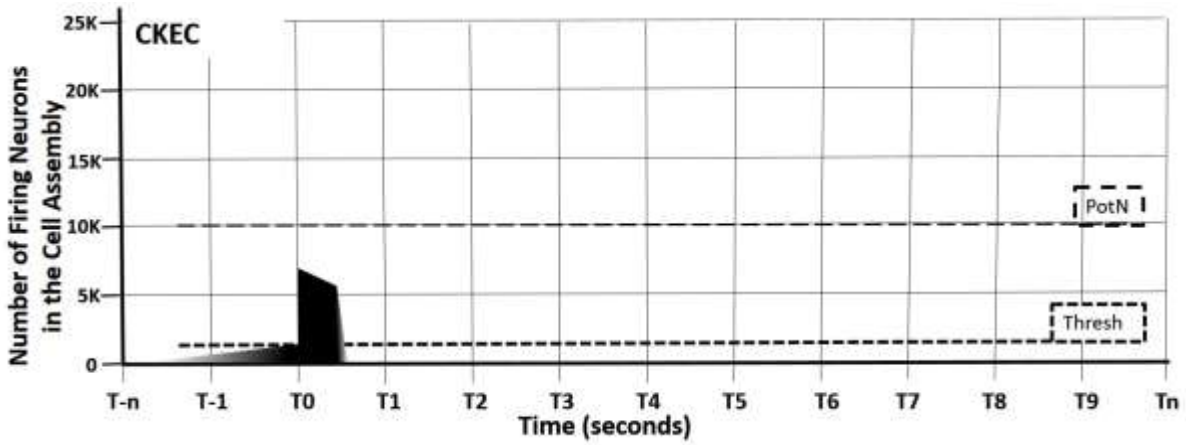
APPENDIX I

The 'First Steps to Making Coffee' TACAP Main Analysis Descriptions.

At the kitchen entrance …

01 CA: COGNITIVE – Kitchen Entrance Check (CKEC)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CKEC	10	2	7	6	-1.0	0.0	0.4	0.5

INPUTS: "… at kitchen entrance".

CA: VISUAL – Kitchen Entrance General (VKEG).

OUTPUTS: CA: VISUAL – Kitchen Entrance General (VKEG),

CA: COGNITIVE – Make Coffee (CMC),

CA: COGNITIVE – Approach Hot Water Area (CAHWA).

Primed by the various CAs that have bought the subject to the kitchen entrance, the CA is ignited at T0, or just before, and represents the expectation of what, in general, the kitchen should look like. It checks for major disasters: fire, smoke, steam, flooding, major damage to cabinets and window, but not details such as whether the cooker is on. It also checks that there is no one else in the kitchen and that the floor is clear of obstructions, e.g. shopping not yet unpacked.

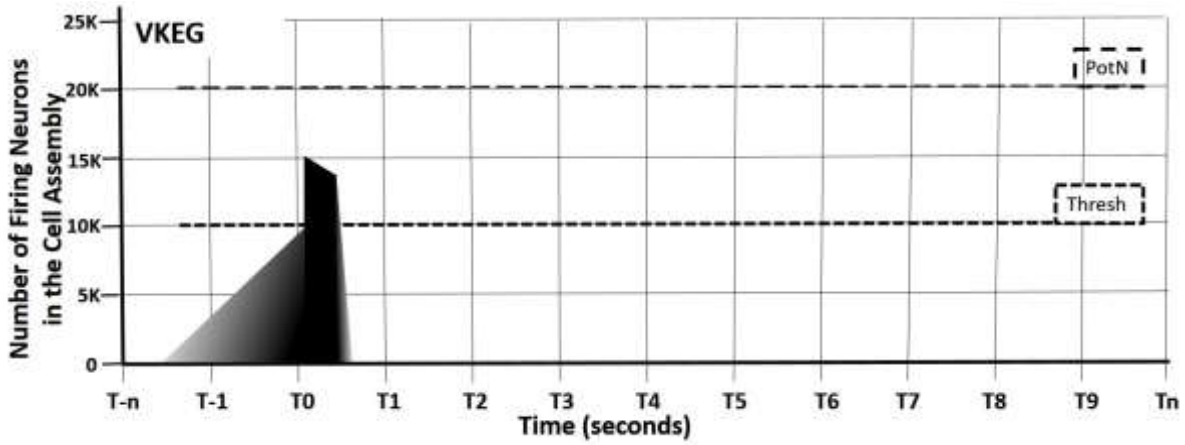
This CA, or something similar, must rationally exist because if there is a major problem with the kitchen then it will be immediately detected at the entrance. For a cognitive CA this one is modelled as being fairly large (PotN 10K) because a general view of the kitchen is a complicated one, so its expectation CA must also be fairly large. Its threshold (2K) is fairly low and most (IgMax 7K) of its potential neuron membership are modelled as firing after ignition as the CA will nearly always last only very briefly, whether the kitchen is judged satisfactory or not.

Post ignition it then takes input from 'CA: VISUAL – Kitchen Entrance General' (VKEG) and makes a match comparison of expectation to visual input. Note, the comparison process is here modelled as part of CKEC but an alternative would be to have a CA that took inputs from both

cognitive and visual CAs and it then makes the comparison. This sort of general comparison of expectations to visual input must be a fairly common type of operation. Whatever CA Architecture (CAA) chosen, however, the effect of the visual input is basically inhibitory, the cognitive CA is turned off either because the kitchen is judged as satisfactory or other emergency dealing CAs are ignited. If satisfactory, the cognitive CA to Make Coffee (CMC) is reignited. This must precede the striding into the kitchen as alternatives at this point involve going to other kitchen locations, and such movements are all highly practiced and would have similar CAs to the making coffee one.

There is a CAA issue concerning how tasks might share common CAs, for example, the early stages of making either coffee or tea are behaviourally identical, but still might use different CAs, or, perhaps more likely, neuron membership may overlap between coffee and tea making CAs, if exactly the same CAs are not used, which may be simplest option for analysis purposes.

02 CA: VISUAL – Kitchen Entrance General (VKEG)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VKEG	20	10	15	14	-0.8	0.1	0.3	0.4

INPUTS: CA: COGNTIVE – Kitchen Entrance Check (CKEC).

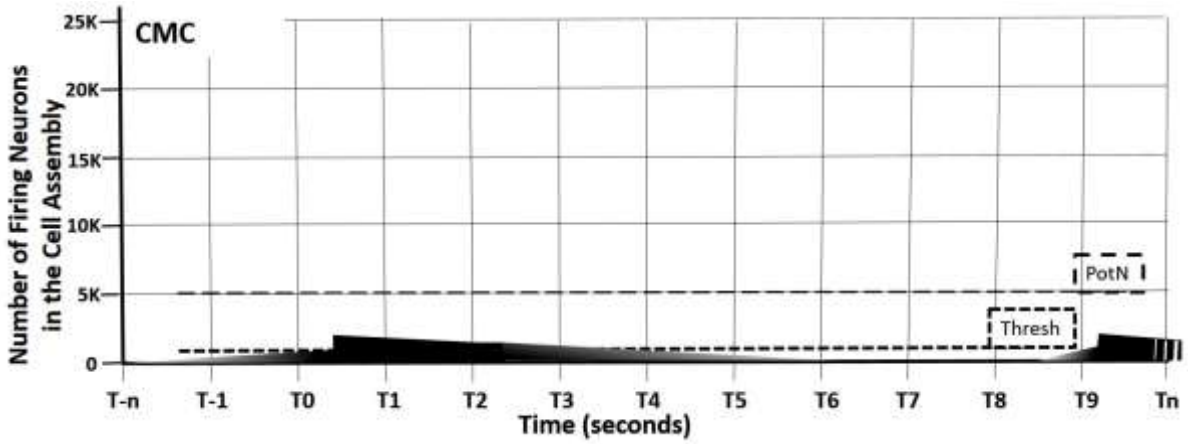
OUTPUTS: CA: COGNTIVE – Kitchen Entrance Check (CKEC).

Typically visual CAs are large (PotN 20K for VKEG) because the visual cortex is large and with complex scenes then thresholds need to be relatively high, but if CAs are to persist then there must also be a sufficiency of neurons that can fire as some fatigue and so CA ignition can be maintained.

A saccade takes about a quarter of a second and during such eye movements retinal output to the optic nerve is suppressed. Thus this CA cannot ignite until after the kitchen entrance is reached (T0), and the prior visual CAs are suppressed. Its function is primarily as the data provider for CKEC.

The CA will be suppressed (overwritten) by following visual input, although if the cognitive check fails then it may persists for several saccades as the problem is generally inspected.

03 CA: COGNITIVE – Make Coffee (CMC)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CMC	5	1	2	1.5	-1.0	0.4	2.5	4.0

INPUTS: "… at kitchen entrance".

