

Toward Spinozist Robotics: Exploring the Minimal Dynamics of Behavioural Preference

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A. r c

A preference is not located anywhere in the agent's cognitive architecture, but it is rather a constraining of behaviour which is in turn shaped by behaviour. Based on this idea, a minimal model of behavioural preference is proposed. A simulated mobile agent is modelled with a plastic neurocontroller, which holds two separate high dimensional homeostatic boxes in the space of neural dynamics. An evolutionary algorithm is used for creating a link between the boxes and the performance of two different phototactic behaviours. After evolution, the agent's performance exhibits some important aspects of behavioural preferences such as durability and transitions. This paper demonstrates 1) the logical consistency of the multi-causal view by producing a case study of its viability and providing insights into its dynamical basis and 2) how durability and transitions arise through the mutual constraining of internal and external dynamics in the flow of alternating high and low susceptibility to environmental variations. Implications for modelling autonomy are discussed.

keywords : o nc o o c d on
dyn c y o c o co n on o on y o o c

1 Introduction

o do n od d n d o o nc c
o o n c n o o d c on o cy ood
d o n y d n y o y o n on n con n
nc o ndo no y n d o d n d c d
d o z on o d c d o o
o nc o no n n o y c on o c
c c c z d y n o co o nd co c n con
o non d o c o n d c nd c y M
on y o o n n o y c o o y o d od y
o d y o n n on on n n n on c
n on o c od y on nd n n o o c
on d nd on ody o y nd dyn c o nd ncy
o d no o on on nd n
d nc o c n n M on y
n c d o o d o
o n o d d nd no c n o d n on d
o o n c n no n c y o n ny o c n
o o n d d n **preference** n o co n
c o c o c n c d c n
o o n od n nd o on n n o n
c nc y c y nd o o nc y
n y n n n y d o o y n o d
no d n nc n o d o nd nd c d o
dyn c y c o con n n o dy nd
cond on nc y c n nc o
c y c o con o n on
o d **preference** ny co n conno on
y no c d y n d n on n on nd co
nz dyn c y c o y d n do no do
c o c n o conc n nc n o
co n c on n n d c con nd o
con c n n o nd o o c y o o
minimal dyn c o d y ny n nc
o d o o o d c on o yn c n
c nd nd d o o d c yn co d
n co n c nc B y o o ood nn c
nd d o c o c c c c on o **preference**
nd d c **disposition tendency commitment conation** c

n n o dyn c y
- yn c y o c o co n on y c y n d o
c o c c d c n on coo d n on nd
n n B o nd y o y

n n n nd c n n nc

A pinoz's approach

n con o nc on co on o c dyn c

n nn y nd n o n o o od o
o o o c c n on y on o y o c n
o n c o nc c d y nd n on n
 o c n c d
o

o A y c c n n n d n n o
con o d d c o d n nc on dn o
o nd n n nc o n c on n o o c
on o n n c y n co n on c
o o o on o no nd o co n n
n n nd n on n dyn c nc n ocon o
o o coo dn on n n n on n on
n n n y yn c c n no on n
on c n c n n n on o do o o
on c do n o coo dn on c n
n c on c nno n n n nd n o o
c on A n oc d c n c d
n nd n c yn c c c n n
c on n o o c on nd y y o no n c
y o o coo dn on A n c n
d o on n nc d o
o c c n d n on o nd d o o
n c co ond o n o o o n n d o
o nc dyn c n o n c o
o o o ond n o o n con on y d n
c n c y n y co c n no o c o
n n o y con on no on c n
c y dyn c on o o coo dn on o occ
nd c c nc n nc on o o c c
o n c nd oc n o o o o
o c nno c^ood d d o c o c d_o o on o_od
nd n n o o o o c c d_o d

o n c d

Agent. An n od d d d o o
 c c odyo d nd od c yo o d o o o o
 c nd n c d nd o d n n d n A n
 y o o o d c y d n
 n n oc y on o ody o o oc d
 n on o n o o o c c d n oc y o
 c n o c y o o n n oc nd
 o on o n c c d y d dn d ne o o
 o o o y d dn o n on d
 o n nd o on d o d n c
 n o o n o o od n o c **A** nd **B**
 o n d n o = d n o o dd c on o do
 no n c o nd od ne d do od c d
 y n ody

Plastic controller. A y conn c d con n o c n n
 n o NN B d n con o
 o on o o n on d y

