Part A Chapter 4

Adaptive Behaviour

The fourth class of behavioural patterns addressed is adaptive behaviour. In this case, based on certain experiences, an agent's behaviour can change forever, or at least for longer lasting periods of time. Other terms sometimes used for specific types of adaptive behaviour are conditioning, or learned behaviour. The example discussed is learning to react on a wasp. If humans encounter a wasp, basically two types of attitudes can be shown. Some act in a relaxed manner, maybe trying not to be too close to the wasp, but without any panic reaction. Others may react in a completely different manner. They show behaviours like getting very nervous or even panicking, and trying to hit the wasp or immediately running away. This difference in behaviour, and, particularly, how the relaxed form of behaviour can transform to the panicking form, will be discussed in this chapter.

1 External Dynamics Characterizing Adaptive Behaviour

A first question is how it can be observed that an agent has adapted, i.e., has changed its behaviour. One way of addressing this question is to take a set of behaviour traces before the change and a set of behaviour traces after the change and by comparing these sets find a dynamic property in which these sets differ. For our case this would look like this.

Dynamic property satisfied by traces *before* the adaptation:

EAB1

for all time points until some time point t

if the agent observes that a wasp is close to the agent,

then the agent will show relaxed behaviour

Dynamic property satisfied by traces *after* the adaptation:

EAB2

for all time points after some time point t

if the agent observes that a wasp is close to the agent,

then the agent will panic

Notice that both properties define stimulus-response behaviour, but not the same; therefore they indicate that adaptation has taken place.

To find out such a distinction in dynamic properties is useful. It defines in which respect the behaviour has changed over time. However, it does not give any information why, under which circumstances, such a change in behaviour has occurred or will occur. The above properties define the *result* of adaptation, but give no information about the *process* of adaptation itself. The next challenge is to find external dynamic properties that define that a process of adaptation takes place.

time *trace*	*time point 0*	*time point 1*	*time point 2*	*time point 3*	*time point 4*	*time point 5*	*time point 6*	*time point 7*	*time point 8*
trace 1	wasp close	wasp close relaxed	wasp stings relaxed	wasp close relaxed ouch!	wasp close panicking	no wasp panicking	no wasp relaxed	wasp close relaxed	wasp close panicking
trace 2	wasp close	wasp close relaxed	no wasp relaxed	no wasp relaxed	wasp close relaxed	wasp close relaxed	no wasp relaxed	wasp close relaxed	wasp close relaxed
trace 3	wasp close	wasp stings relaxed	wasp close relaxed ouch!	no wasp panicking	wasp close relaxed	wasp close panicking	no wasp panicking	wasp close relaxed	wasp close panicking
trace 4	wasp close	wasp close relaxed	no wasp relaxed	wasp close relaxed	wasp stings relaxed	no wasp relaxed ouch!	no wasp relaxed	wasp close relaxed	wasp close panicking

From these example traces (and a number of similar ones) it seems that the criterion for adaptation (or *conditioning*) to take place is that the wasp stings. Or is a better criterion that the wasp stings and the agent panics, as in trace 1? Among the example traces at least some traces are present in which the wasp stings and the agent does not panic. What will happen then, the next time the agent encounters a wasp? In these traces (i.e., trace 4) the agent panics if later on a wasp is close. Then the following external dynamic property holds for all these traces.

EAB3

for all time points
if the agent observes that a wasp stings,
then for all later time points
    if the agent observes that a wasp is close to the agent,
    then the agent will panic

If panicking itself is also a condition for the behaviour adaptation, i.e., traces 3 and 4 do not lead to panic later on, then also the panic reaction itself can be included as part of the conditions; this leads to the following dynamic property:

EAB4

for all time points
if the agent observes that a wasp stings,
and after that the agent panics
then for all later time points
if the agent observes that a wasp is close to the agent,
then the agent will panic

Note the conditional statement after the 'then'. Due to this conditional, the behaviour entailed by the property depends on (the interaction with) the external world. In traces where never a wasp is close again, not any particular behaviour is entailed by this property. These traces without further encounters give no information about whether or not the agent has adapted.

These properties can be slightly reformulated by taking all conditionals in once (but note the time quantifiers; they are essential):

EAB5

for all time points
if the agent observes that a wasp stings,
and at a later time point
the agent observes that a wasp is close to the agent
then the agent will panic

To be complete, also the ouch! response is covered by the following dynamic property:

EAB6

for all time points
if the agent observes that a wasp stings,
then the agent will shout ouch!

