Objects and Affordances: An Artificial Life

Giorgio Tsiotas (tsiotas@cs.unibo.it) Department of Computer Science, 7 Mura Anteo Zamboni Bologna, 40127 Italy
Anna M. Borghi (annamaria.borghi@unibo.it) Department of Psychology, 5 Viale Berti Pichat Bologna, 40127 Italy
Domenico Parisi (domenico.parisi@istc.cnr.it) Institute of Sciences and Technologies of Cognition (ISTC), 15 Viale C. Marx, Rome, 00137 Italy

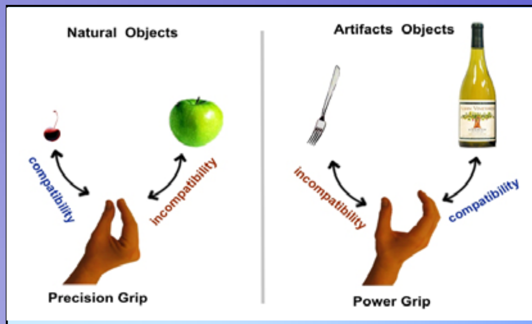
ABSTRACT. We simulate organisms with an arm terminating with a hand composed by two fingers, a thumb and an index, each composed by two segments, whose behavior is guided by a nervous system simulated through an artificial network. The organisms, which are trained using a genetic algorithm, live in a bidimensional environment containing four objects, either large or small, either grey or black. In the baseline simulation the organisms learn to grasp small objects with a precision grip and large objects with a power grip. In Simulation 1 the organisms learn to perform two tasks: in Task 1 they continue to grasp objects according to their size, in Task 2 they have to categorize the objects' color by using a precision or a power grip. Learning occured earlier when the grip required to respond to the object and to decide the color was the same than when it was not, even if object size was irrelevant to the task. The simulation replicates the result of an experiment by Tucker & Ellis (2001) suggesting that seeing objects automatically activates motor information on how to grasp them.

INTRODUCTION

Perception and action are strictly interwoven and that perception is guided and filtered by action.
The cognition is embodied and depends on the experiences that result from possessing a body with given physical characteristics and a particular sensorimotor system.
Seeing an object tends to evoke the object's affordances, re-activating previous experiences and interactions with the object, even for tasks not relevant.

MICRO-AFFORDANCE. Protruding object parts may activate reaching motor behaviors, whereas objects of a specific size may activate specific grasping behaviors. Micro-affordances facilitate simple and specific kinds of interactions with objects but they do not pertain complex, goal-mediated actions. Seeing an object does not elicit simply a grasping behavior, but a specific type of grasping behavior which is suitable for that particular object.

ELLIS & TUCKER EXPERIMENTS



Tucker & Ellis have demonstrated the role played by affordances in eliciting motor behavior by presenting participants with real objects of different sizes.

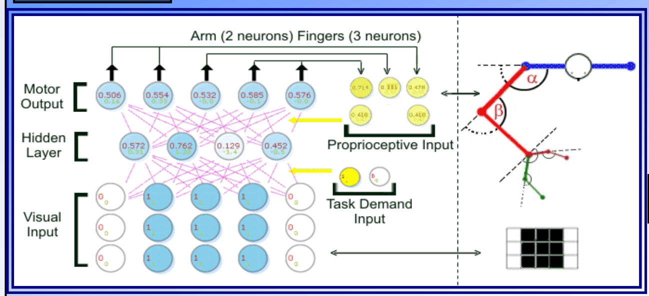
Participants had to categorize the objects as natural or artefact by executing with their hand either a power grip or a precision grip. They found a compatibility effect between the kind of grasping movement and a task-irrelevant dimension, the object's size.

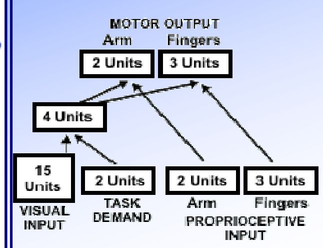
AIM

Reproduce with an Artificial Life connectionist simulation the situation explored by Tucker & Ellis (T&E). Assessing whether previous grasping experiences with objects of different size influenced the organism's performance when the object's size was irrelevant to the task at hand, i.e., in a task in which the organisms had to perform a different kind of grip depending on the color of the object.
Connectionist simulations not only make it possible to replicate behavioral tasks but they also allow us to analyze the activation patterns of the neural network's hidden units, i.e., the neural organization that emerges in the network acquires in order to solve the problem.

