

# AI Lecture: Braitenberg Vehicles

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## Introduction

When looking at mechanisms with cognitive functionality (and artificial intelligence in general) it is useful to begin with the simplest cases.

Braitenberg 'vehicles' are very simple mobile machines that use basic sensory-motor connections to produce seemingly cognitive behaviors.



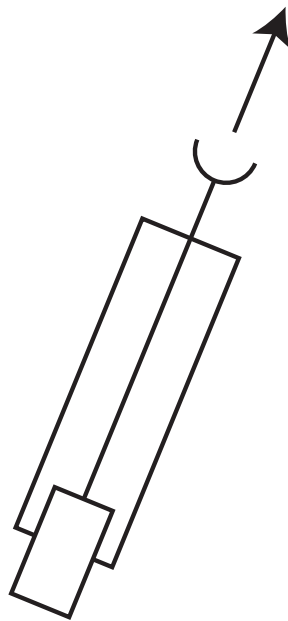
## Braitenberg's approach

'We will talk about machines with very simple internal structure ... when we look at these machines or vehicles as if they were animals in a natural environment ... we will be tempted, then, to use psychological language in describing their behavior. And yet we know very well that there is nothing in these vehicles that we have not put in ourselves.'

This and all other quotes and figures are from the first five chapters of (Braitenberg, 1984)

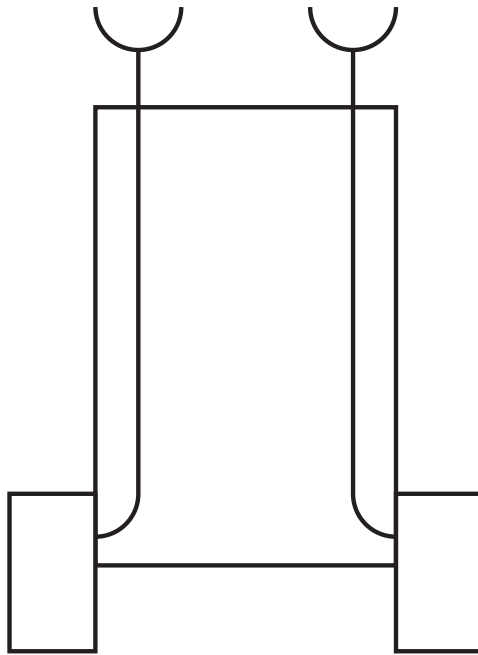
## Vehicle 1: approach (pp. 3-5)

Vehicle 1: the simplest vehicle. The speed of the motor (rectangular box at the tail end) is controlled by a sensor (half circle on a stalk, at the front end). Motion is always forward, in the direction of the arrow, except for perturbations.



## Vehicle 2a: fear (pp. 6-9)

This vehicle spend more time in the places with less stimulation, and speeds up when exposed to more stimulation.

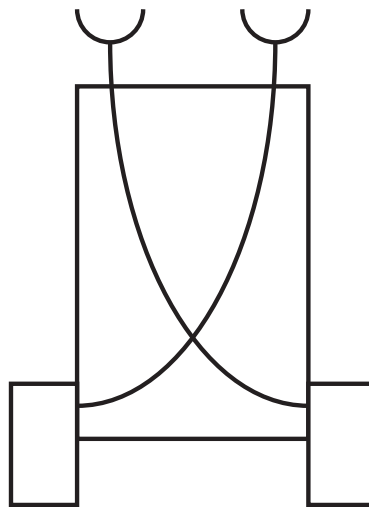


If the stimulation is directly ahead, the vehicle may hit the source.