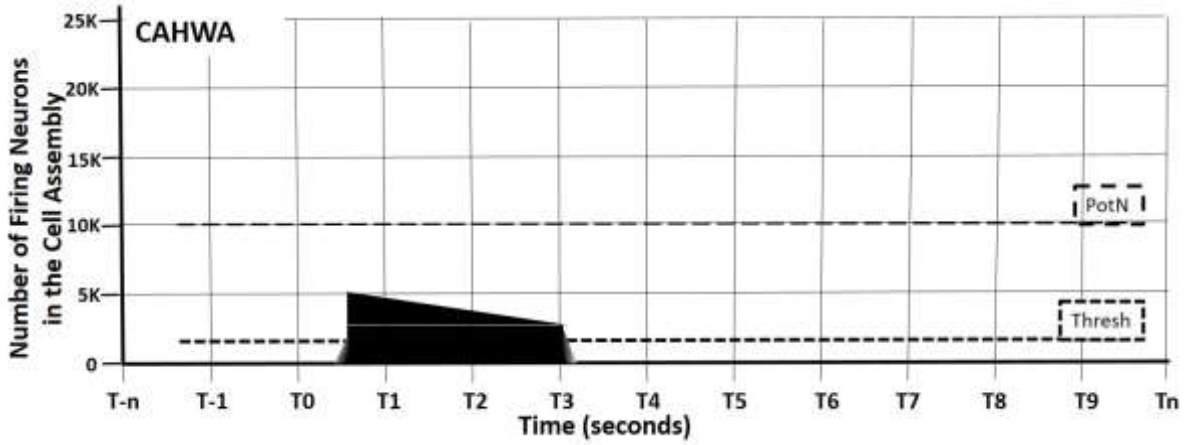
CA: COGNITIVE – Kitchen Entrance Check (CKEC).

OUTPUTS: CA: COGNITIVE – Approach Hot Water Area (CAHWA).

Discussed in general (Sections 3.3.1 and 3.3.2), the Make Coffee CA is already primed, and probably more so at the kitchen entrance, and must ignite when the general kitchen checking CA (CKEC) extinguishes as there are several possible destinations within the kitchen, including, for example, curvetting through 130 degrees to go to the fridge (section 3.3.2).

In its minimal decision making form where the CA does not contain a plan for making coffee, the CA is quite small (PotN 5K) and post-ignition, after directing the subject to the hot water making area it decays until it is below threshold. It remains primed, however, as it needs to be re-ignited when water is added to the empty kettle as the amount added depends on what hot beverage, in what sized mug or cup, is being prepared, e.g. a count of 15 (seconds) for a small mug of coffee versus 20 for a large mug (N.B. The kettle has no external indicator of how much water is in it).

04 CA: COGNITIVE – Approach Hot Water Area (CAHWA)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CAHWA	10	2	5	3	0.5	0.6	3.1	3.2

INPUTS: CA: COGNITIVE – Kitchen Entrance Check (CKEC),

CA: COGNITIVE – Make Coffee (CMC).

CA: VISUAL – Approach Hot Water Area (VAHWA).

OUTPUTS: CA: VISUAL – Approach Hot Water Area (VAHWA).

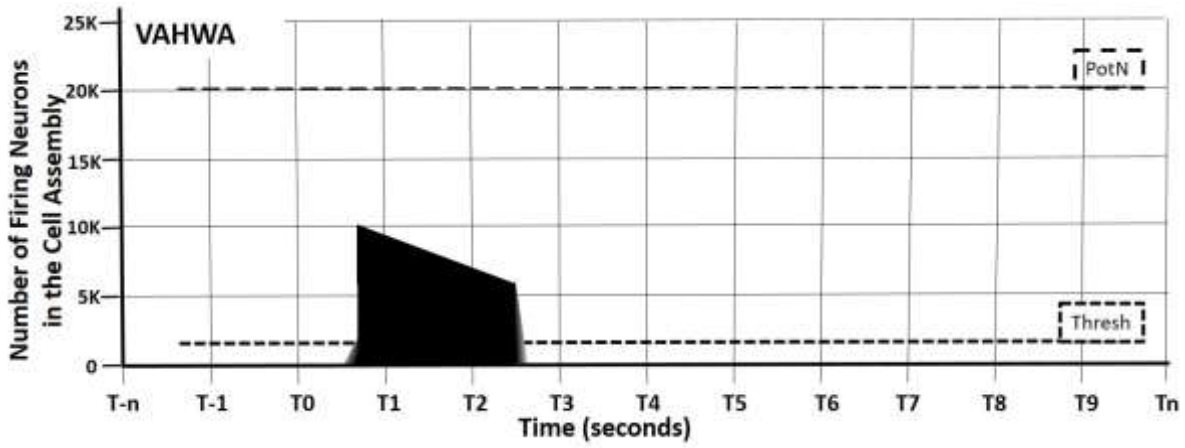
CA: COGNITIVE – Kettle in Hot Water Area (CKHWA);

CA: MOTOR – Stride to Hot Water Area (MSHWA).

Apart from flow-field related visual inputs, the CA operates, like the kitchen entrance check (CKEC), as an expectation, checking the foveal input against what should be in the hot water area, how it is organised (the strong expectation is "neatly"); if the kettle were missing then this would certainly cause a "pause & consider" CA; output from the CA causes ignition of the kettle search and identify CA (CKHWA)

This CAHWA CA will persist the longest of the three related approach CAs (motor, visual and cognitive), i.e. until after movement to the hot water area has stopped (MSHWA); the visual (VAHWA) CA extinguishes even earlier as the flow fields become increasingly peripheral close to the hot water area.

05 CA: VISUAL – Approach Hot Water Area (VAHWA)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VAHWA	20	2	10	6	0.6	0.7	2.5	2.6

INPUTS: CA: COGNITIVE – Approach Hot water Area (CAHWA).

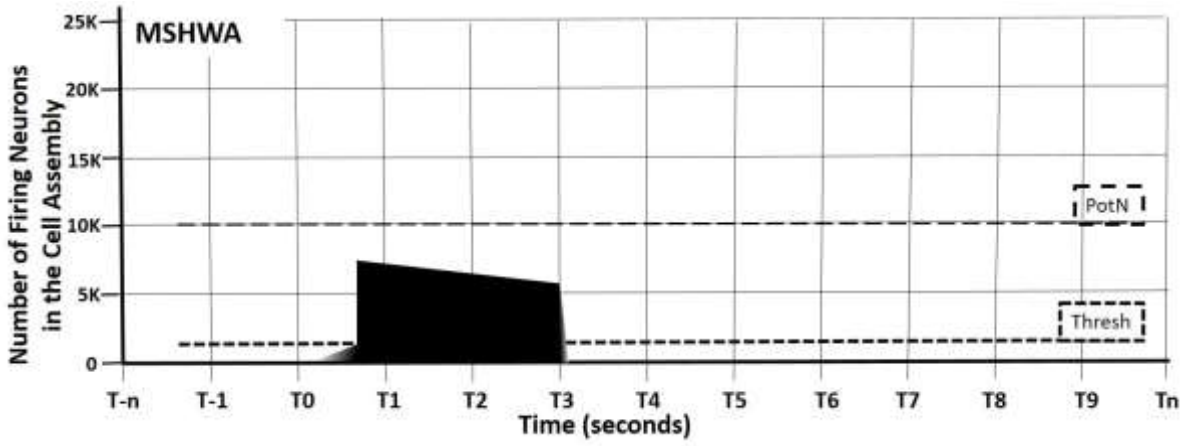
OUTPUTS: CA: COGNITIVE – Approach Hot Water Area (CAHWA).

The CA is part of the specialised visual processing involved with moving through an environment. Interest in visual flow fields (Gibson, 1950) was rekindled with Marr's (1982) computational approach to vision; the theory remains that flow fields are handled separately from other, more integrated, visual processes.

A lot of neurons (PotN 20K) are potentially involved and a low threshold of 2K is set since this sort of processing is used constantly and can be for many hours (e.g. car driving. N.B. different

CAs are ignited as visually the road ahead (and behind one hopes for safety reasons) changes). On the other hand, in this highly practiced task of about 3 seconds the proposed CAA is that VAHWA is a self-terminating CA and that the neurons at ignition are not much replaced, hence fatigue is relatively high (IgMax – IgFat = 10K – 6K = 4K), i.e. 40% of the neurons have fatigued but sufficient survive to maintain ignition above threshold (2K). P50% & D50% are very fast as part of this type of visual processing: an on-demand, switch on-off facility.

