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A Dissociation between Perception and Action in the Material-weight Illusion

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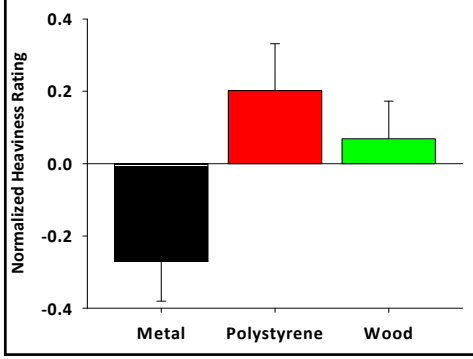
Paired t-tests

- **Grip force rate**
  - Lower application of force to the polystyrene block compared to either the metal (19.5 N/s; p<.005) or wood blocks (20.6 N/s; p<.01) during the first lift. Comparison between polystyrene and wood, however, does not survive Bonferroni correction.
  - Nearly identical rates of force applied to all the blocks on later lifts (all p values > .07).

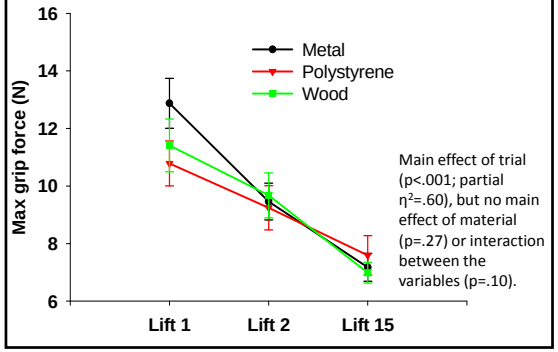
Paired t-tests

- **Load force rate**
  - Load force was applied to the polystyrene block at a substantially lower rate than the metal (13.3 N/s; p<.005) or wood blocks (17.7 N/s; p<.005) for the first trial.
  - Nearly identical rates of force were applied to all the blocks in later lifts (all p values > .09).
  - The similarity between metal and wood blocks for the majority of these measures for the first lift is probably due to biomechanical limitations (i.e., ceiling effects in how much these forces can be overestimated due to the muscular properties of the hand).

Main effect of material, with factor of trial removed

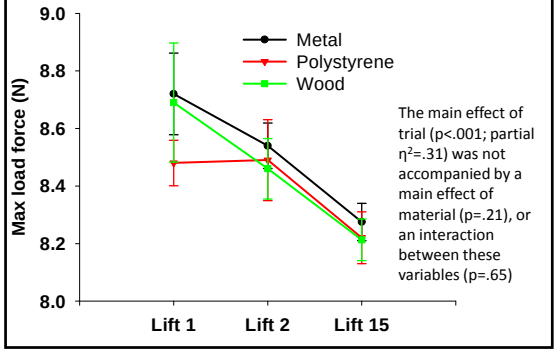


Maximum grip force rate



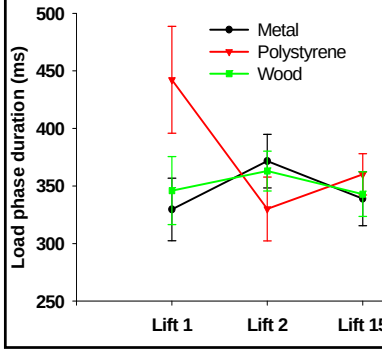
Main effect of trial (p<.001; partial η^2=.60), but no main effect of material (p=.27) or interaction between the variables (p=.10).

Maximum load force rate



The main effect of trial (p<.001; partial η^2=.31) was not accompanied by a main effect of material (p=.21), or an interaction between these variables (p=.65)

Load phase duration



No main effect of material (p=.13) or trial (p=.50). Significant interaction between material and trial (p<.05; partial η^2=.12). Longer LP_{dur} during their first lift with the polystyrene block than with the wood (by 96 ms; p<.05) or metal (by 42 ms; p<.05) blocks. None of the other comparisons for the later trials reached significance (all p values > .2)

A dissociation between perception and action in the material-weight illusion

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Introduction

When objects have different **sizes** and identical mass, the smaller object feels heavier than the larger one when they are lifted in turn (Charpentier, 1891). This is the '**size-weight illusion**' (SWI).