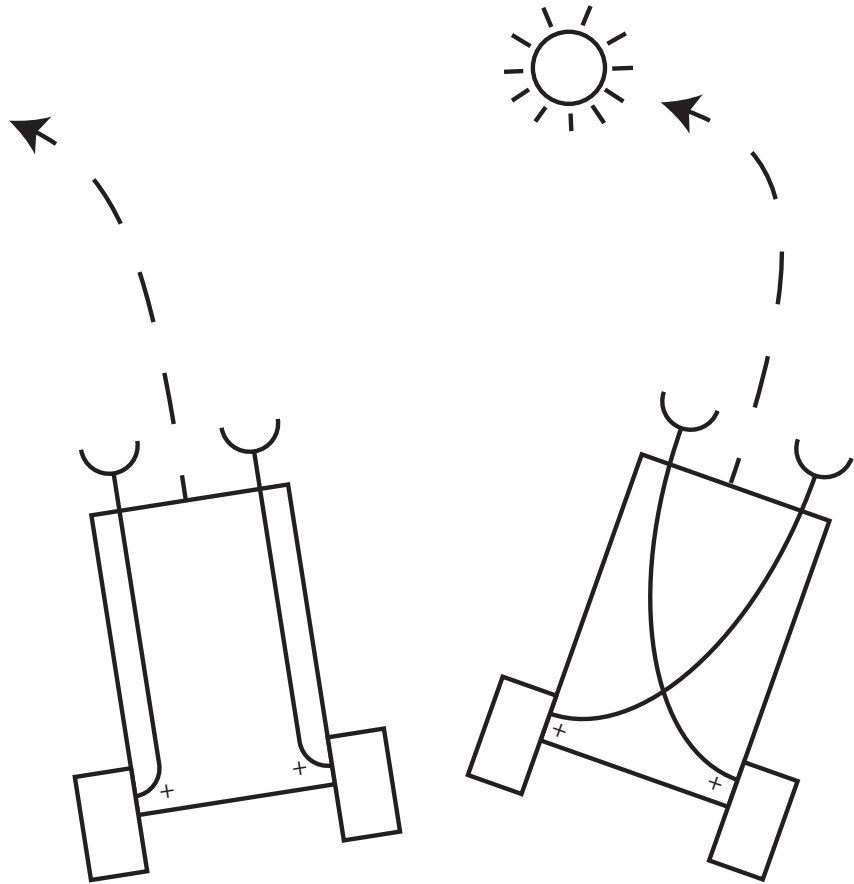
Otherwise, it will tend to turn away from the stimulation. ▶ ◀ ≡ ▶ ≡ 🔍 ↻

## Vehicle 2b: aggression

If the sensor-motor connections are crossed, the behaviour changes. If the stimulation is directly ahead, the vehicle moves directly towards it as before. But, if the stimulation is to one side, the vehicle will tend to veer towards it with increasing speed.



# Fear and aggression



## Anthropomorphic interpretation

Braitenberg illustrates the potential for over-blown interpretation.

‘Let Vehicles 2a and 2b move around in their world for a while and watch them. Their characters are quite opposite. Both DISLIKE sources. But 2a becomes restless in their vicinity and tends to avoid them, escaping until it safely reaches a place where the influence of the source is scarcely felt. Vehicle 2a is a COWARD, you would say.

Not so Vehicle 2b. It, too, is excited by the presence of sources, but resolutely turns toward them and hits them with high velocity, as if it wanted to destroy them. Vehicle 2b is AGGRESSIVE, obviously.’



# LEGO NXT demo of behaviours

`http://www.youtube.com/embed/-2iX7noTTAw`



## More behaviors

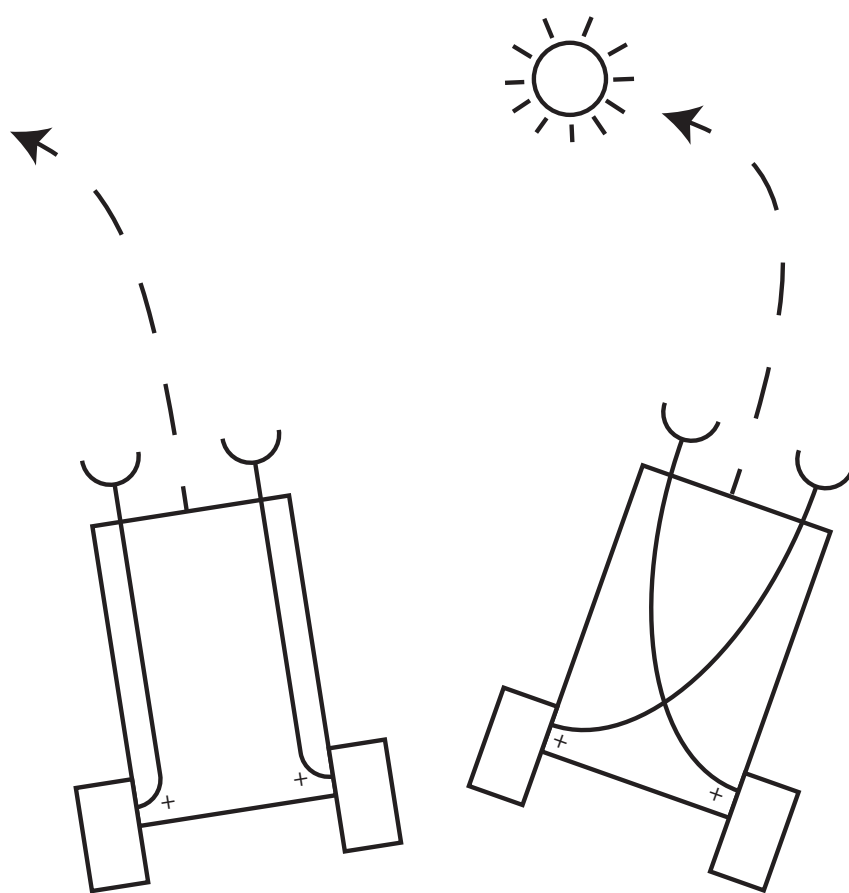
`!http://www.youtube.com/embed/yUVcI5Pw2o4`