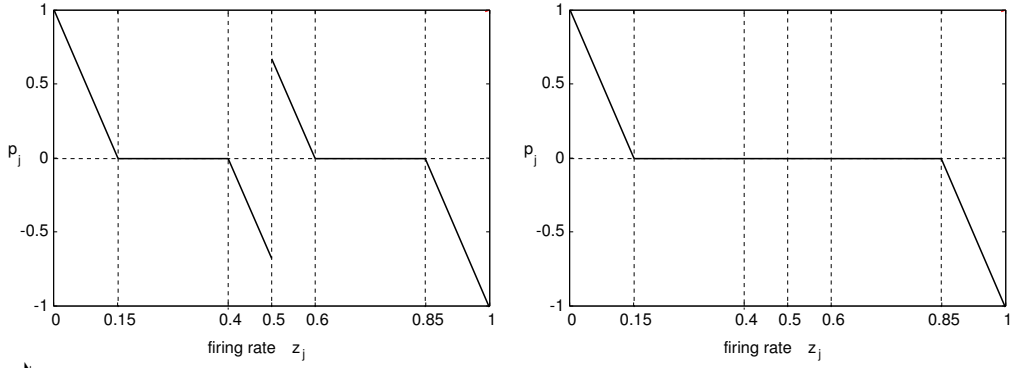
$$y_i - y_i \sum_{j=1}^N w_{ji} z_j y_j \quad | \quad z_i x = e^{-x - b_i};$$

y_i n c o n o n on i z_i n i
 n : ; con n b_i n - ;

n d n o o c c o o d n o n o n d d
 od o d on y co ond n o n
 o : ; : nd : ; : o n n / nd o c n on c on
 y nd o o o **A o B** o o on y
 n o d c o o on o o n n n
 on nd o o o **A B** nd o on o o o
B A n n n o on d n
 o on y n o c o on no
 d o n nd o n on c o d n od c n
 n n y c c y o o n / o
 n nd n on nc on c n o o c on
 d /
 c n o o n c o d nd n y on
 n o yn c n on nd n n
 o n on **i o j** d d cco d n o

▲w_{ji} j_iZ_ip Z_j

Z_i nd Z_j n o nd o yn c n on
 c y **▲w_{ji}** c n n o o **w_{ji} p x** c
 nc on / nd **j_i** o c n n ; : c
 n c y o c conn c on / o c y c
 o o n o od c o nd c nc
 on **y** o n d c on o n n o n o o o c
 on / o n o n on **j Z_j** n ; : o
 : ; : c



nd o n o n on n on

4.1 Evolutionary setup

A o on o n o d n n d n c o
 A n o $w_{ji}; i b_i; j_i$ nd n
 n d y d c o c d cod d n y o
 n co ond n o c on o n
 c on n y c d o o nd c o on o o
 c dd ndo c o o d no y B
 d n o o on o c n
 o n n o d n y ndo y n n o
 o n on cco d n o n nd o y d cod
 o n o o n on o c d cco d n o n
 n d nd d n on ω

d

n n c

5.1 Basic phototactic behaviours

nod o c c o on y o o o c c
o nd n n nc o n n dyn c n d o
on cc on o on y d d n o on n
c o n c n n **A** o o **A** con n
A nd n n **B** n o on y o n
o o o **A** nd n n nc o n n dyn c
n o nd n c o n c n n **B** o o
B n n **A** nd con n **B** y n n
o c n o o o n n n on o y n
o o c on o **A** n n o c n **B** n o
no o o o o o c d nc n
o o n on n o y o o o n
o o n n y c y o o
o y o o o **B** o o n n
n o n cc c on no o o
nc

5.2 Transitions

n n d n o y d n o on c n
n c o n y d nc n
con n ~~1816 0 Td (w)Tj 7.54912 0 Td (e204554 0 Td (neurons)Tj 40.0036 0 Td (b)Tj 6.k 7.1890eak)Tj~~

n d no n o no nd co
 ond o n n od c n n y
ndo nd n on y c
o o c n n o **A o B** no n o
 n o o o d n on d n o on
n nd n n

1 - .
0.8 - .
0.6 - .
0.4 - .
0.2 - .
0 - .