06 CA: MOTOR – Stride To Hot Water Area (MSHWA)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MSHWA	10	2	7	6	0.6	0.7	3.0	3.1

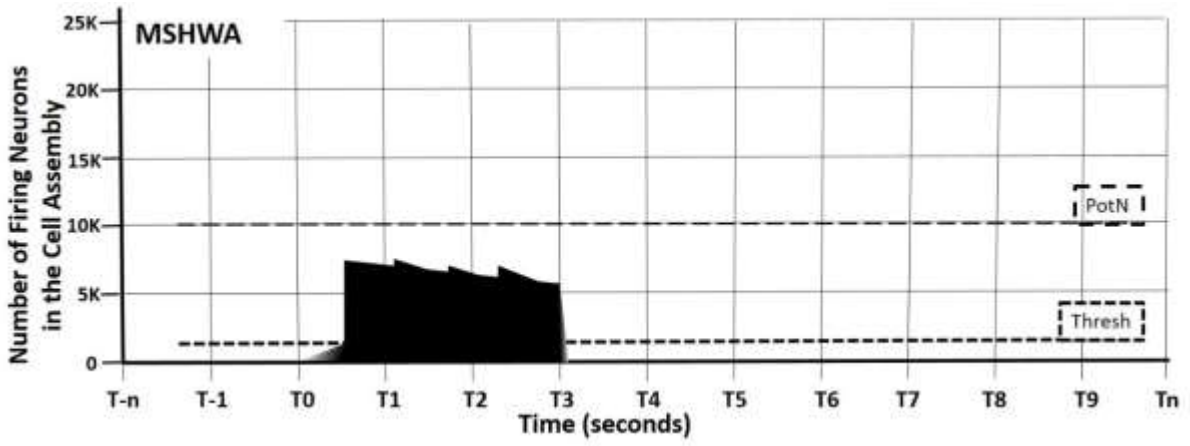
INPUTS: CA: COGNITIVE – Approaching Hot Water Area (CAHWA).

OUTPUTS: *motor behaviours …*

From the shuffle zone outside the kitchen entrance, the right foot is planted in the centre of the entrance as described above (section 3.3.2). The CA is ignited by CAHWA once the general kitchen check CA confirms the kitchen is in a suitable state. There is no observable behavioural pause at the entrance and from detailed analysis the main subject always approaches the hot water preparation area with three strides (left, right, left) and then a right footed half stride that curves the right foot so it ends up next to the left (Figure 3). The strides are longer than a usual walking step around the house and the whole behaviour is very precise in that it ends with the body close, but not touching, the hot water preparation area; toes are never stubbed or the knees hit the cabinet beneath the work surface, although the knees come within a few centimetres of this vertical surface.

The other three resident adults have also been observed approaching the hot water area. The subject's daughter, in her early 30s and nearly as tall as her father, takes the same three strides and the final right foot movement in a manner indistinguishable from those described above. In contrast, the wife, in her early 70s, takes five steps, not strides, as she is considerably shorter, but repeated observation suggests that a similar behavioural invariance is present. The fourth resident, in his early 30s, had only lived in the house for about 6 months and doesn't use the kitchen that much. Observed from his approach to the kitchen down the corridor, his behaviour was inconsistent, e.g. either foot could be the launch one, and, indeed, he was much less accurate at reaching the hot water area, a final shuffle being required. The obvious conclusion is that the family who have all lived in the house for over twenty years have a CA for approach that the new lodger does not.

As a learned and highly practiced behaviour, the MSHWA one need be of only modest size (PotN 10K), with a low threshold (2K) and most of its neurons firing on ignition since it cannot persist meaningfully beyond the completion of the behaviour. The CA does, however, have to be of sufficient size to take cognitive approach inputs from CAHWA based on that CA's visual inputs from VAHWA as the three strides need to compensate for the location of the launching right foot, which may vary up to 30cm in front of or behind the bar on the floor of the kitchen entrance.



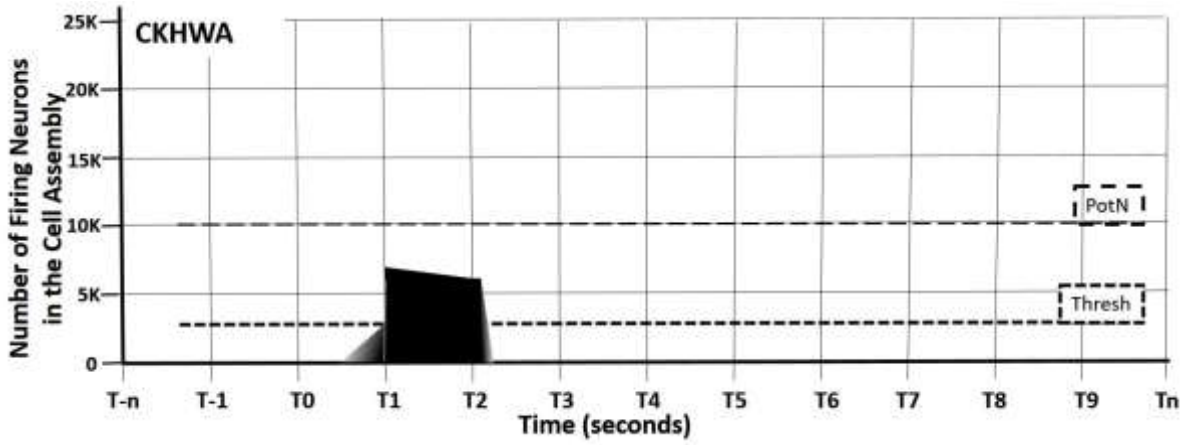
It is likely that the basic SCAM diagram is not an adequate representation of this CA, which, for example, might have internal processes representing the strides and terminal shuffle as shown above.

A number of alternative CA Architectures (CAAs) were considered for MSHWA, notably a CAA where this motor CA might ignite its associated visual CA (VAHWA) and receive feedback from this, rather than being mediated by the cognitive CA (CAHWA).

As a codicil to the above concerning the invariant striding behaviour, this occurs when the subject is not carrying something into the kitchen, most probably an empty coffee mug. In a more complete analysis an alternative CA involving striding to the sink to deposit an empty mug to the right of the sink in preparation for washing needs specifying, although the CAs involved are similar to the ones described above; there is a sidestep from sink to hot water area after mug deposition.

A further CAA issue concerns the extent that CAs are common in different tasks. Behaviourally there is no difference between making tea rather than coffee when going to the hot water area and filling the kettle. There is a difference as to how much water is put in the kettle (25% less for a small mug).

07 CA: COGNITIVE – Kettle in Hot Water Area (CKHWA)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CKHWA	10	3	7	6	0.8	1.0	2.1	2.2

INPUTS: CA: COGNITIVE – Approach Hot Water Area (CAHWA),

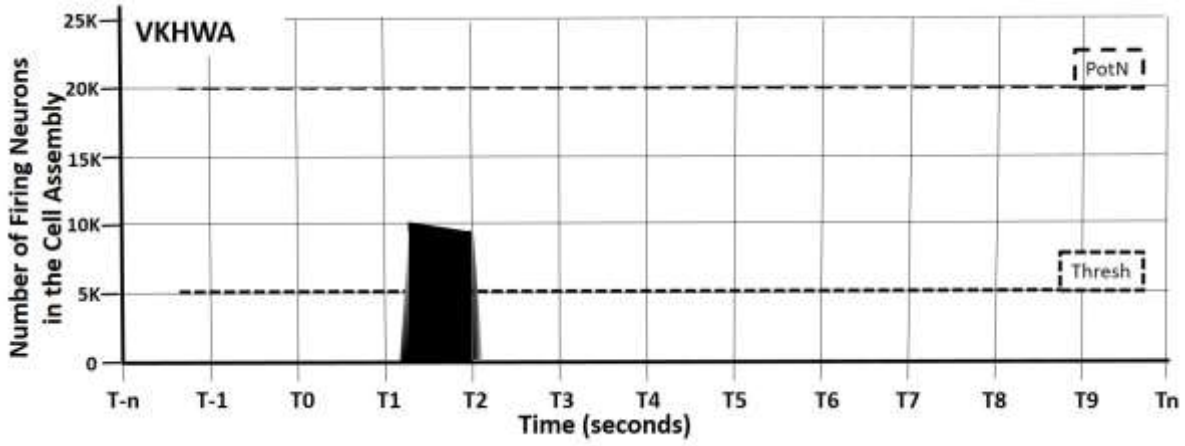
CA: VISUAL – Kettle in Hot Water Area (VKHWA).

OUTPUTS: CA: VISUAL – Kettle in Hot Water Area (VKHWA).

CA: COGNITIVE – Kettle Handle (CKH).

The kitchen's hot water area is a complex of small and medium sized objects which are nearly all in standard locations, although the kettle and circular tray may lay within an area of about 5cm radius beyond their footprints. The CA therefore needs to be reasonably sized (PotN 10K), although the threshold is low (3K). Ignition lasts about a second before being replaced by the more detailed target, the kettle handle (CKH).