# Inhibition

‘The violence of Vehicle 2b, no less than the cowardice of the companion 2a, are traits that call for improvement. ... What comes to mind is to introduce some inhibition in the connections between the sensors and the motors, switching the sign of the influence from positive to negative. This will make the motor slow down when the corresponding sensor is activated.’

(Braitenberg, 1984, p. 10).

## Vehicles 2a and 2b



## Vehicle 3a: love

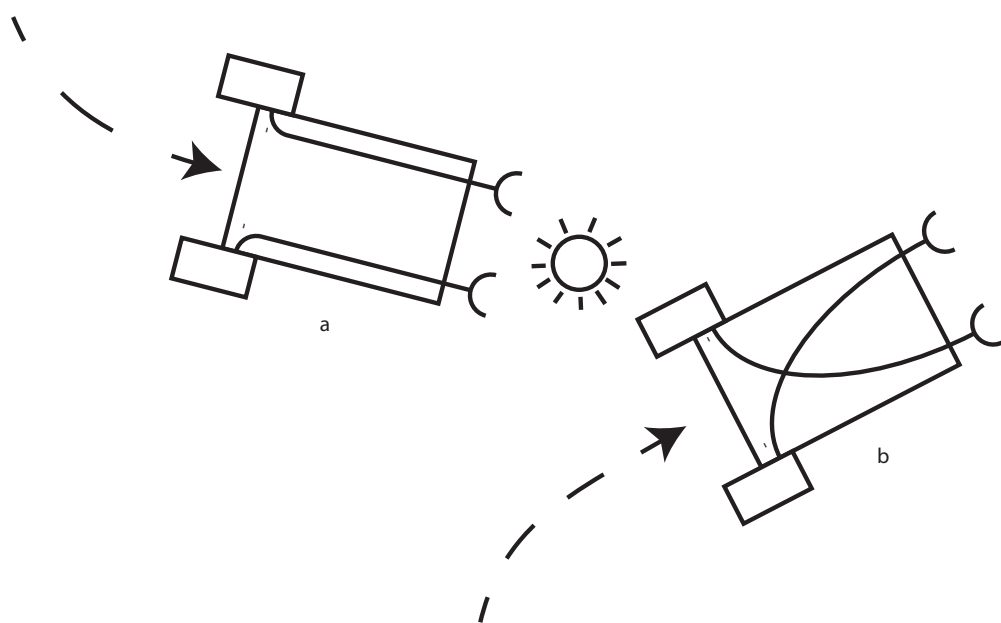
Making the connections of vehicles 2a and 2b *inhibitory* produces vehicles 3a and 3b.

These show completely different behaviour.

Approaching the stimulation, Vehicle 3a will orient towards it and come to rest facing it.

Vehicle 3b on the other hand will come to rest facing away from the stimulation.