Moreover, the behaviour if no stinging, and hence no adaptation has taken place has still to be specified:

EAB7

for all time points
if the agent observes that a wasp is close to the agent
and at no earlier point in time the agent observed that a wasp stung,
then the agent will behave relaxed

Remember that at the start of Section 1 the two properties **EAB1** (before adaptation) and **EAB2** (after adaptation) were expressed, to have some form of measure for the difference in behaviour. The above properties have been expressed in order to describe patterns of behaviour that make such a difference.

Explanation of Adaptive Behaviour from the Perspective of Behaviourism

A natural question then is whether indeed the specified description shows the adaptive behaviour. To be more precise, this is the question whether in any trace satisfying

- property **EAB3**
- at least until some point in time **EAB1** holds
- at some point of time a wasp stings

there is a time point after which property **EAB2** holds.

- Ø Is this indeed is the case?
- Ø Take a typical example trace, where after adaptation a wasp is close, and give an explanation why the agent panics.

Another specific type of adaptive behaviour was already encountered in Chapter 3, where in the first variant of motivation-based behaviour too strong dynamic constraints were imposed on persistence of desires and intentions. After a period of disappeared food the agent developed behaviour it did not have before, and which lasted forever, namely to go to p2 as soon as food is there and no screen is present. A question for this example is:

- Ø How can a dynamic property in a form like **EAB3** or **EAB5** be expressed for this case?

2 Internal Dynamics Generating Adaptive Behaviour

To realize adaptive behaviour, something (a mental property) should change within the agent, and this change is to persist. A most simple way to obtain this is by assuming a mental property s for sensitivity for wasps. However, to also take into account an internal pain state leading to the response ouch!, another internal property p is used (notice that this is not strictly needed for the ouch! response). The internal dynamics is illustrated by the following traces. Notice that at some places at the time axis more time points are distinguished than for the external trace to make a difference between internal events. To keep the numbering of time points comparable to the external traces the numbering has been refined by using, for example, time points 3a and 3b.

time trace 1	*time point 0*	*time point 1*	*time point 2*	*time point 3a*	*time point 3b*	*time point 4*	*time point 5*	*time point 6*	*time point 7*	*time point 8*
input	wasp close	wasp close	wasp stings	wasp close	wasp close	wasp close	no wasp	no wasp	wasp close	wasp close
internal				p	s	s	s	s	s	s
output		relaxed	relaxed	relaxed	relaxed ouch!	panicking	panicking	relaxed	relaxed	panicking

time trace 2	*time point 0*	*time point 1*	*time point 2*	*time point 3*	*time point 4*	*time point 5*	*time point 6*	*time point 7*	*time point 8*
input	wasp close	wasp close	no wasp	no wasp	wasp close	wasp close	no wasp	wasp close	wasp close
internal									
output		relaxed	relaxed	relaxed	relaxed	relaxed	relaxed	relaxed	relaxed

time trace 3	*time point 0*	*time point 1*	*time point 2a*	*time point 2b*	*time point 3*	*time point 4*	*time point 5*	*time point 6*	*time point 7*	*time point 8*
input	wasp close	wasp stings	wasp close	wasp close	no wasp	wasp close	wasp close	no wasp	wasp close	wasp close
internal			p	s	s	s	s	s	s	s
output		relaxed	relaxed	ouch!	panicking	relaxed	panicking	panicking	relaxed	panicking

time trace 4	*time point 0*	*time point 1*	*time point 2*	*time point 3*	*time point 4*	*time point 5a*	*time point 5b*	*time point 6*	*time point 7*	*time point 8*
input	wasp close	wasp close	no wasp	wasp close	wasp stings	wasp close	no wasp	no wasp	wasp close	wasp close
internal						p	s	s	s	s
output		relaxed	relaxed	relaxed	relaxed		ouch!	relaxed	relaxed	panicking

The following internal dynamic properties hold for these traces.

IAB1

at any point in time

if the agent observes that a wasp stings,

then after this the internal state property p holds

IAB2

at any point in time

if the internal property p holds,

and the agent observes that a wasp is close

then after this the internal state property s holds

IAB3

at any point in time

if the internal state property s holds,

then at all later time points the internal state property s holds

IAB4

at any point in time
if the internal state property s holds,
and the agent observes that a wasp is close
then the agent will panic

