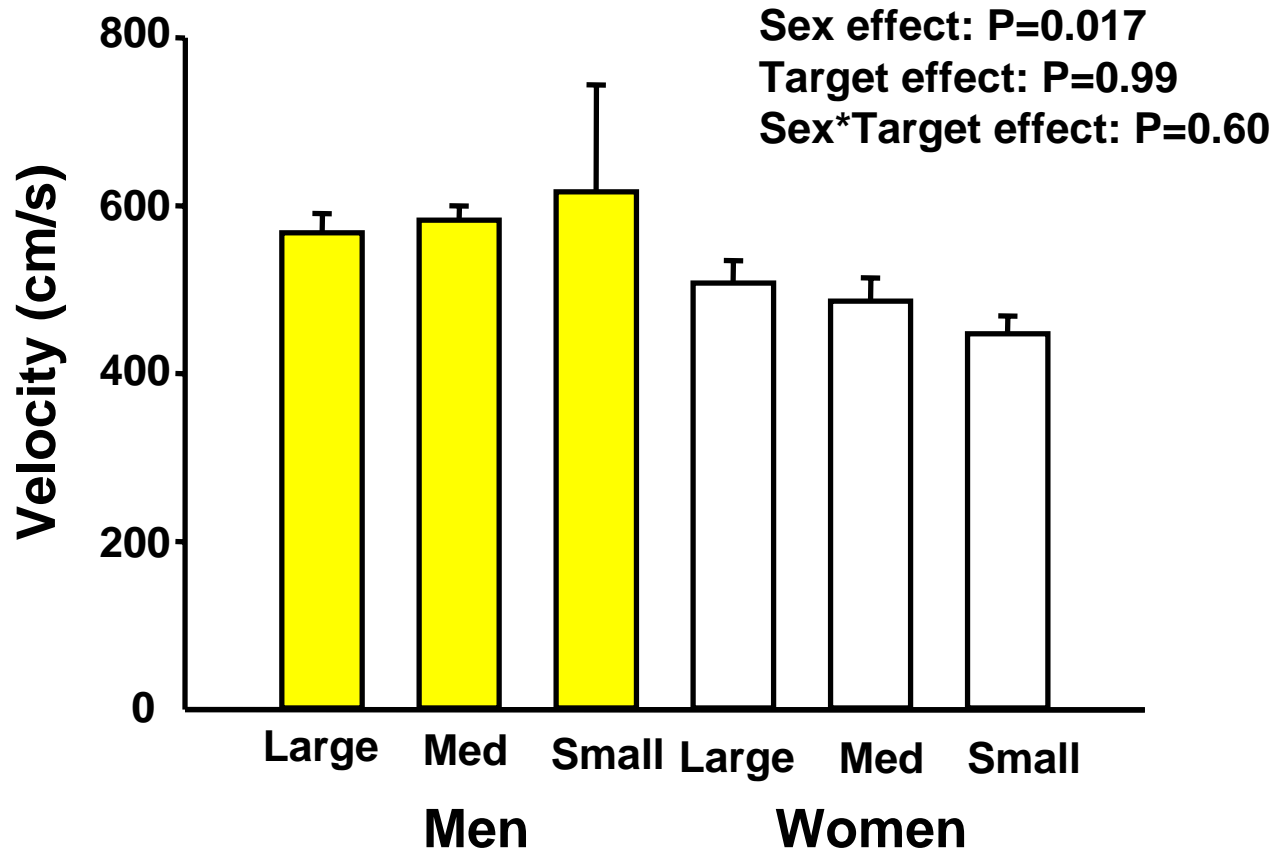
Hammering on the large nail: A hit



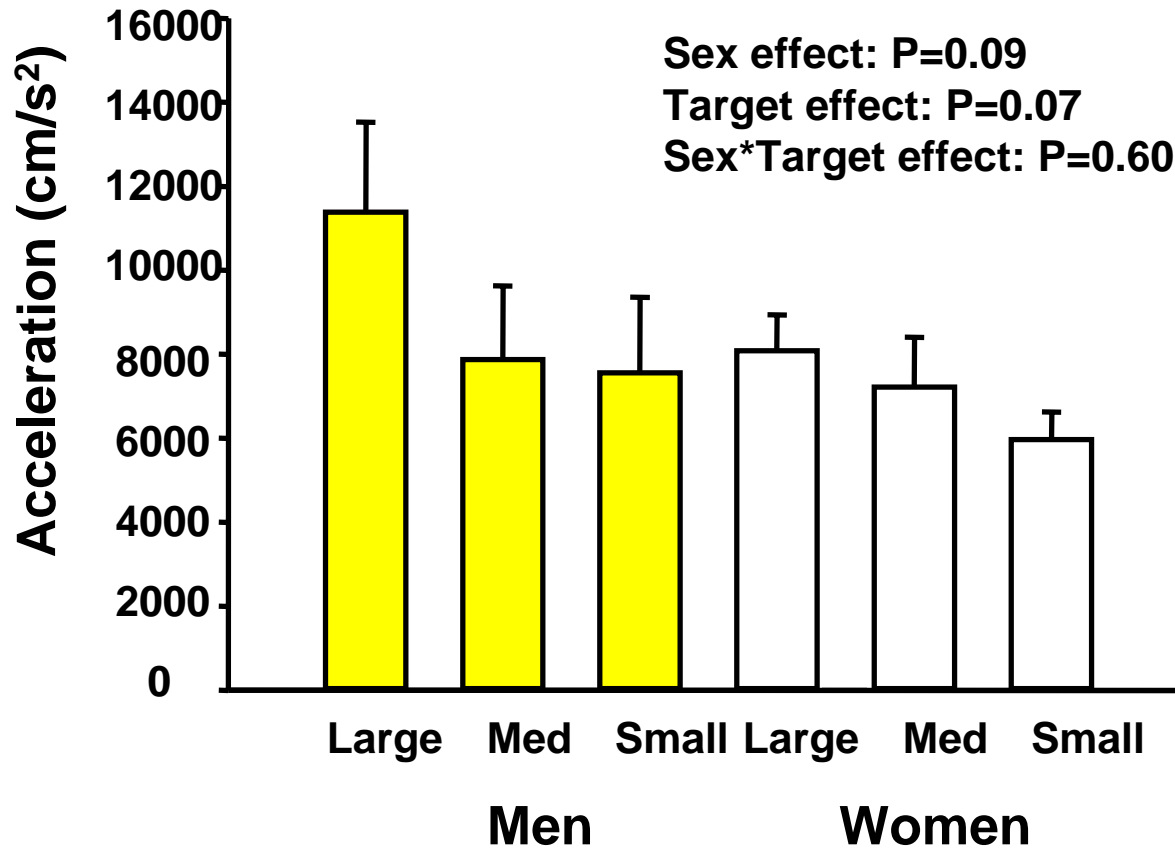
Hammering on the small nail: A miss



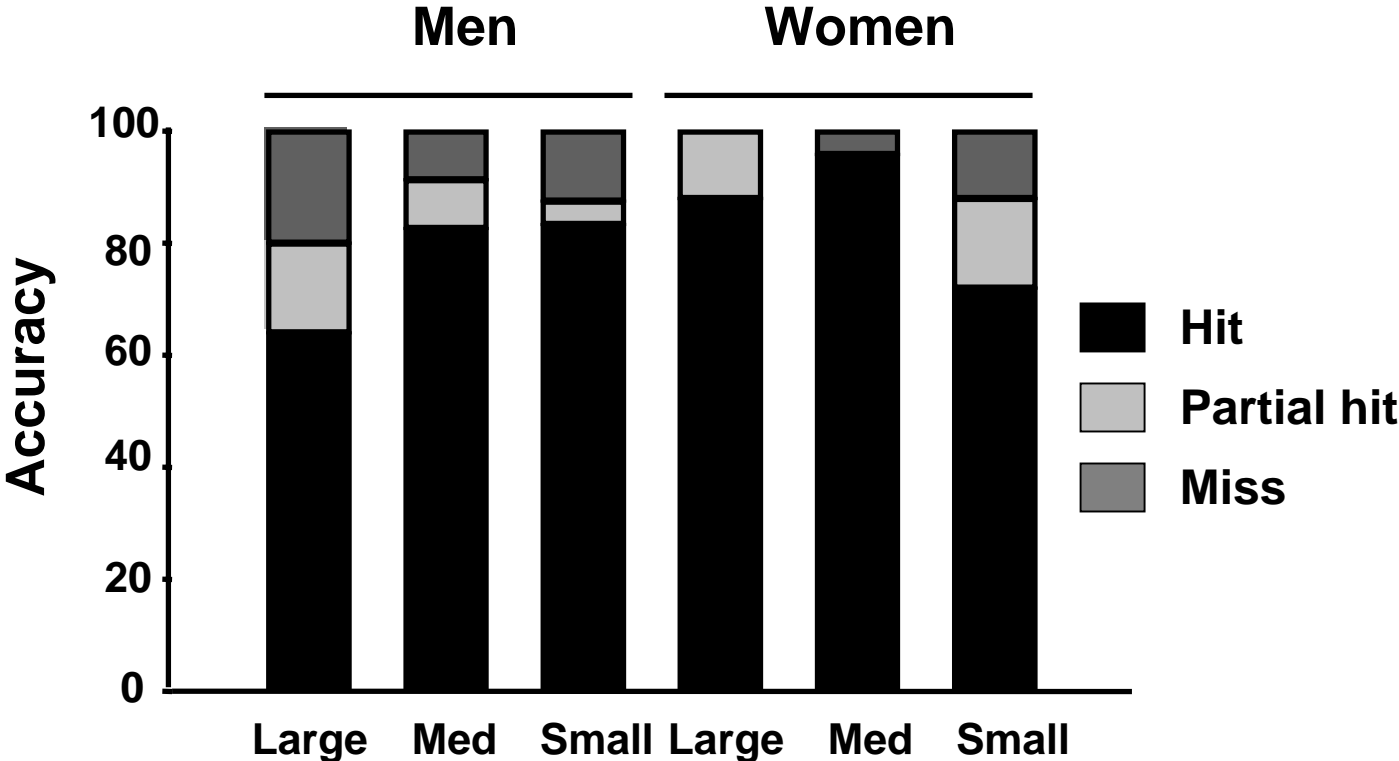
No significant effects of target size on peak velocity



A trend towards higher acceleration in larger target sizes



No significant differences in accuracy among targets



Women: Chi-square = 6, df = 4, P = 0.20

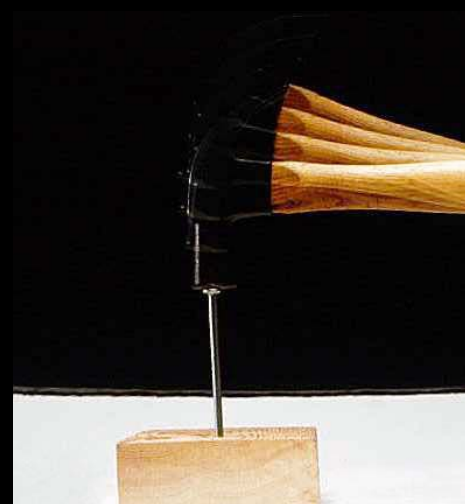
Men: chi-square = 3, df = 4, P = 0.23

Conclusions

- (1) No evidence for a reduction in accuracy across different target Sizes
- (2) No evidence for a reduction in velocity across different target sizes
- (3) A strong trend ($P=0.07$) for a reduction in acceleration in the smaller Target sizes

Strategy for maintaining accuracy across targets of different sizes:

