Supporting information: Intuitive physical reasoning about objects’ masses transfers to a visuomotor decision task consistent with Newtonian physics

Nils Neupärtl\textsuperscript{1,2*}, Fabian Tatai\textsuperscript{1,2}, Constantin A. Rothkopf\textsuperscript{1,2,3}

1 Centre for Cognitive Science, Technical University of Darmstadt, 64283 Darmstadt, Germany
2 Institute of Psychology, Technical University of Darmstadt, 64283 Darmstadt, Germany
3 Frankfurt Institute for Advanced Studies, Goethe University, 60438 Frankfurt, Germany

* neupaertl@psychologie.tu-darmstadt.de

**Puck Motion**

From Newtonian physics we know the relationships between a change in momentum $\Delta p$ by a force $F$ exerted over a time $\Delta t$:

$$\Delta p = F \Delta t$$  \hspace{1cm} (1)

The impulse is transferred to a puck of mass $m$ resulting in a change of speed $\Delta v$:

$$\Delta p = m \Delta v$$  \hspace{1cm} (2)

As the puck is initially at rest, the release velocity $v_0$ when shooting the puck can therefore be expressed as:

$$v_0 = \frac{F \Delta t}{m} \propto \Delta t$$  \hspace{1cm} (3)

Therefore, in the simulations the change in momentum $\Delta p$ increases linearly with press-time $\Delta t$ and proportionally to force $F$ and thus the initial velocity $v_0$ also scales linearly with the press-time. Once released, a frictional force $F_{fr}$, which can be expressed in terms of the gravitational force $F_g$ and the friction coefficient $\mu$:

$$F_{fr} = \mu F_g = \mu mg,$$  \hspace{1cm} (4)

which slows the puck down with an acceleration $a_{fr}$, which accordingly to Newton’s second law $F = ma$ is:

$$a_{fr} = \mu g$$  \hspace{1cm} (5)

until at rest after some time $T$:

$$v_T = 0 = v_0 - a_{fr} T$$  \hspace{1cm} (6)

During this time the puck has moved a distance $s_T$

$$s_T = \frac{1}{2} a_{fr} T^2$$  \hspace{1cm} (7)

Solving eq. (6) for $T$ and substituting into eq. (7), substituting the acceleration $a_{fr}$ from eq. (5) and using the expression for the initial velocity $v_0$ from eq. (3) allows finding the press-time required for propelling the puck over a distance $\Delta x$ in manuscript eq. 1.
Position and velocity updates per frame:

We used the difference equations corresponding to the above equations of motion:

\[
x_{t+\delta t} = x_t + v_t \delta t
\]  
\[
v_{t+\delta t} = v_t - a_f \delta t.
\]