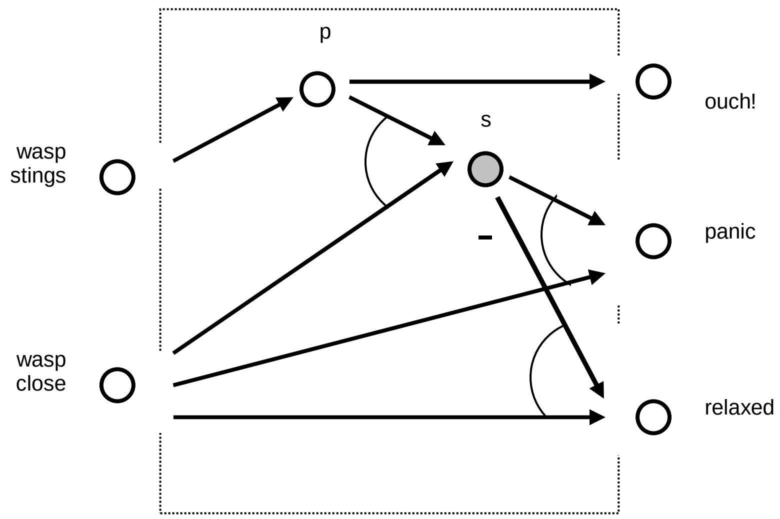
IAB5

at any point in time
if the internal state property s does not hold,
and the agent observes that a wasp is close
then the agent will behave relaxed

IAB6

at any point in time
if the internal state property p holds,
then the agent will shout ouch!

Notice that the internal state property p is not claimed to be persistent (the pain is just for a short time), whereas the internal state property s has to be persistent in virtue of property **IAB3**. In graphical format, these properties are depicted as follows.



Explanation of Adaptive Behaviour from a Functionalist Perspective

Take a typical example trace where the agent has adapted and where a wasp is close.

- Explain from a functionalist perspective why the agent panics.
- Give an iterated explanation of the internal state properties that are involved in the explanation.

The properties specified above do not leave open the possibility of ‘unlearning’ the learned behaviour. A question is how, if on the basis of certain circumstances (e.g., some psychotherapy) such an unlearning process is allowed to take place, the properties have to be modified.

- Ø How can the internal and external dynamic properties be modified to take into account the possibility of a therapy that recovers the old behaviour?

3 Relative Adaptation

The case analysed in Sections 1 and 2 displays adaptive behaviour in an absolute sense. A binary criterion for measuring whether adaptation has taken place was whether or not property **EAB2** holds after some point in time. In many cases adaptive behaviour is more relative, such as, for example, ‘exercise improves skill’. In this example the criterion is whether after doing many exercises the skill has improved compared to the skill before the exercises. Another variant of this property is in the form: ‘the more exercise, the higher the skill’. Here both in the antecedent and in the consequent a relative statement is expressed. Within the context of the case of Sections 1 and 2 the following relative adaptivity property can be expressed informally in the following form:

> The more often a wasp has stung the agent, the more panic the agent will show when a wasp is close.

One interpretation of this property is to look at one trace, and check that if over time the number of times a wasp has stung the agent increases, then also over time the panic reactions will become more severe. However, a more broad interpretation takes into account comparison between two possible traces, one with a fewer times of stinging wasps than the other, and then check whether the panic is more severe in the latter trace. This case of relative adaptive behaviour will not be worked out in detail in this context.

4 *Aplysia*’s Adaptive Behaviour

The case study above did not involve physical (neurological) mechanisms to realise the adaptive behaviour. If the actual underlying neural mechanisms are taken as a point of departure to analyse adaptive behaviour, the sea hare *Aplysia* is an appropriate species to study, since its neural mechanisms have been well-investigated. In this Section the *Aplysia* case study will be introduced and the internal state properties and their dynamics to analyse its adaptive behaviour are presented.

4.1 External Perspective on *Aplysia*

Aplysia is a sea hare that is often used to do experiments. It is able to learn; for example, it performs classical conditioning in the following manner. This (a bit simplified) description is mainly based on (Gleitman, 1999), pp. 155-156. First the (learning) behaviour viewed from an external perspective is addressed.

Behaviour before learning phase

Initially the following behaviour is shown:

- a tail shock leads to a response (contraction)
- a light touch on its siphon is insufficient to trigger such a response

Learning phase

Now suppose the following experimental protocol is undertaken. In each trial the subject is touched lightly on its siphon and then, shocked on its tail (as a consequence it responds).

Behaviour after a learning phase

It turns out that after a number of trials (three in the current example) the behaviour has changed:

- the animal also responds (contracts) on a siphon touch.

Note to characterise behaviour there is a difference between the *learned* behaviour (which is simply an *adapted* stimulus-response behaviour) and the *learning* behaviour, which is a form of *adaptive* behaviour, no stimulus-response behaviour. To specify such behaviours the following sensor and effector states are used: tail shock, siphon touch, contraction. In terms of these state properties the following dynamic properties can be specified in executable format. The first property holds always, whereas the second property only holds after a learning phase.

