Human Affordances of Stacking: Best Placement or Best Outlook?

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Humans face the everyday need of using objects to pursue their goals for simple and common tasks. The possible usages assigned to objects are called *affordances* (Gibson 1977). (Şahin, Çakmak et al. 2007) proposes a good summary of different classifications and definitions of affordances. (Costantini and Sinigaglia 2011) believe that affordances are driven not only by physical properties of the object but also by its placement and reachability in the space. However, at what extent the geometrical properties of an object can overtake displacement in space? How much influence do geometrical properties have in the process of selecting the objects to complete a task? Do we always try to minimize muscular effort or are we also guided by appearance? Those are the scientific questions that we have addressed in this paper.

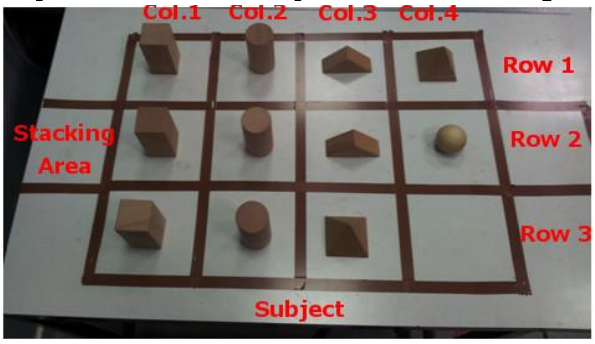

Figure 1- Example of experimental setup (first layout) and object used in the experiment.

In this work, an affordance is defined as a possible way to use a reachable object to fulfil a task. We assume that affordances depend mainly on the position of the objects on the table, the availability of objects with similar physical features, their reachability, and their visually perceived physical properties.

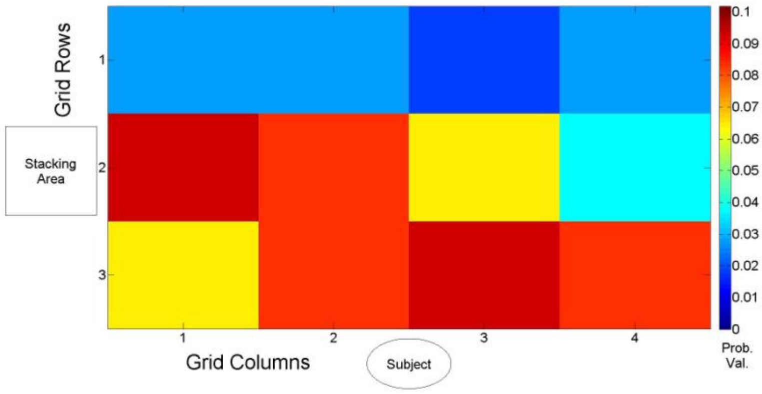

Figure 2 - Probability of picking a cuboid as first object given its position on the grid. The higher the probability the more red the cell.

To find answers to our questions, human subjects were asked to build the tallest stack using a given set of objects. The experiments were executed on 9 right handed adult subjects between the ages of 20 and 30, with no history of any motor impairment diseases. The study was approved by the King's College London Ethical Committee, REC reference Number BDM/12/13-27. Subjects wore the Measurand Inc ShapeHand motion capture glove to collect their movements. Subjects were asked to build the tallest stack out of the given objects, which were laid out on a grid on the table (Figure 1). Five different types of objects were used in the experiment (3 cuboids, 3 cylinders, 2 triangles, 2 pyramids and 1 ball). The objects were laid out on a 3x4. Four different layouts were used as a setting to conduct the investigation (Table 1). 108 trials were executed in total, 12 per subject. The task is to build the stack on the left hand side of the grid in a separate cell. The subjects were given no time limit to complete the task. All the subjects started the taks from the same initial position, according to the calibration requirements of the measurement device, arm and fingers flat in front of their body, thumb alligned to the palm). At the end, subjects return to the same initial position. Subjects were asked to sit upright and move only their dominant arm and hand when stacking. To avoid bending or rotation of the torso, non dominant hand was holding the side of the table. Subjects were asked to hold on to the table with their free hand, to stop them from rotating their torso. Before starting a trial, some time was given to each subject to observe the grid. Initially, there are eleven different possible objects of five different types that can be picked up. Each object has a probability of 1/11 to be picked first. As the task of the experiment is to build the tallest stack, it is trivial that subjects wouldn't pick the ball or the pyramid first. This narrows the probability of picking up one of the other types to 1/3. The cuboid was picked out 76 times, the cylinder 18 times and the triangle 14 times. This means that the cuboid was picked as the first object 72.2% of the time across all subjects. The cuboid was also the most frequent to be picked as a second object. 48.1% of the time over all the picks. In comparison, the cylinder was picked as the second object 36.1% of the time. The results show a clear connection between the type of object grasped and its preferred picking priority to place it on the stack.