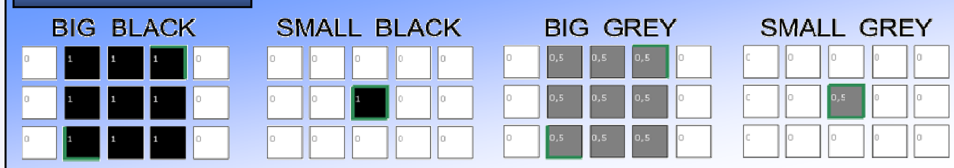
ARTIFICIAL LIFE CONNECTIONIST SIMULATION

THE MODEL

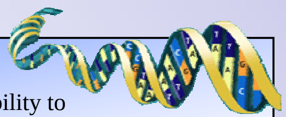




THE PATTERN SET



GENETIC ALGORITHM

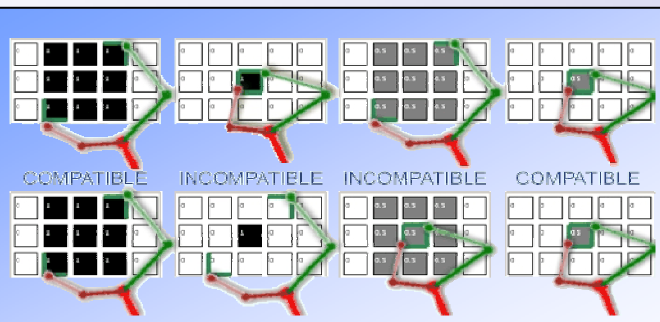


The population, every generation, is composed of 100 organisms.
Each organism is assigned a fitness value reflecting the organism's ability to perform the task. The 20 best organisms are selected for (nonsexual) reproduction and each of them generated 5 offspring inheriting their parent's genotype with the addition of some random mutations for the new generation. The process is repeated for 2000 generations.

THE SIMULATION

TASK 1 Grasping Objects

TASK 2 Color Recognition

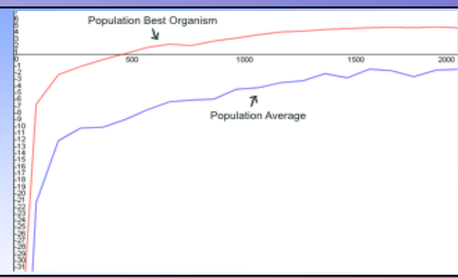


Task 2 reproduced the laboratory situation devised by T&E, with some small variations. In our simulation, teaching the network to distinguish between natural objects and artifacts would have been rather implausible. For this reason we decided to train the network to respond to objects of different color.

RESULTS

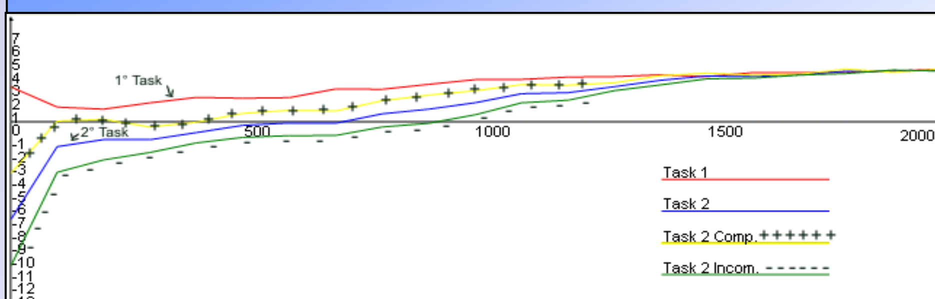
SIMULATION 1

In Simulation 1 the organisms had to learn to react appropriately to the object's affordances: they had to learn to reach the object and grasp it in the appropriate way, i.e., using a power grip for large objects and a precision grip for small ones. This reflects exactly what we typically do in real life.



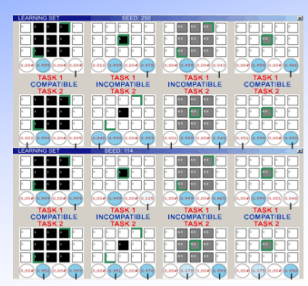
SIMULATION 2

In Compatible Condition the average fitness for all the generations tested was superior than the average fitness in the Incompatible Condition



HIDDEN UNITS

TASK 1: the network typically uses a single hidden unit, the value of which switches from 0 to 1.
TASK 2: for the majority of the replications:
- **Compatible condition:** the networks maintain the same activation patterns used in Task 1 and a new unit is simply added to encode the new task
- **Incompatible condition:** the network has to be re-organized, and different units are used to encode the 2 tasks.



CONCLUSION. Our results confirm the findings obtained by T&E in their experiments: seeing objects automatically elicits motor information concerning the way we interact with the objects. Even if the object's size is irrelevant to the task at hand, seeing the object activates the kind of prehension appropriate for its size. When the kind of grip and the object's size are compatible, responding to the object's color is quicker than when the kind of grip and the object's size are not compatible.