- Maintain constant velocity
- Decrease acceleration

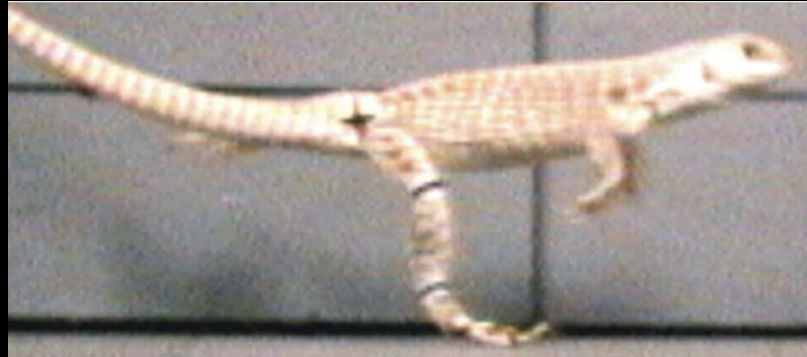


Implications for tasks that require high forces and accuracy



Some considerations in using humans as experimental animals

For many animals,
performance is
instinctual

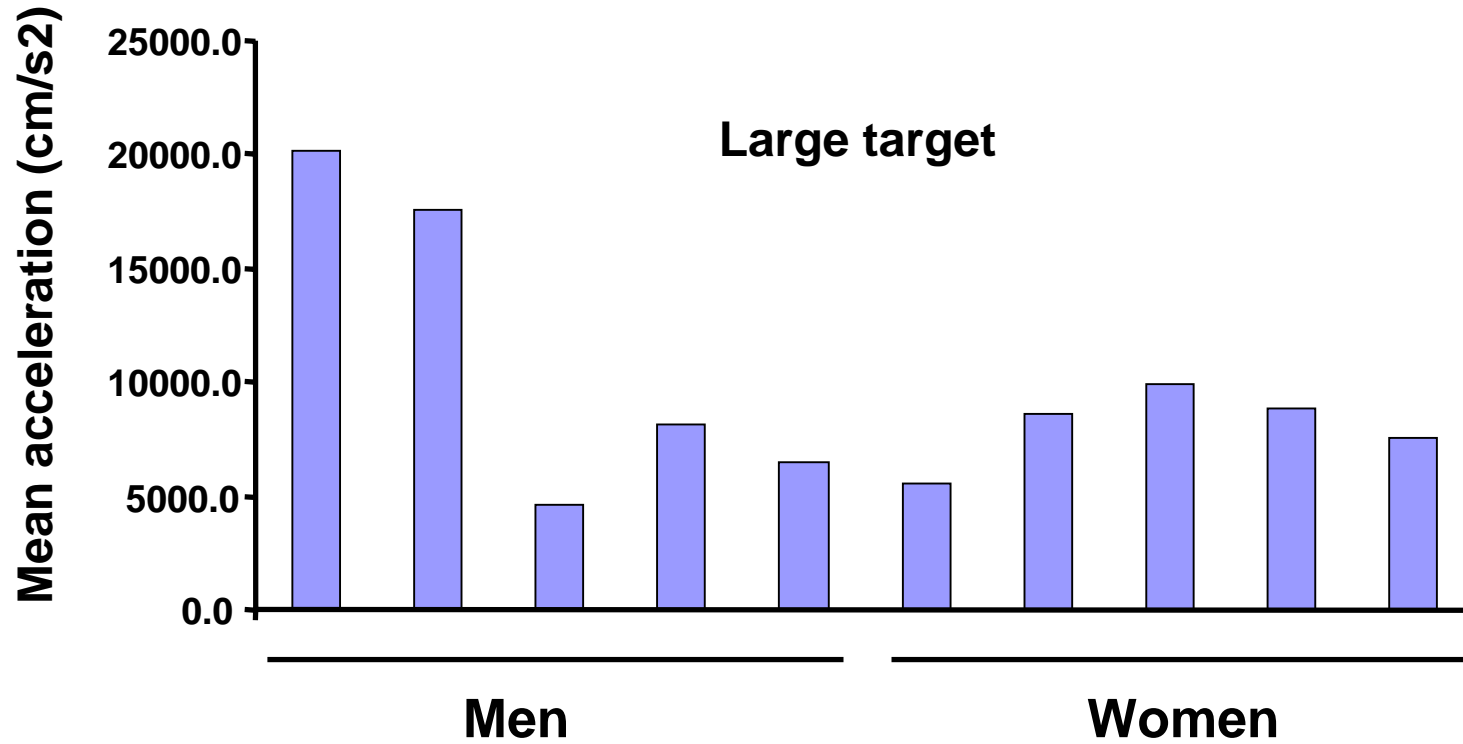


For humans, “performance”
is a more nebulous concept

“They get ideas”



Variation among individuals



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