08 CA: VISUAL – Kettle In Hot Water Area (VKHWA)



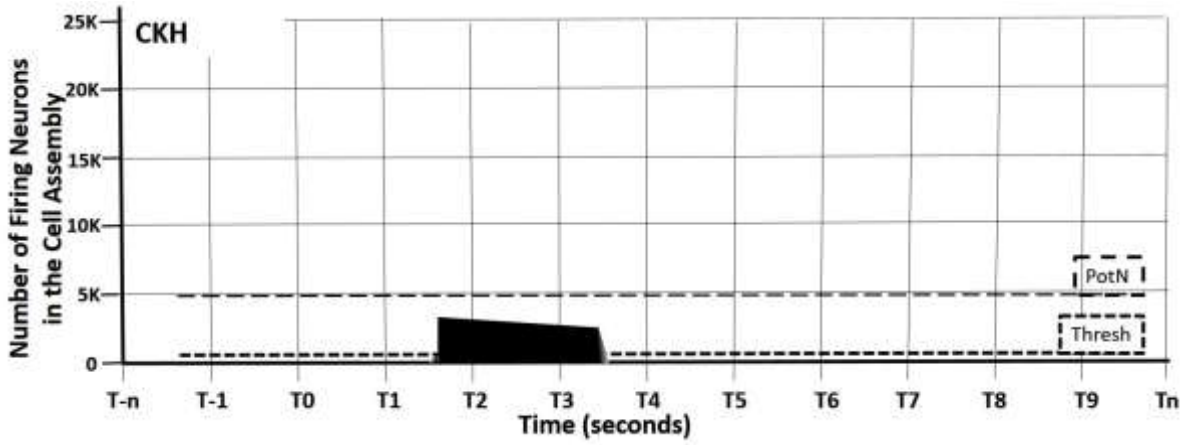
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VKHWA	20	5	10	9	1.2	1.3	2.0	2.1

INPUTS: CA: COGNITIVE – Kettle In Hot Water Area (CKHWA),

OUTPUTS: CA: COGNITIVE – Kettle In Hot Water Area (CKHWA.

Primed and ignited from inputs from CKHWA, feedback between the two CAs directs and identifies the kettle's location within the cluttered hot water area. The CA gradually decays post-ignition as the more specific kettle handle target is acquired in the next two CAs (CKH and VKH).

09 CA: COGNITIVE – Kettle Handle (CKH)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CKH	5	1	3	2	1.5	1.6	3.5	3.6

INPUTS: CA: COGNITIVE – Kettle In Hot Water Area (CKHWA).

CA: VISUAL – Kettle Handle (VKH).

OUTPUTS: CA: VISUAL – Kettle Handle (VKH).

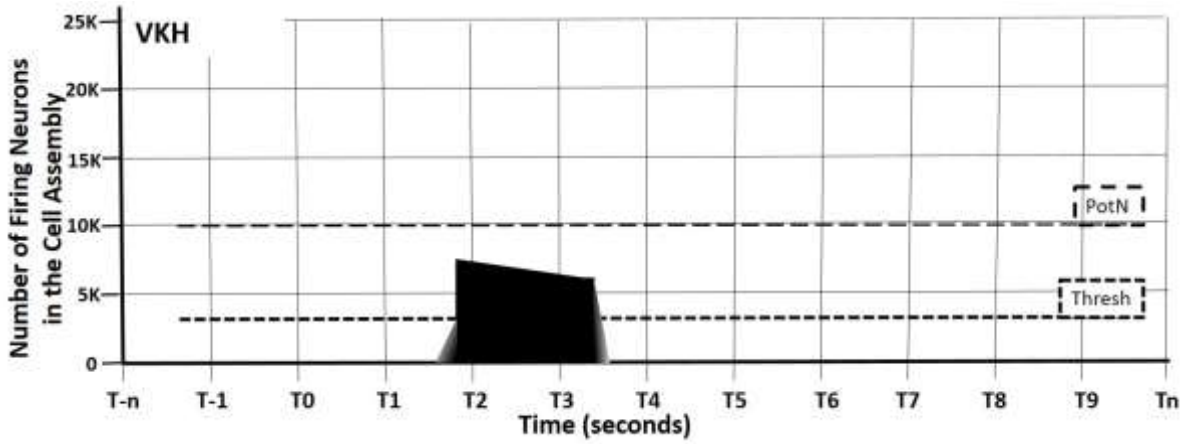
CA: MOTOR – Right Arm Ballistic (MRAB).

CA: COGNITIVE – Right Hand Approach (CRHA).

As an object the kettle's handle is very simple, being a uniform, matt dark grey/black and smoothly shaped. Thus it does not need a large CA (PotN 5K) to be identified as the critical task target for control of the right hand approach to the handle. The CA does have to represent the current orientation of the handle, but the corner location of the hot water area means that the handle will virtually always be to the right within an arc of less than 90 degrees.

The CA persists for about two seconds and then decays quickly and before the right hand actually grips the handle because the hand obscures its target in the final approach stage. N.B. general introspective experience suggests that once part of an object is gripped so as to transport the object, the gripped part of the object itself is ignored, whether it be a kettle handle, a book, a bag or whatever; a CA for the object itself must still be ignited as different objects are treated differently while being transported, e.g. I wouldn't try and empty a book over the kitchen sink (below this is the CA 'Lift Kettle' (CLK) to indicate its difference from when the kettle is, for example, located on its base unit).

10 CA: VISUAL – Kettle Handle (VKH)



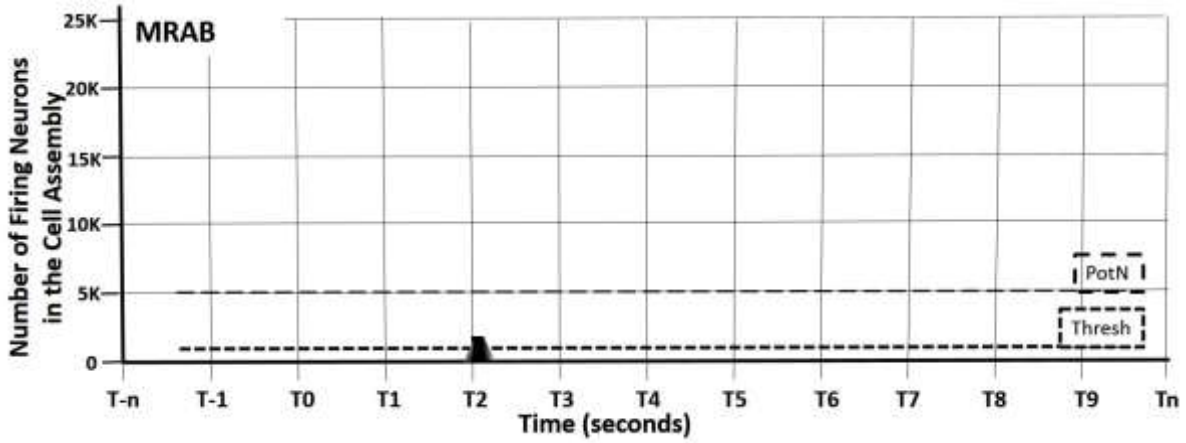
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VKH	10	3	7	6	1.6	1.8	3.3	3.4

INPUTS: CA: COGNITIVE – Kettle Handle (CKH).

OUTPUTS: CA: COGNITIVE – Kettle Handle (CKH).

Like CKH, which primes and ignites this CA (Threshold 3K), VKH is smaller than many other visual CAs (PotN 10K). It provides feedback to CKH which it pre-extinguishes.

11 CA: MOTOR – Right Arm Ballistic (MRAB)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MRAB	5	1	2	2	1.9	2.0	2.1	2.2

INPUTS: CA: COGNITIVE – Kettle Handle (CKH)

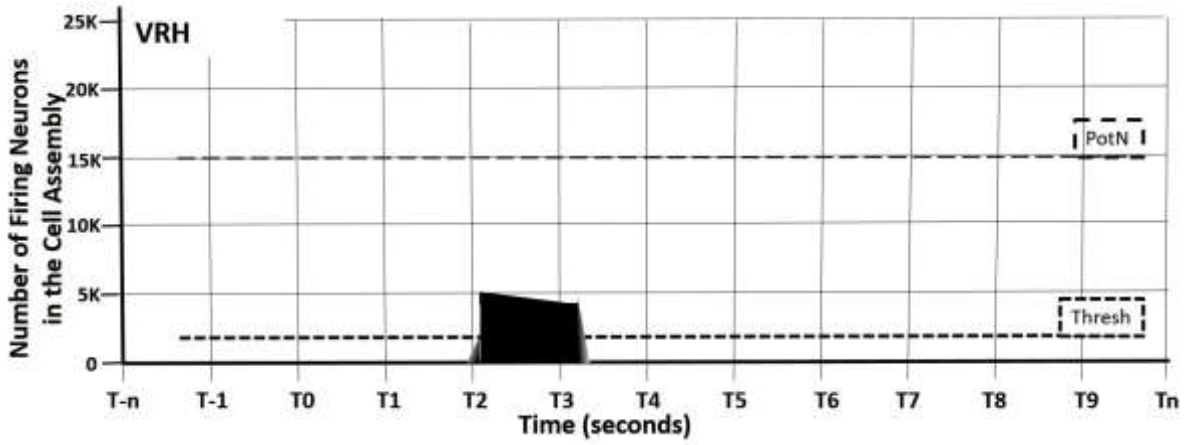
OUTPUTS: CA: VISUAL – Right Hand (VRH)

This is the first of the two parts of normal human reaching behaviour. Visually it is open-loop control, i.e. without feedback, although there must be some kinaesthetic feedback, not least the position of the arm when the hand is launched towards its target. It is ignited by CKH when feedback from VKH to CKH establishes that the target kettle handle has entered reach.