A similar weight illusion has been described when lifting objects that appear to be made from different **materials** which have been altered to have identical mass (Seashore, 1899). Blocks made from a heavy-looking material (e.g., metal) feel **lighter** than a block made from a lighter-looking material (e.g., polystyrene) with equal size and mass. This is the '**material-weight illusion**' (MWI).

We examined what forces are applied to objects that elicit this illusion when they are lifted. We predicted that:

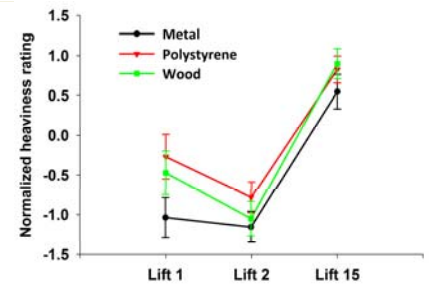
(1) Forces on early trials will scale to each participant's **expectations** of how much a particular block will weigh - excessive force will be applied to the metal block and insufficient force applied to the polystyrene block.

(2) Forces on later trials will scale to the **real** weight of each block - identical levels of force applied to all the blocks.

(3) MWI will persist **throughout -** polystyrene block will feel the heaviest, metal block will feel the lightest.

Results

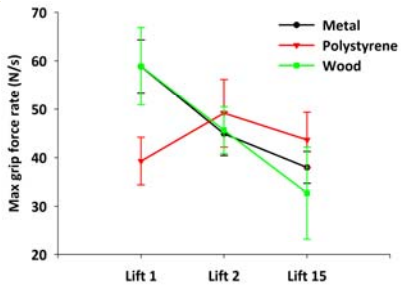
Perception of heaviness



Main effect of material ($p < .05$).

No interaction between lift and material ($p = .38$).

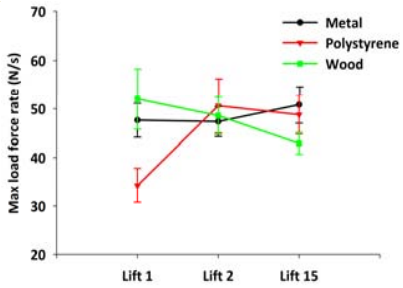
Maximum grip force rate



No main effect of material ($p = .62$).

Significant interaction between lift and material ($p < .005$).

Maximum load force rate



No main effect of material ($p = .36$).

Significant interaction between lift and material ($p < .01$).

Discussion

Participants experienced a robust MWI throughout all trials, **always rating the polystyrene block as heavier than the metal one**.

The application of forces during the first lift reflected the **expected** weight of each block. These forces were then quickly and implicitly scaled to the **real** weight of each block.

Lifting forces never matched perceived heaviness, consistent with SWI findings (Flanagan & Beltzner, 2000).

Judgements of weight must be made relative to expectations of heaviness, while lifting forces scale to individual exemplars.

Materials & methods

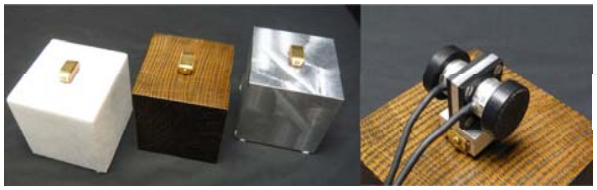
22 participants lifted specially constructed 10 cm^3 blocks.

– An **aluminium** block, hollowed out to weigh 695 g.

– An **expanded polystyrene** block, filled with lead to weigh 695 g.

– A **wood** block naturally weighed 695 g.

A grasp handle containing a force transducer was attached to a small mount on the top of each block.



Participants sat with their eyes closed while one of the blocks was placed in front of them.

Participants opened their eyes, reached out, gripped the grasp handle, and lifted the blocks ~5 cm directly upward.

The block was held stationary for several seconds before it was replaced.

Participants then gave an unconstrained numerical value to represent how heavy the block felt to them during the lift.

The perceptual measures of heaviness were normalized to a z-score distribution for each participant.

The maximum grip and load force rates for each block were taken from the force transducer.

References

Charpentier A (1891) Analyse expérimentale: de quelques éléments de la sensation de poids. Arch Physiol Norm Pathol 3:122-135.

Flanagan JR, Beltzner MA (2000) Independence of perceptual and sensorimotor predictions in the size–weight illusion. Nat Neurosci 3:737–741.

Seashore CE (1899) Some psychological statistics 2. The material weight illusion. Univ Iowa Stud Psychol 2:36-46.

Acknowledgements

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