EP1 Contraction Upon Tail Shock

At any point in time t,
if a tail shock occurs
then it will contract

EP2 Contraction Upon Siphon Touch

At any point in time t,
if a siphon touch occurs
then it will contract

The learning behaviour itself is expressable as follows. Here for simplicity it is assumed that after three trials the adaptation has been achieved.

EP3 Learning Contraction Upon Siphon Touch

At any point in time t,

if a siphon touch occurs

and at three different earlier time points t1, t2, t3,

a siphon touch occurred, directly followed by a tail shock

then it will contract

As in the earlier example, the temporal complexity of the learning behaviour specification is higher than that of the learned behaviour (which is of a simple stimulus-response form..

4.2 Internal Perspective on *Aplysia*

Roughly spoken the internal neural mechanism for Aplysia's conditioning can be depicted as in Figure 2.

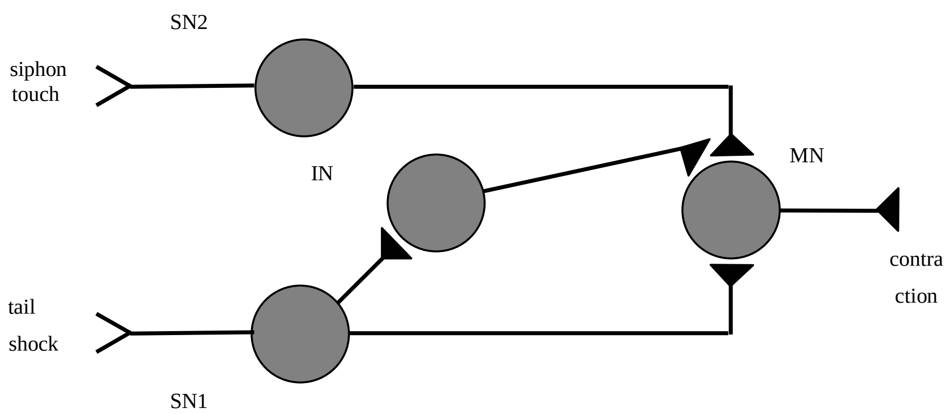


Figure 2 Neural Mechanisms in *Aplysia*

A tail shock activates a sensory neuron SN1. Activation of this neuron SN1 activates the motoneuron MN; activation of MN makes the sea hare move. A siphon touch activates the sensory neuron SN2. Activation of this sensory neuron SN2 normally does not have sufficient impact on MN to activate MN. After learning, activation of SN2 has sufficient impact to activate MN. In addition, activation of SN1 also leads to activation of the intermediary neuron IN. If both SN2 and IN are activated simultaneously, this changes the synaps between SN2 and MN: it makes that in this synaps more neurotransmitter is produced if SN2 is activated. After a number of times this leads to the situation that also activation of SN2 leads to activation of MN.

To model the example the following internal state properties are used:

- sensory neuron SN1 is activated
- sensory neuron SN2 is activated
- intermediary neuron IN is activated
- motoneuron MN is activated
- the synaps has strength r (expressed by S(r)); i.e., the synaps between SN2 and MN is able to produce a certain amount of neurotransmitter

The dynamics of these internal state properties involve temporal relationships, which are analysed in more detail in the next section.

4.3 Local Dynamic Properties

To model the dynamics of the example, the following local properties (in executable format) are considered. They describe the basic parts of the process. See also Figure 3 for a graphical overview of these local properties.

LP1

At any point in time,
if a tail shock occurs
then SN1 will be activated

LP2

At any point in time,
if a siphon touch occurs
then SN2 will be activated

LP3

At any point in time,
if activation of SN1occurs
then IN and MN will be activated

LP4

At any point in time,
if activation of SN2occurs
and activation of IN occurs
and the synaps has strength r with r < 4
then the synaps will have strength r+1

LP5

At any point in time,
if activation of SN2occurs
and the synaps has strength 4
then MN will be activated

LP6

At any point in time,
if activation of MN occurs
then it will contract

LP7

At any point in time,
if the synaps has strength r with r < 4
and the synaps has not strength r+1
then the synaps will have strength r

LP8

At any point in time,
if the synaps has strength 4
then the synaps will have strength 4

LP9

At any point in time,
if the synaps has strength r+1 with r < 4
then the synaps will have not strength r

LP10

At the start, the synaps has strength 1

4.4 Simulation

A special software environment has been created to enable the simulation of executable models. Based on an input consisting of dynamic properties in *leads to* format, the software environment generates simulation traces. An example of such a trace can be seen in Figure 4. Here, time is on the horizontal axis, the state properties are on the vertical axis. A dark box on top of the line indicates that the property is true during that time period, and a lighter box below the line indicates that the property is false. This trace is based on all local properties identified above. In property LP1 and LP2 the values (0,0,1,3) have been chosen for the timing parameters e, f, g, and h. In all other properties, the values (0,0,1,1) have been chosen. As can be seen in Figure 4, at the beginning of the trace the organism has not performed any conditioning.

