# Supplement to *Natural science: Active learning in dynamic physical microworlds*: Design and Box2D settings for pilot

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## 1 Design

Table 1: The test worlds for Experiment 1 - Within 1 stipulated the force between objects of Colour 1 while Within 2 stipulated the force between objects of the other colour. Global (1) and Global (2) indicate the two global force counterbalance conditions.

| World | Within 1 | Within 2 | Between | Colour 1 | Global (1) | Global (2) |
|---|---|---|---|---|---|---|
| 1 | 3 | 3 | 3 | yellow | none | north |
| 2 | 3 | 3 | 0 | red | none | east |
| 3 | 3 | 3 | -3 | yellow | none | south |
| 4 | 3 | 0 | 3 | red | none | west |
| 5 | 3 | 0 | 0 | yellow | none | north |
| 6 | 3 | 0 | -3 | red | none | east |
| 7 | 3 | -3 | 3 | yellow | none | south |
| 8 | 3 | -3 | 0 | red | none | west |
| 9 | 3 | -3 | -3 | yellow | none | north |
| 10 | 0 | 0 | 3 | red | east | none |
| 11 | 0 | 0 | 0 | yellow | south | none |
| 12 | 0 | 0 | -3 | red | west | none |
| 13 | 0 | -3 | 3 | yellow | north | none |
| 14 | 0 | -3 | 0 | red | east | none |
| 15 | 0 | -3 | -3 | yellow | south | none |
| 16 | -3 | -3 | 3 | red | west | none |
| 17 | -3 | -3 | 0 | yellow | east | none |
| 18 | -3 | -3 | -3 | red | west | none |

## 2 Box2D settings

Box2D is available here `github.com/erincatto/Box2D`. The javascript port we used is available here `box2d-js.sourceforge.net/`.

Our demo code is available here `www.ucl.ac.uk/lagnado-lab/experiments/neil/apl/exp_1/demo.html` and here: `www.ucl.ac.uk/lagnado-lab/experiments/neil/apl/exp_1/physics_world_exp1.html`. After landing at these locations, right click to view the source code. Below is a list of the Box2D variables and functions set in our pilot code:

- Number of steps (frames): 1800
- Trial length = 30s
- Box2D step size: 1/60s ($\approx 17ms$)

- Ratio (pixels to meters): 100 (200 on retina screens)
- Object velocity cap: $30\,{}^{\mathrm{m}}/_{\mathrm{s}}$
- Criterion for refreshing puck locations and velocities: Fastest object is moving at less than $0.15\,{}^{\mathrm{m}}/_{\mathrm{s}}$
- Pause time if locations refreshed = 500ms
- World width: 6m (600 pixels / 1200 on retina screens)
- World height: 4m (400 pixels / 800 on retina screens)
- Global forces: $+3\,{}^{\mathrm{m}}/_{\mathrm{s}^2}$
- Attractive forces: $+1\,{}^{\mathrm{m}}/_{\mathrm{s}^2}$ either Up, Right, Down or Left
- Repulsive forces: $-3\,{}^{\mathrm{m}}/_{\mathrm{s}^2}$
- Controlled object attraction to cursor: $2 \times \mathrm{distance}(\mathrm{cursor}, \mathrm{controlledobject})\,{}^{\mathrm{m}}/_{\mathrm{s}^2}$
- Controlled object damping: 10[1]
- Puck masses: 1kg
- Puck friction: .05[2]
- Puck elasticity: .75
- Puck damping: .1
- Puck radius: .25 m
- Puck object types: Dynamic
- Fist masses: 10kg
- Fist friction: .05[3]
- Fist elasticity: .5
- Fist damping: 10
- Fist radius: .25 m
- Fist object types: Dynamic
- Wall elasticity: .99
- Wall friction: .1
- Wall width = .2m
- Wall object types: Static

[1] Damping in Box2D slows objects while they are not in contact with any other objects (like wind resistance). The controlled object was given high damping so it would not oscillate for a long time around the cursor location.

[2] Friction in Box2D occurs when two objects slide past each other while touching (e.g. a puck sliding along a boundary wall).

[3] Friction in Box2D occurs when two objects slide past each other while touching (e.g. a puck sliding along a boundary wall).