It's assumed in the model to be a small CA (PotN 5K) that exists for between, say, 50 and 150ms.

In the CAA described here it is assumed that this CA primes and ignites a visual CA (VRH), rather than a cognitive one, as the right hand, as expected, enters view.

12 CA: VISUAL – Right hand (VRH)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VRH	15	2	5	4	2.0	2.1	3.2	3.3

INPUTS: CA: MOTOR – Right Arm Ballistic (MRAB).

OUTPUTS: CA: COGNITIVE – Right Hand (CRH).

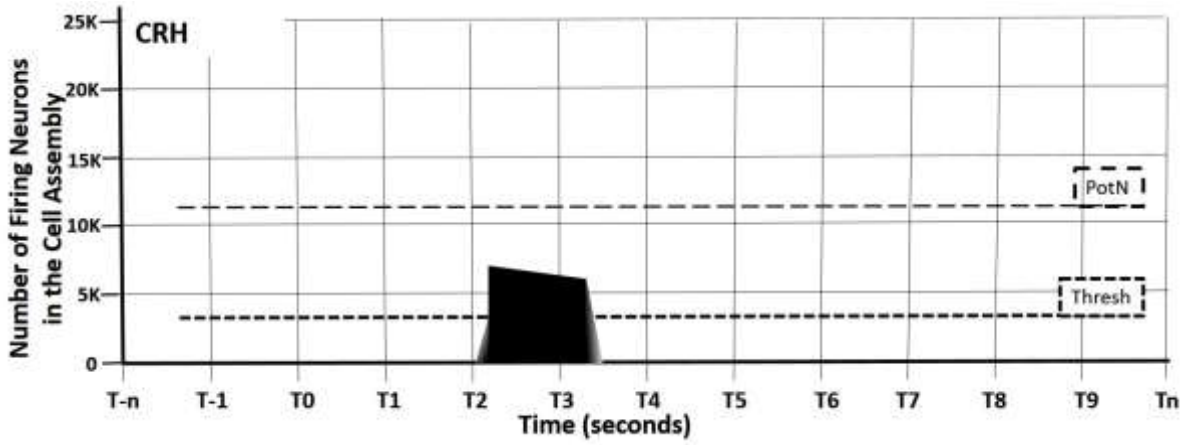
Ignited by MRAB, the CA predicts where the right hand will appear and then identifies its position and general configuration.

Note, human babies acquire visual tracking & the concept of object permanence fairly early in development. Also, we do often look at our hands, probably because kinaesthetic feedback is less precise than vision, and touch.

It's relatively small for a visual CA (PotN 15K) and has a low threshold (2K), strong ignition (IgMax 5K) and relatively little fatigue (IgFat 4K) because although ignition is only about a second here, it may have to persist for much long periods of time so must have a structure that facilitates neuron rotation to counter fatigue.

The CA is different from those used in manipulative tasks, but often precedes and initiates such tasks and subtasks.

13 CA: COGNITIVE – Right hand (CRH)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CRH	12	3	7	6	2.1	2.2	3.4	3.5

INPUTS: CA: VISUAL – Right Hand (VRH)

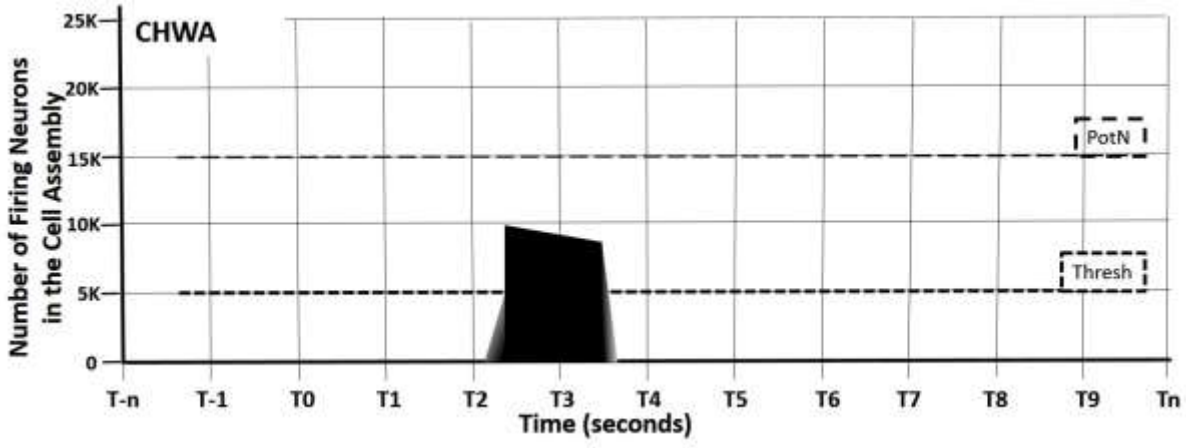
OUTPUTS: CA: COGNITIVE – Hot water Area (CHWA)

CA: COGNITIVE – Right Hand Approach (CRHA)

Representing a general model of the hand, the CA, like VRH, needs to be of sufficient size (PotN 12K) to counter fatigue (IgFat 6K), and ditto w.r.t to threshold (3K) and IgMax (7K).

It causes CHWA to ignite so that the hand can be placed in its context relative to itself and its target, the kettle handle (CKH); these three CAs will be used as inputs by CRHA to control the right hand's final approach to the kettle handle.

14 CA: COGNITIVE – Hot water Area (CHWA)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CHWA	15	5	10	8	2.2	2.4	3.5	3.7

INPUTS: CA: COGNITIVE – Right Hand (CRH),

CA: VISUAL – Hot Water Area (VHWA).

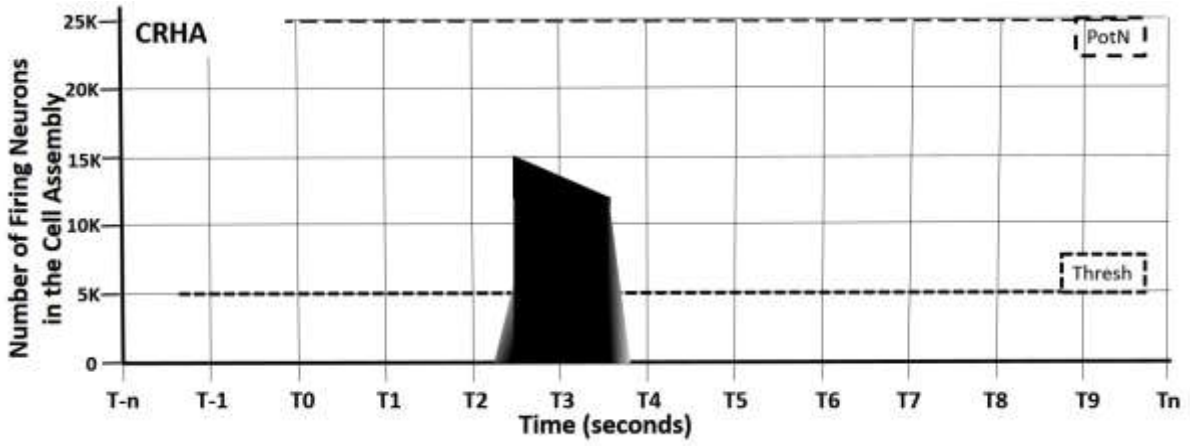
OUTPUTS: CA: VISUAL – Hot Water Area (VHWA),

CA: COGNITIVE – Right Hand Approach (CRHA).

This CA supplies a specialised representation of the hot water area, basically ignoring expected, static objects except for those that might interfere with the right hand's approach to the kettle handle. It provides the context for the hand's "flight path", in effect the tunnel of clear, relevant space between the tray holding the coffee cone (which is a potential flight hazard on the left) and the left side of the drainer, which could mean a wall on the right of over 20cm if large pots and their lids are draining, and which considerably narrows the hand's possible path to the kettle handle.

It is big for a cognitive CA (PotN 15K) because it not only deals with a complex visual input, but a specialised one that provides the critical input for CRHA to plan the hand-to-kettle flight path which CRHA then controls. In CAA terms it is here modelled as one of number of hot water area CAs. An alternative CAA would be to have a sufficiently general hot water area visual CA that it could be directed to different aspects of its input (visual attention). The preference here is due to it being a highly practice task so CAs will be relatively specialised, which is not to say that neurons in the CHWA at one time could not be part of other hot water related CAs at other times.