A c n n n o c n o do no c n
od d o c n d o o n
c y o n d n n dyn c o
n n d n c on c o c y o d
o d no d o o NN o c n n
dyn c n o no on o c n n n o d
n B d o n n
o n on n n o c yn c c y
o c n A B d yn c

d y

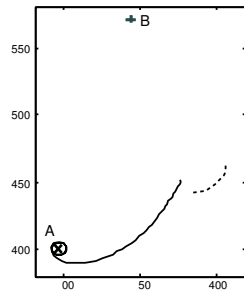
5.3 What makes a preference change?

o n c y d c y c o y o o
n on do no n n on c d o y y
c o n n o n n y d c o d e c on
n con o co od d dyn c y o n
c on y o d nc on n ndo no dyn c nd
n y d n n c on n o c y o n on
n n o d o dy c o d n c o c n c o
nc

5.3.1 Persistence of preference

n nc o nc o y n
n o on o o d o on d
n o c n o n

B n c o od c n on nd o n
o no o y o nd **B** n n nc no o
o on no on n n on n c o o n
on n o c n od c c n o nc n n
o n n y n nd n od o nd **t**
o o **A** nd **B** d no n d od
d y y co d c d o n on n c o
nd o n n dyn c od c con c



no on $B \rightarrow A$ $A \rightarrow$ nd c t o on o
B c n d o o **A** nd o n **A** d
 o n dd n y **B** on y o **A** nd no
 o A n n n c o no
B nd n c o o c c n n n co ond n
 o o o n t n **does**
not approach **B** n n on y o o on
A

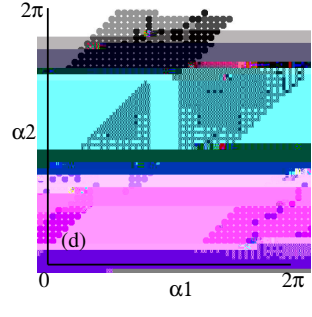
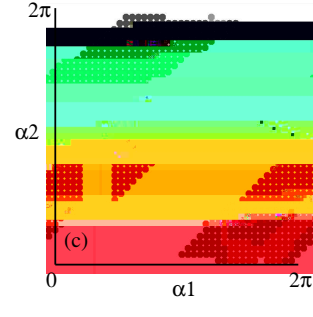
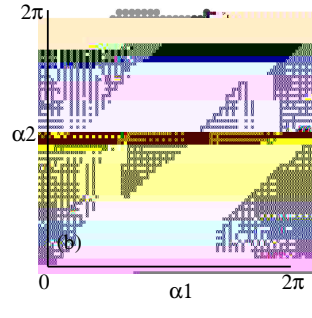
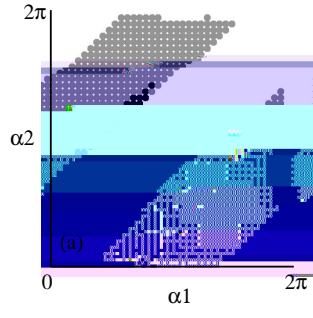
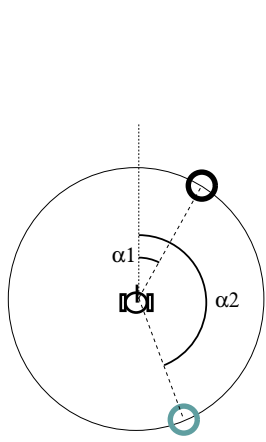
5.3.2 Effects of reducing external variability

A o o nc o ndo no c o n o on nd
nc o nc n d n n dyn c no
nd nd n o o y o n on n co n n c
nc **through interactions** b ndo n c o on
o c o o n on o n c n n
c on o y o c n o d n o o
o n on n e o do e nc n
d n n n on n c on c n o
y n o on o ody c

nc - o n o on o c o c
 n n c y co ond o on n o o n y d n
 d c on n d on n no o
 o o c n o d dyn c on n
 d n c o n o d o o c d nc on d nc on
 d o on y o n n o n o n d
 n on d n o n n d c d
 o o o on o y nc ndo no y n d
 o o o on n n on n c o n
 con y d c on y c d y n on n
 on c n d o o y d y n c o
 o o c y **strong** nd **weak commitment** o c o c
 B d on d c n nd od y co
 ond n o d n n / / o c c on o n
 co d c o c d y n nc on o d n
 n n o on o o o c d d nc
 c o c n n n n o n
 o nc o n y d n d o y o n
 d n on n / n c o n c n o n y
 nc o **B** d c on n o n o
 on o n o y o c **B** o c c
 n o on d o d c on o o c