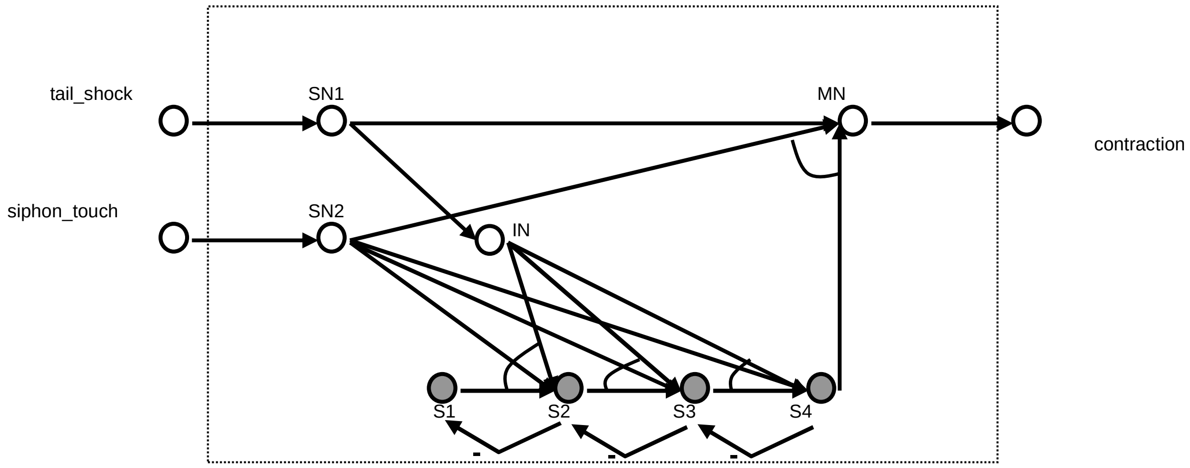


Figure 3 Dynamics of *Aplysia*'s Internal Adaptation Mechanisms

The initial siphon touch it receives does lead to the activation of sensory neuron SN2, but the synaps between SN2 and motoneuron MN does not produce much neurotransmitter yet (indicated by internal state property S(1)). Thus, the activation of SN2 does not yield an activation of MN, and consequently no external action follows. In contrast, it is shown that a shock of the organism's tail does initially lead to the external action of contraction. This can be seen in Figure 4 between time point 10 (when the tail shock occurs) and time point 13 (when the animal contracts). After that, the actual learning phase starts. This phase consists of a sequence of three trials where a siphon touch is immediately followed by a tail shock. As a result, the sensory neuron SN2 is activated at the same time as the intermediary neuron MN, which causes the synaps to produce an increased amount of neurotransmitter. Such an increment of the amount of neurotransmitter is indicated by a transition from one internal state property to another (first from S(1) to S(2), then to S(3), and finally to S(4)). As soon as internal state property S(4) holds (see time point 44), the conditioning process has been performed successfully. From that moment, Aplysia's behaviour has changed: it also contracts on a siphon touch.

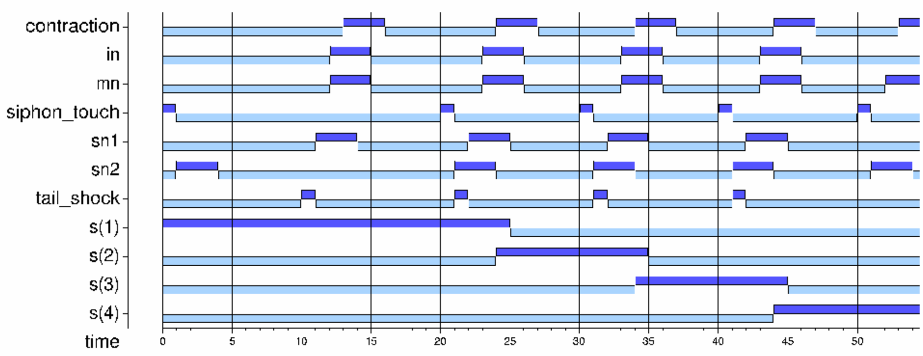
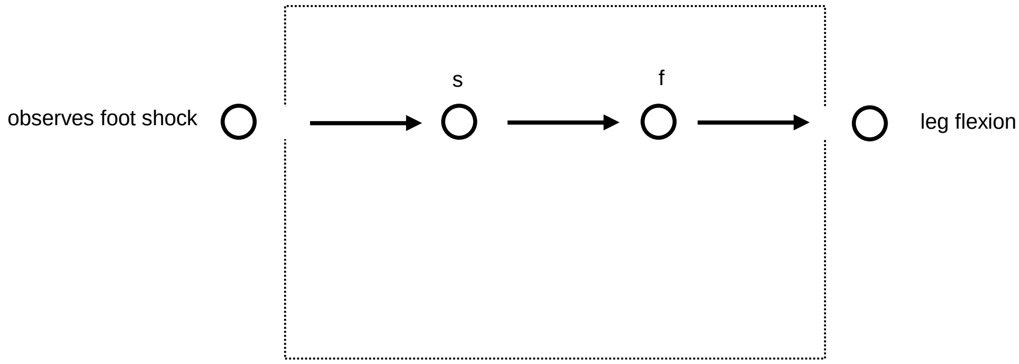