Table 2 shows that subjects prefer to pick cuboids first before moving on to different objects, even though triangles and cylinders can be an equally good fit as a base. Cuboids and cylinders are functionally equivalent in terms of stability and height for building a stable stack, but the latter were an undermined early candidate as base of the stack. It seems that people preferred to pick a cuboid over a cylinder as the cuboid suggests a more stable base on first look. This might answer the question that, probably, humans are influenced by the appearance of objects when they are up to simple and quick decisions, discarding equally functional, but less attractive options. Subjects generally tried to build the stack quickly so it is likely that subjects don't diverge very much from their original plan. Average time to build the stack is 42 seconds.

Cube	**Cylinder**	**Triangle**	**Pyramid**
Cube	**Cylinder**	**Triangle**	**Ball**
Cube	**Cylinder**	**Pyramid**	

Cylinder	**Triangle**	**Pyramid**	**Cube**
Cylinder	**Triangle**	**Ball**	**Cube**
Cylinder	**Pyramid**		**Cube**

Triangle	**Pyramid**	**Cube**	**Cylinder**
Triangle	**Ball**	**Cube**	**Cylinder**
Pyramid		**Cube**	**Cylinder**

Pyramid	**Cube**	**Cylinder**	**Triangle**
Ball	**Cube**	**Cylinder**	**Triangle**
	Cube	**Cylinder**	**Pyramid**

Table 1 - Configuration of the objects; subjects were asked to build the tallest stack starting from 4 layouts.

%	Cuboid	Cylinder	Triangle	Pyramid	Ball
1st Pick	72.2	16.7	13.0	0.0	0.0
2nd Pick	48.1	36.1	14.8	0.9	0.0
3rd Pick	57.4	36.1	8.3	0.9	0.0
4th Pick	27.8	65.7	6.5	0.0	0.0
5th Pick	41.7	53.7	4.6	0.0	0.0
6th Pick	25.0	67.6	7.4	0.0	0.0
7th Pick	12.0	15.7	67.6	2.8	1.9
8th Pick	18.5	11.1	62.0	0.0	0.0
9th Pick	0.0	0.9	1.9	73.1	13.9
10th Pick	0.0	0.0	0.9	3.7	0.9

Table 2 - Probabilities, in percentage, of picking an object on the grid in a certain order across all subjects and trials. The mean height of the stack is 8.8 elements.

Figure 2 shows the probability of picking a cuboid as the first object. Subjects showed a biased preference towards cuboids that are closer to them and to the stacking area. Cells nearby those close by the subject or the stacking area were also of great interest. This confirms that given two equal objects, subjects give priority to the secondary criterion of cost of total effort. This complies with results proposed in (Alexander 1997). Our experimental validation clearly proves that people are not selecting objects only based on their position in space or their functional physical properties, but also on the predicted contribution, based on visual observations, of the object to the overall goal of the task is taken into account too. We believe that the general rules that are driving the decisions also take into account the appearance of the object, rather than just functional properties.

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Acknowledgments

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