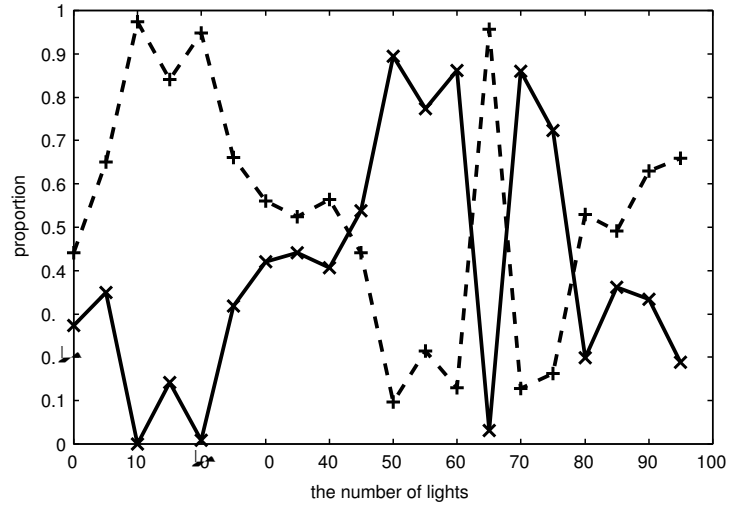
c o n on d o n nc c n o **B** o
A nd o o on y o nd c n
 n do no on co n o c o d
 c d co o n on n co o
 n o n c o c o **A** c n o d o
 o co d dyn c
 no yn d n od o n
 on n d nd nc ndo no dyn c o y on o
 n o nc n **all** c o o co o y
 co d n o o o oo c od o n on n d n
 d nc o on c n o nd o y
 o n o n n n dyn c o y o n c on
 - n od o c y o n on n
 y on o n on n y n n co n
 o d n By con d n od o c y
 con n c on o con nc o o on n o
 n on n y
 o n on ono y o n o c n
 n o o n n nd o c y c n
 n o y o o o c c n n c
 o o c n n n no n o
 o o n nd n o o o dyn c nd o od o
 co n o nc o o No n n nc on od no
 n n c on N nc o d n od c n
 d n d nd d o d d c c
 n con d ono y y y d
 o c o o d n d n n y o c n y
 d n on ono y n con c y o d n n on
 o n o o o on o nc y o o cond
 on d y o n n nd n c o od o
 on n o on n c c o c n d c d co
 d o o n nd o d o y o on ono o y
 y c n n n od y n con n n y
 n n o n d on o c

Disc ssion



L

nc o



o o on o o c d d o d on n d

o n n no on d c nd od oc n
n n od
n nc o nc nd no non o o c
n nc o d n n n n y Acco d n o
conc o no c o n non on nc
nd nd n o o no d y n c o c con
c n on o o A no B o n c on
od n n c o oy no n oc on y n n
dd n n oc on y c d

n o o c n no c o nd n
o n y n nd o on co ond n o
n o c co d od no c n
c o o c o y o d n
y o n on n y y o n o
n co d od c y n o c c nc n
c n o nc B n o od c o n
d o
y c o c o noz n on o d n o
o od o o o o o d o
n dyn c nd o c n o nc n o c n o
con n n o on z on o co n o o d n
d c n o o nd nd n con dyn c y n
y dyn c y o c o nc nd oc d co n
no n c d c on n oo o o dyn c o
n n nd n c o d n o
d o no c o n on o co n co n
ny c c c d n on o nc c d o n
n n o n nd n n on n y
d o o o c n c c n o d
o on z on d
A n no on ono y c n o od c
n o co d o o n od o n o o o o don o
o y o n c on y n o c n
ono y y d y y o on o o n
n o o c on n y cond on o n
c on co ond n o z o c y y d nd
dyn c y con o o n d n o c y nd on n o
o on o y on c c n nd n n
o n n c n o on n n n n
c o o c on con nc o n o n
c y o d on y ono o o n
n c n n no on y c n on n o y n
c o c o n y o d d o c n o n o
con nc o o y o n c on
Acknowledgments: y o o nony o
o co n c y o d y
n Mn y o d c on c nc o nd n n Ad
o / o

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d nd o n o o d on n M y B oz
A / o no b o on d **From Animals
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o A **Dynamics in action: Intentional behavior as a complex
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