# Love v. exploration

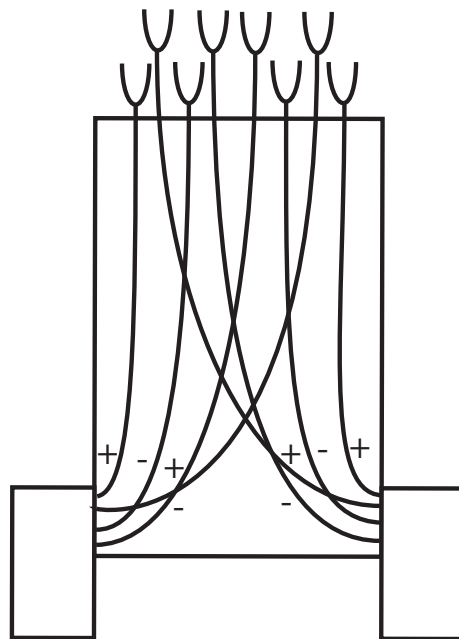


## Optimistic interpretation

'You will have no difficulty giving names to this sort of behavior. These vehicles LIKE the source, you will say, but in different ways. Vehicle 3a LOVES it in a permanent way, staying close by in quiet admiration from the time it spots the source to all future time. Vehicle 3b, on the other hand, is an EXPLORER. It likes the nearby source all right, but keeps an eye open for other, perhaps stronger sources, which it will sail to, given a chance, in order to find a more permanent and gratifying appeasement.' (p. 12)

## Vehicle 3c: a system of values

'... not just one pair of sensors but four pairs, turned to different qualities fo the environment, say light, temoperature, oxygen, concentration, and amount of organic matter.'





## Expected behavior

Given appropriate connections, 'this is a vehicle with really interesting behavior. It dislikes high temperature, turns away from hot places, and at the same time seems to dislike light bulbs with even greater passion, since it turns towards them and destroys them... You cannot help admitting that Vehicle 3c has a system of VALUES, and, come to think of it, KNOWLEDGE'

## Vehicle 4: special tastes

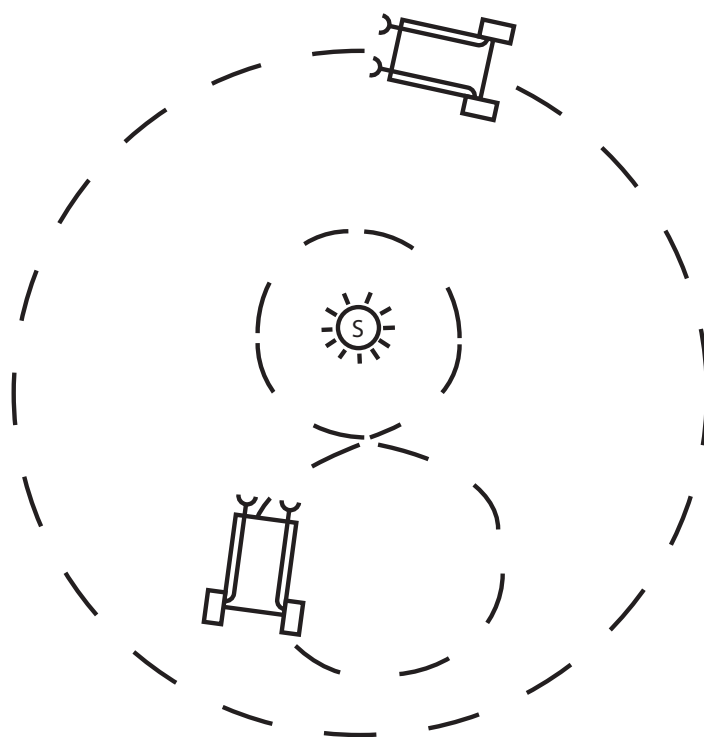
'Let us consider the following improvement. The activation of a certain sensor will make the corresponding motor run faster but only up to a point, where the speed of the motor reaches a maximum. Beyond this point, the speed will decrease again.'



'A 4a vehicle might navigate towards a source (as Vehicle 2b would) and then turn away when the stimulus becomes too strong, circle back and then turn away again over and over again'

## Effects of non-linear, non-monotonic connections

'You will have a hard time imagining the variety of behavior displayed by vehicles of brand 4a.'



## "shy but defensive" behavior

`http://www.youtube.com/embed/17wb0QAJAQE`

## Getting stuck in the corner...

`http://www.youtube.com/embed/LCpaWyntj7w`

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