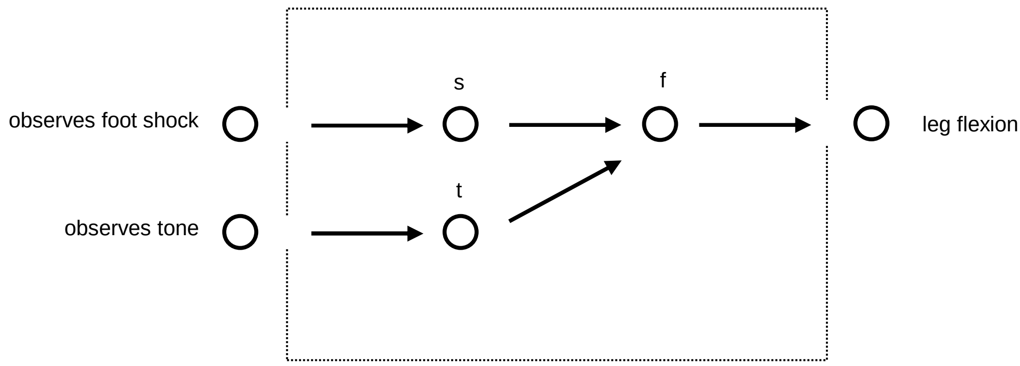
Figure 4 Example simulation trace

5 Conditioning Experiments

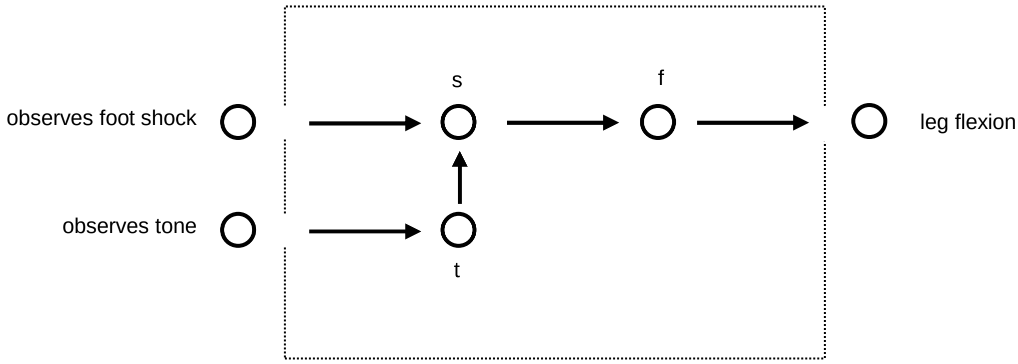
A large body of literature is available reporting how different types of animals show adaptive behaviour in laboratory environments; e.g., (Skinner, 1953). A typical setting for rats is the situation that a rat gets light foot shocks on which it reacts by leg flexions. This is often explained by assuming the following connections.



Here s is an internal sensory processing of the shock, and f an internal preparation for the action leg flexion. Upon hearing a tone, usually no leg flexion is shown. If during such experiments a number of times tone is heard by the animal, before the foot shock occurs, then the behaviour becomes different. After a period of time the animal, shows leg flexions upon hearing the tone, without a foot shock being present. This can be described by assuming that due to learning an additional pathway has been achieved, as follows:



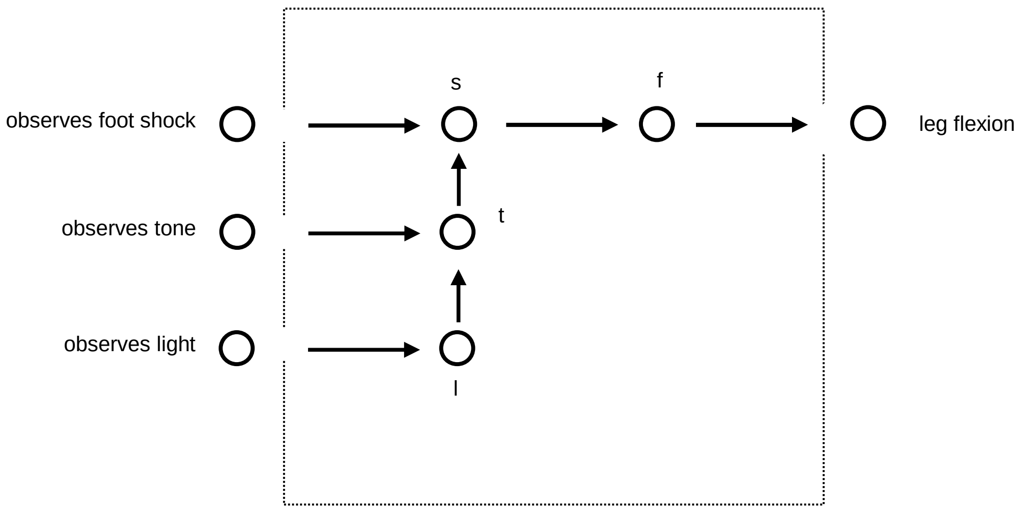
However, also an alternative pathway is possible that explains the same behaviour, but which does not assume a direct connection from t to f, but rather from t to s, as follows; e.g., (Hesslow, 2002).



This pathway makes use of what is sometimes called *conditioned perception*. Another occurrence of this is in *sensory preconditioning*. In this case the experiment runs as follows; see (Brogden, 1939; Hesslow, 2002).

I. Present the animal with repeated paired tone and light stimuli. No overt response.
II. Pair the tone with a foot shock until the tone elicits a conditioned flexion response
III. Present the light alone.

These experiments make clear that sensory preconditioning takes place: the animal shows flexion behaviour in response to the light. A variant of the second picture above can account for these outcomes: a pathway is created from l to t during phase I of the experiment, and one from l to f in phase II.



These descriptions only show the internal dynamics behind the behaviours before and after adaptation. The process of adaptive behaviour itself is not depicted in these diagrams (as they occur in the literature such as (Hesslow, 2002)), and therefore cannot be directly explained from these diagrams. The adaptive process itself can be described in the following manner (similar to the model for *Aplysia*'s conditioning):

- add state properties describing the strength of the connection that is learned, for example from 0 to 3, with 0 the initial strength
- specify executable dynamic properties describing how these strengths are changed during the learning process; for example, increased by one after each trial until 3 is reached,
- specify executable dynamic properties describing how a connection of a certain strength affects the further dynamics; for example, the effect only occurs if the strength is 3.

This leads to the following questions:

- Ø Make a diagram that gives an account of the adaptive process itself.
- Ø Specify a typical trace for this type of adaptive behaviour.
- Ø Give an (iterated) functionalist explanation on the question ‘Why does the animal show this (adaptive) behaviour’.

6 Trust-Based Behaviour

Trust is the attitude an agent has with respect to the dependability/capabilities of some other agent (maybe itself) or with respect to the turn of events. The agent might for example trust that the statements made by another agent are true. The agent might trust the commitment of another agent with respect to a certain (joint) goal. The agent might trust that another agent is capable of performing certain tasks.

We conceive of trust as an internal (mental) state property of an agent that may help him to conduct various kinds of complex behaviour. By having such a cognitive function the agent may be able to cope with complex environments in which otherwise it would be impossible to behave in a proper way.

In (Lewis and Weigert, 1985) trust is analysed referring to observations which in turn lead to expectations: ‘observations that indicate that members of a system act according to and are secure in the expected futures constituted by the presence of each other for their symbolic representations.’ In (Elofson, 1998) it is agreed that observations are important for trust, and he defines trust as: ‘trust is the outcome of observations leading to the belief that the actions of another may be relied upon, without explicit guarantee, to achieve a goal in a risky situation.’ Elofson notes that trust can be developed over time as the outcome of a series of confirming observations. The evolution of trust over time, also called the dynamics of trust, is addressed as a case study in this section.

Trust is based on a number of factors, an important one being the agent's own experiences with the subject of trust; e.g., another agent. Each event that can influence the degree of trust is interpreted by the agent to be either a *trust-negative experience* or a *trust-positive experience*. If the event is interpreted to be a trust-negative experience the agent will loose his trust to some degree, if it is interpreted to be trust-positive, the agent will gain trust to some degree. The degree to which the trust is changed may depend on the characteristics of the agent. This implies that the trusting agent performs a form of continual verification and validation of the subject of trust over time. For example, you can trust a car, based on a multitude of experiences with that specific car, and with other cars in general.