15 CA: COGNITIVE – Right Hand Approach (CRHA)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CRHA	25	5	15	12	2.3	2.5	3.6	3.7

INPUTS: CA: COGNITIVE – Kettle Handle (CKH)

CA: COGNITIVE – Right Hand (CRH)

CA: COGNITIVE – Hot water Area (CHWA),

CA: VISUAL – Right Hand Approach (VRHA),

CA: TOUCH – Right Hand on Kettle Handle (TRHKH).

OUTPUTS: CA: VISUAL – Right Hand Approach (VRHA)

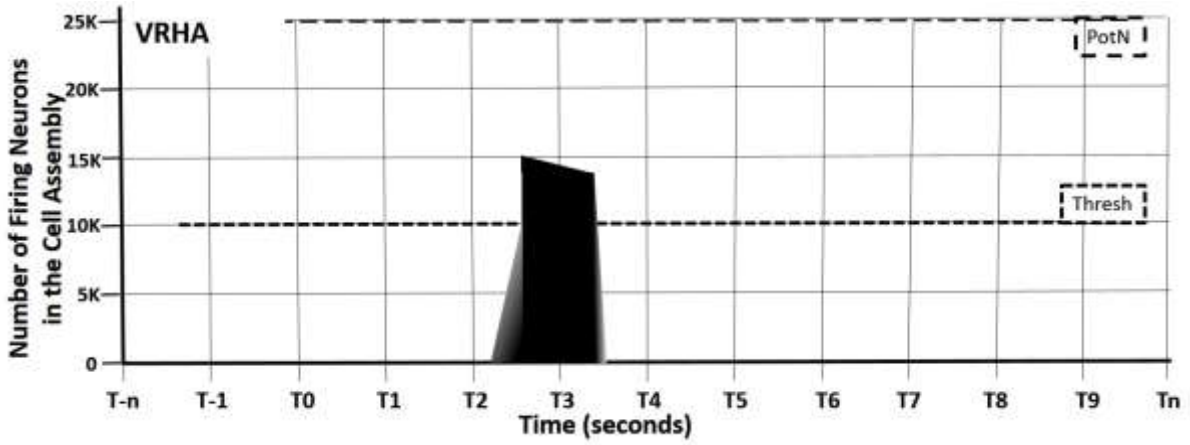
CA MOTOR – Right Hand Approach (MRHA),

CA: TOUCH – Right Hand on Kettle Handle (TRHKH),

This is big for a, still task specialised, cognitive CA (PotN 25K) and it undoubtedly is composed of a number of CAs below the level of this analysis. It's main functions are to: (i) integrate inputs from cognitive CAs concerning the kettle handle, right hand and the hot water area; (ii) compute the right hand's path to the kettle handle, avoiding obstructions, and (iii) control that path under visual negative feedback control, including (iv) adjustments to the hand and wrist in preparation to gripping the kettle handle at the trajectory's termination; and (v) it's final function before self-extinction is to supress MRHA and so halt the reaching behaviour once the handle is touched (TRHKH) and ignite the cognitive CA for gripping the kettle handle (CRHG).

It is well primed by its cognitive inputs and has a low threshold (5K) and a high IgMax (15K) while still having sufficient potential neurons to cope with both fatigue and the internal inhibition of some of its own neurons during processing (IgFat 12K). It may only last a second or so, but it is a cognitively complex, active second.

16 CA: VISUAL – Right Hand Approach (VRHA)



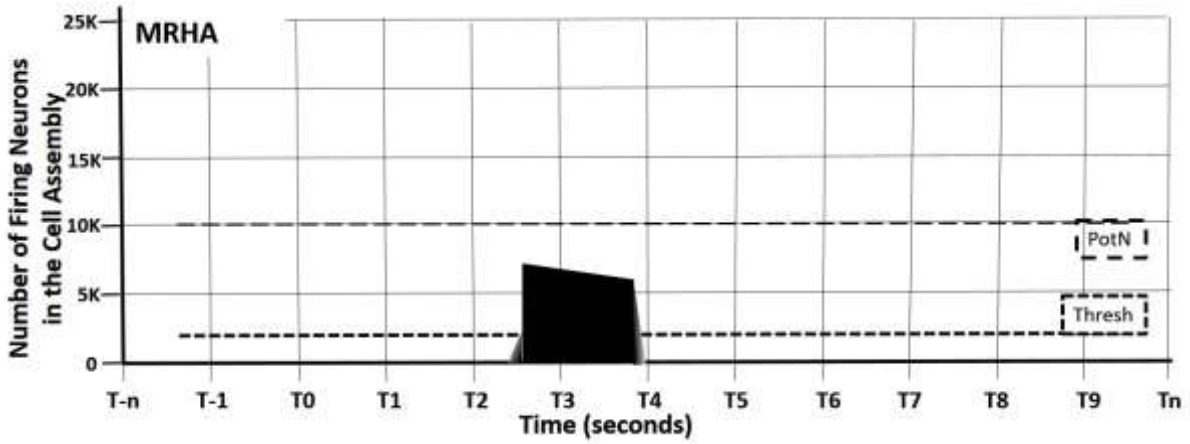
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VRHA	25	10	15	14	2.3	2.6	3.3	3.4

INPUTS: CA: COGNITIVE – Right Hand Approach (CRHA).

OUTPUTS: CA: COGNITIVE – Right Hand Approach (CRHA).

This CA provides the visual input to CRHA that allows visual negative feedback control of the right hand approaching the kettle handle. It is fairly large, even for a visual CA (PotN 25K) and is well primed and finally ignited by CRHA. Although here lasting less than a second, it must have fatigue resisting capabilities by neuron rotation as in other tasks it may have to remain ignited for much longer. It extinguishes before CRHA when the hand obscures the target kettle handle in the final approach stage.

17 CA: MOTOR – Right Hand Approach (MRHA)



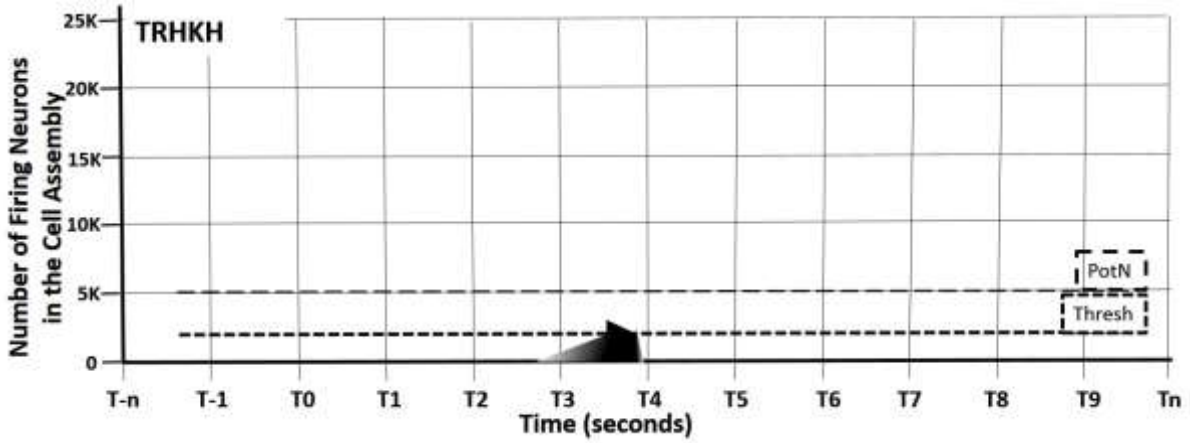
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MRHA	10	2	7	6	2.4	2.7	3.7	3.8

INPUTS: CA: COGNITIVE – Right Hand Approach (CRHA).

OUTPUTS: *motor behaviour …*

The CA provides the motor component to CRHA's control of the hand approaching the kettle handle and also for configuring the hand so as to be ready to grasp the kettle handle. N.B. In the CAA used in the analysis, here there is no direct I/O between the visual and motor systems except via the cognitive one (CRHA); an alternative would be I/O between VRHA and MRHA, which may be plausible for fine control; similarly when the kettle handle is touched and TRHKH is ignited, it could be used to extinguish MRHA rather than, as modelled, extinction is via CHRA suppressing it.

18 CA: TOUCH – Right Hand to Kettle Handle (TRHKH)



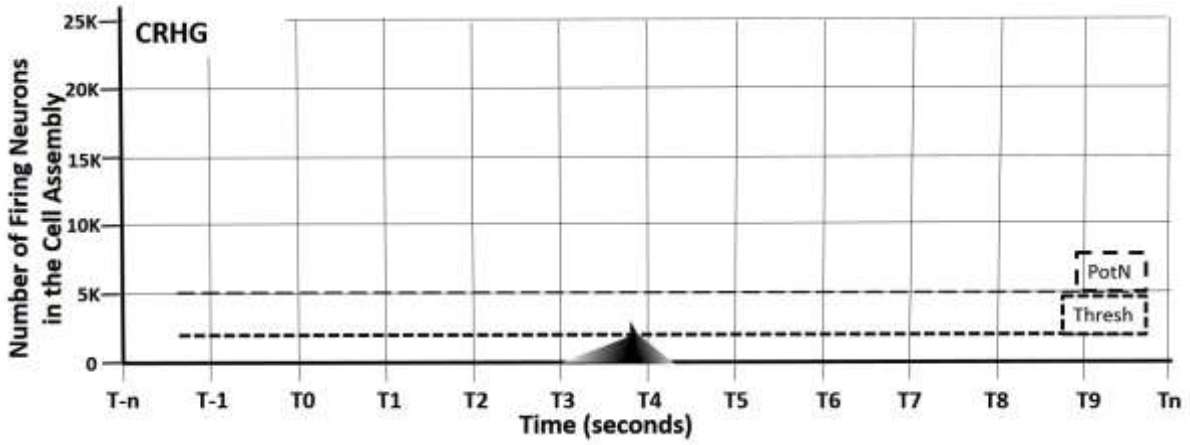
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
TRHKH	5	2	3	2	3.0	3.5	3.8	3.9

INPUTS: CA: COGNITIVE – Right Hand Approach (CRHA)

OUTPUTS: CA: COGNITIVE – Right Hand Approach (CRHA)

This CA signals the end of the right hand's kettle approaching behaviour. Although a small CA (PotN 5K), it has a low threshold (2K) and will have been extensively primed by CRHA (IgTIg – P50% = 0.5 seconds) because it is so critical that the reaching behaviour is neatly halted, even if CRHA slows the approach in the final fractions of a second.

19 CA: COGNITIVE – Right Hand Grip (CRHG)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CRHG	5	2	3	2	3.2	3.7	3.8	4.2

INPUTS: CA: COGNITIVE – Right Hand Approach (CRHA).

CA: TOUCH – Right Hand Grip (TRHG).

OUTPUTS: CA: TOUCH – Right Hand Grip (TRHG).

CA: MOTOR – Right Hand Grip (MRHG).

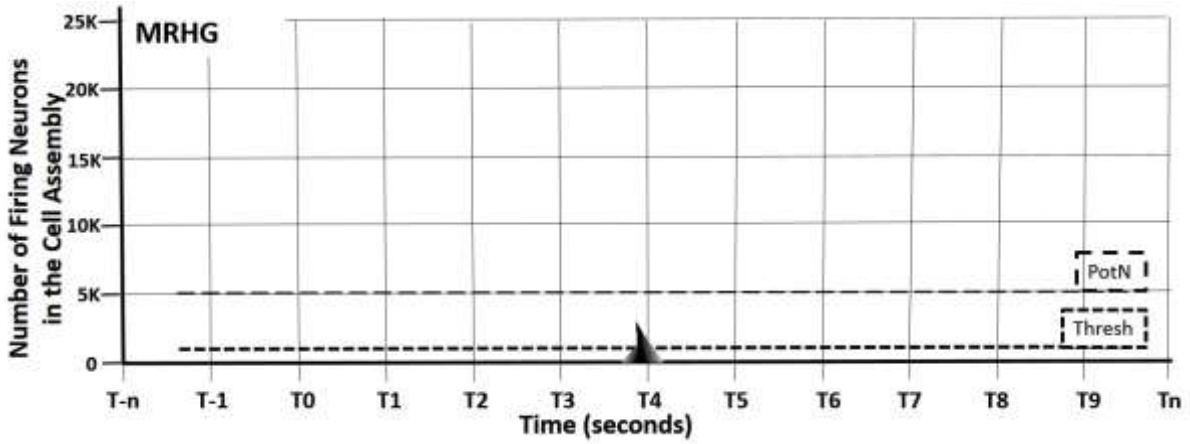
CA: COGNITIVE – Right Hand Hold (CRHH).

Like TRHKH this CA is well primed (IgTIg – P50% = 0.5 seconds) and then ignited as CRHA's final function. It needs only to be a small CA (PotN 5K) since its only concern is the actual closing of the right hand on the kettle handle. It doesn't last long, just sufficient to ignite its motor CA (MRHG). There is also negative feedback from TRHG relating to the force of the gripping behaviour.

Before extinction CRHG ignites the right hand holding of the kettle (CRHH). It is modelled as decaying quite slowly (IgTEx – D50% = 0.4 seconds) so as to allow re-ignition if there is a problem with holding the kettle, howsoever rare.

In a very early SCAM analysis the difference between gripping the kettle handle and then holding it were not differentiated. Subsequently it became clear that this resulted in a SCAM diagram that could not be described using the SCAM parameters because what was needed was an initial ignition to represent the grasp and then a steady holding-the-kettle-handle state. Just as there are two answers to Popper's Black Swan problem (either the theory's wrong or, by definition, it is not a swan), so we have preferred the latter option, i.e. to separate the initial grip from the subsequent, long term holding of the kettle handle. Some psychological justification for this is offered below concerning CRHH.

20 CA: MOTOR – Right Hand Grip (MRHG)



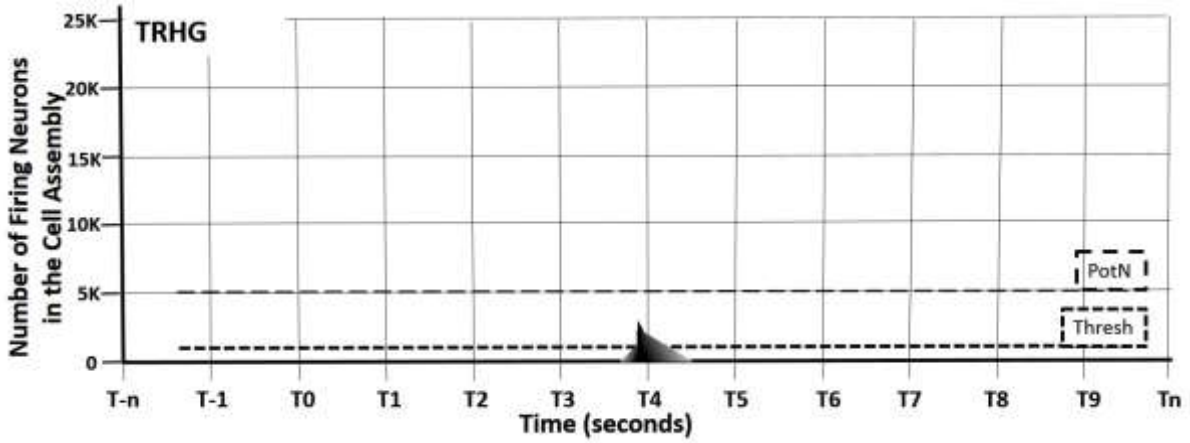
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MRHG	5	1	3	2	3.7	3.8	3.9	4.0

INPUTS: CA: COGNITIVE – Right Hand Grip (CRHG).

OUTPUTS: *motor behaviour …*

This is a fairly standard small motor CA (PotN 5K), specialised for the task but one of (tens of?) thousands of other similarly specialised ones (e.g. gripping one's coffee cup before drinking from it and, indeed, picking up any "well known" object). It is ignited by CRHG and extinguishes itself as the grip is transformed into the stable holding behaviour of MRHH.

21 CA: TOUCH – Right Hand Grip (TRHG)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
TRHG	5	1	3	2	3.7	3.8	3.9	4.3

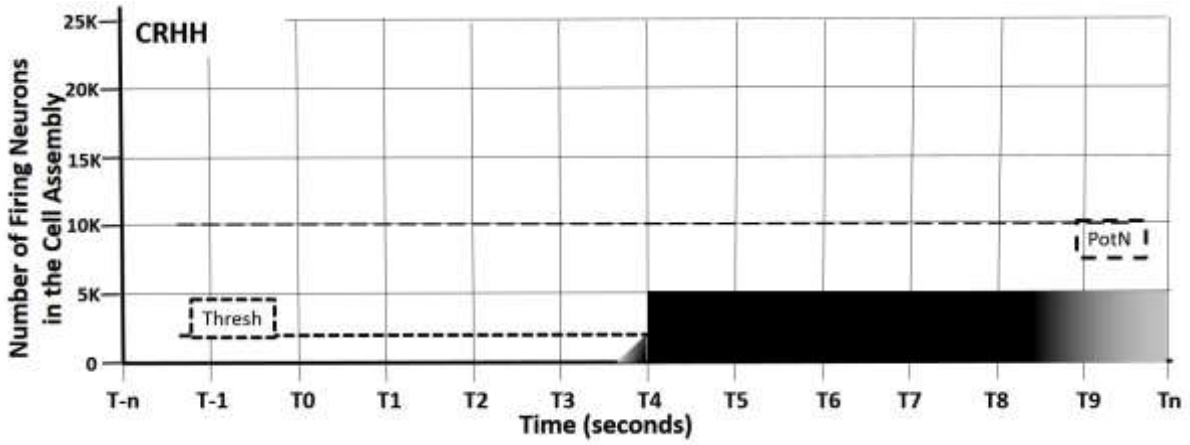
INPUTS: CA: COGNITIVE – Right Hand Grip (CRHG)

OUTPUTS: CA: COGNITIVE – Right Hand Grip (CRHG)

Negative feedback control here is crude in that as soon as this CA is ignited, along with its motor complement, it simply confirms that there is adequate, expected grip (e.g. the kettle

handle is not damp and friction poor) and sends output to CRHG. It is modelled as decaying slowly (IgTEx – D50% = 0.4 seconds) in case of early "gripping errors".