For a first analysis, a simple example of trust-based behaviour is introduced. For this example it is hard to define the behaviour from an external behaviourist perspective. A functional definition is feasible, however, and given. It is discussed what kind of explanations of trust-based behaviour are possible from the functionalist perspective. To this end a simple example of trust-based behaviour is discussed. The main purpose of this example is to identify a number of issues for further analysis. The example is in the context of buying fruit depending on the trust in the fruit quality in a specific shop close to your home. Sometimes, due to lack of time, you have to buy in this shop. So, you will always continue to have experiences in this shop. At other times you have the time go to a shop further away. In these cases the decisions whether or not to avoid the nearer shop are made.

6.1 External Dynamics

As possible *input* two types of *experience states* are assumed:

positive experience (pe or +), or *negative experience* (ne or -).

The possible *outputs* are:

avoid to buy (a) or *not avoid to buy* (na)

The dynamics is described as some input-output correlation C: Input_Traces x Output_Traces. This C is assumed functional in this case: each sequence of experience states the agent receives as input leads at each point in time to exactly one decision to buy or not to buy. In this case the behaviour is hard to describe from an external, behaviourist viewpoint, whereas it is possible to specify it from the internal, functionalist point of view.

6.2 Internal Trust Dynamics

Four possible *internal trust states* are assumed:

- unconditional trust (ut)
- conditional trust (ct)
- conditional distrust (cd)
- unconditional distrust (ud)

The functional roles of the trust states are specified in executable format as follows:

if the agent has a positive experience pe as input,
and the agent is in trust state ud,
then the agent will be in trust state cd, and not anymore in ud

if the agent has a positive experience pe as input,
and the agent is in trust state cd,
then the agent will be in trust state ct, and not anymore in cd

if the agent has a positive experience pe as input,
and the agent is in trust state ct,
then the agent will be in trust state ut, and not anymore in ct

if the agent has a negative experience ne as input,
and the agent is in trust state cd,
then the agent will be in trust state ud, and not anymore in cd

if the agent has a negative experience ne as input,
and the agent is in trust state ct,
then the agent will be in trust state cd, and not anymore in ct

if the agent has a negative experience ne as input,
and the agent is in trust state ut,
then the agent will be in trust state ct, and not anymore in ut

if the agent is in trust state ct,
then the agent will not avoid to buy

if the agent is in trust state ut,
then the agent will not avoid to buy

if the agent is in trust state cd,
then the agent will avoid to buy

if the agent is in trust state ud,
then the agent will avoid to buy

All trust states are persistent, until they are changed by one of the specified rules.
Notice that these functional role descriptions show many dependencies among the trust states, and that the decision to buy or not to buy may depend on very long histories; this is the reason that it is not easy to specify the behaviour from an external behaviourist perspective. As an example, starting with the state ct of conditional trust, a sequence of experiences

+ + - + - - + - -

leads to the subsequent trust states and buy/no buy decisions as depicted in the table below.

	time point 0	time point 1	time point 2	time point 3	time point 4	time point 5	time point 6	time point 7	time point 8
input	+	+	-	+	-	-	+	-	-
internal	ct	ut	ut	ct	ut	ct	cd	ct	cd
output	na	na	na	na	na	na	a	na	a

Here the trust state and the experience state at one time point determines the trust state of the next time point (at the right hand side). For example, at time point 2 the trust state is ut and the experience state is -. The resulting trust state in time point 3 (after update) is ct.

Explanation of Trust-Based Behaviour: Functionalist Perspective

We will consider an explanation from a functionalist perspective and one from an interactivist perspective. A functionalist explanation would run as follows:

Why does the agent at time point 9 avoid to buy?

The agent avoids at time point 9 to buy, because it has a conditional distrust.

Why did the agent have conditional distrust at time point 9?

The agent has conditional distrust at time point 9, because it had a negative experience at time point 8, and at that time it had a conditional trust.

Why did the agent have conditional trust at time point 8?

The agent has conditional trust at time point 8, because it had a positive experience at time point 7, and at that time it had a conditional distrust.

……..

And so on, 9 steps back in time.

The following questions are relevant in this context:

- Can you give a trace of 20 experience states, so that if the first experience is changed into the opposite one, and the other experience states remain the same, the decision at time 20 also changes?
- Can the same be done for a trace of 1000 long?
- Do you think it is realistic and/or reasonable to count your experiences of a long time ago in your decisions?

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