22 CA: COGNITIVE – Right Hand Hold (CRHH)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CRHH	10	2	5	5	3.8	4.0	-	-

INPUTS: CA: COGNITIVE – Right Hand Grip (CRHG).

CA: MOTOR – Right Hand Hold (MRHH).

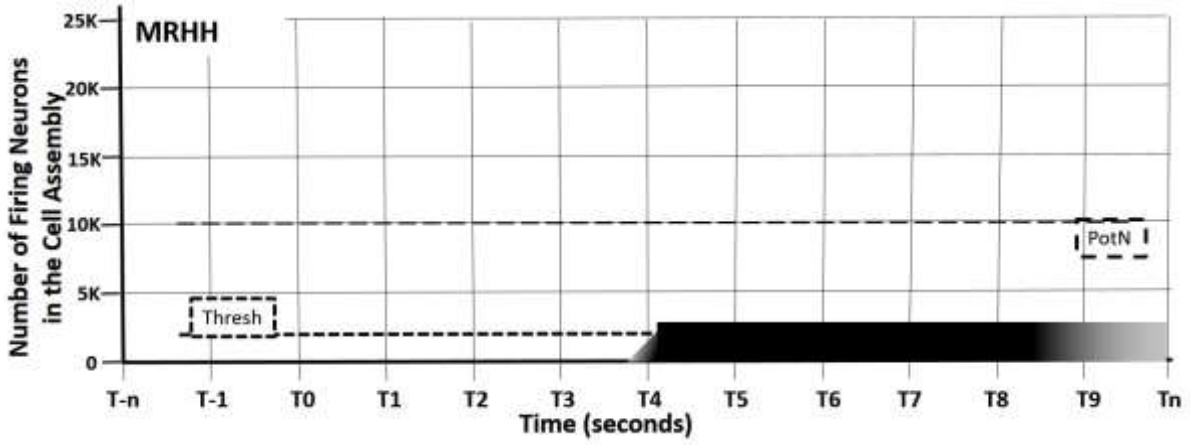
OUTPUTS: CA: MOTOR – Right Hand Hold (CRHH),

CA: COGNITIVE – Lift Kettle (CLK).

Unusually in this highly practiced task, this CA is a fairly general one, hence its size (PotN 10K). It has a low threshold (2K), strong relative ignition (5K) and effectively no fatigue. The CA continues ignited beyond the duration of this analysis.

The experiential/introspective psychology, at least, is quite odd about holding objects as once they are held it seems we forget what we are holding. As evidence, often one looks at one's hand during a task to see just what is in it. Obviously different objects are treated differently, but it seems that once a hold is established, it is one or more CAs associated with the object, rather than the hold on it, which remain task relevant, i.e. ignited.

23 CA: MOTOR – Right Hand Hold (MRHH)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MRHH	10	2	3	3	3.9	4.1	-	-

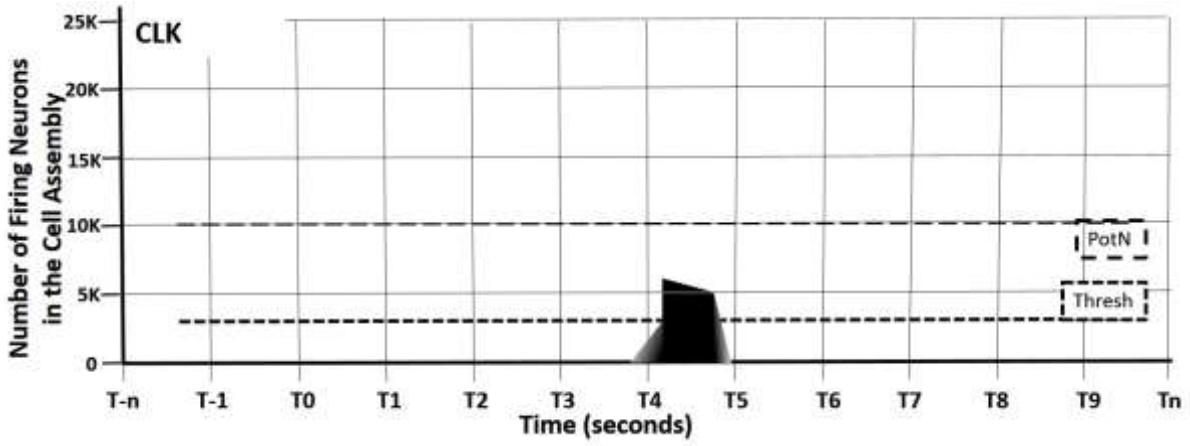
INPUTS: CA: COGNITIVE – Right Hand Hold (CRHH).

OUTPUTS: CA: COGNITIVE – Right Hand Hold (CRHH)

Following CRHH, it just ignites, persists, and unless there is imperfect performance, e.g. the kettle over the drainer "in flight" hits an obstruction, as a motor CA it causes a solid hold on the kettle handle, notwithstanding later orientations of the kettle itself.

As discussed with CA 06 MSHWA (Motor Stride to Hot Water Area), the CA's actual behaviour will be more complicated than as suggested by the flat line in its SCAM diagram. For example, while going over the drainer, or when decelerating over the right hand sink, then the hold might change; that the SCAM is over simplified at this stage of the research is not denied, it is only a start after all.

24 CA: COGNITIVE – LIFT KETTLE (CLK)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CLK	10	3	6	5	4.0	4.2	4.7	4.8

INPUTS: CA: COGNITIVE – Right Hand Hold (CRHH),

CA: VISUAL – Lift Kettle (VLK)

CA: KINAESTHETIC – Kettle Weight (KKW).

OUTPUTS: CA: VISUAL - Lift Kettle (VLK)

CA: MOTOR – Lift Kettle (MLK),

CA: KINAESTHETIC – Kettle Weight (KKW),

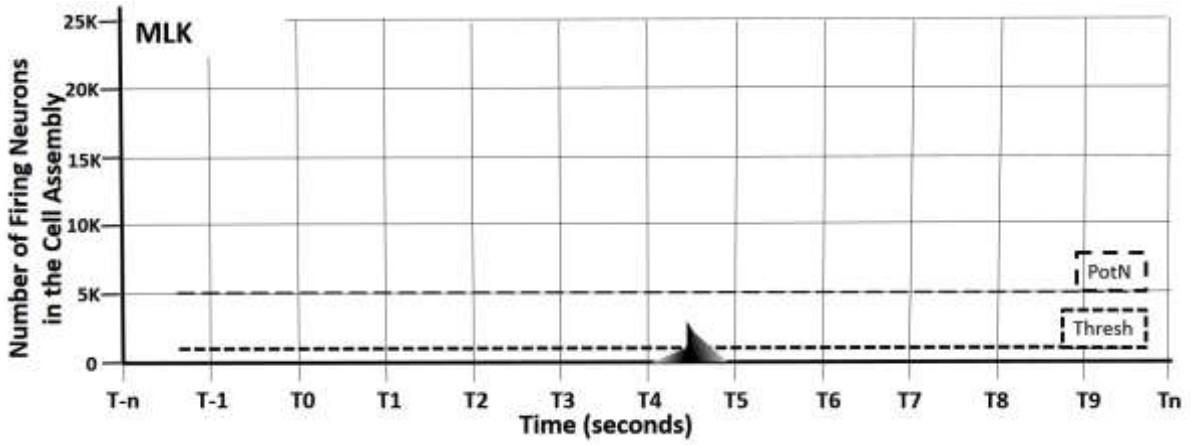
CA: COGNITIVE – Drainer (CD),

CA: COGNITIVE – Move Kettle to Sink (CMKS).

The ergonomics and CA perspective agree that a new subtask starts here, but within the SCAM model the line is blurred in that some CAs are already ignited and will persist beyond the duration of this analysis (CRHH and MRHH).

Empty, the kettle weighs 1.7Kg and if previously boiled water remains in it, it may weigh a third more (e.g. with about a pint/half litre: 2.3Kg/1.7Kg = 1.35). The initial vertical lift of the kettle from its base (it must be vertical because the base has a central, circular hub that the kettle locates on) critically signals the kettle's weight via kinaesthetic feedback (KKW). There is visual tracking of the kettle (VLK). The CA is well primed (P50% - IgTIg = 0.2 seconds) and it persists for longer than the motor behaviour (MLK) because it must ignite both cognitive CAs for the sub-task's continuation (CD and CMKS).

25 CA: MOTOR – Lift Kettle (MLK)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MLK	5	1	3	2	4.1	4.3	4.4	4.5

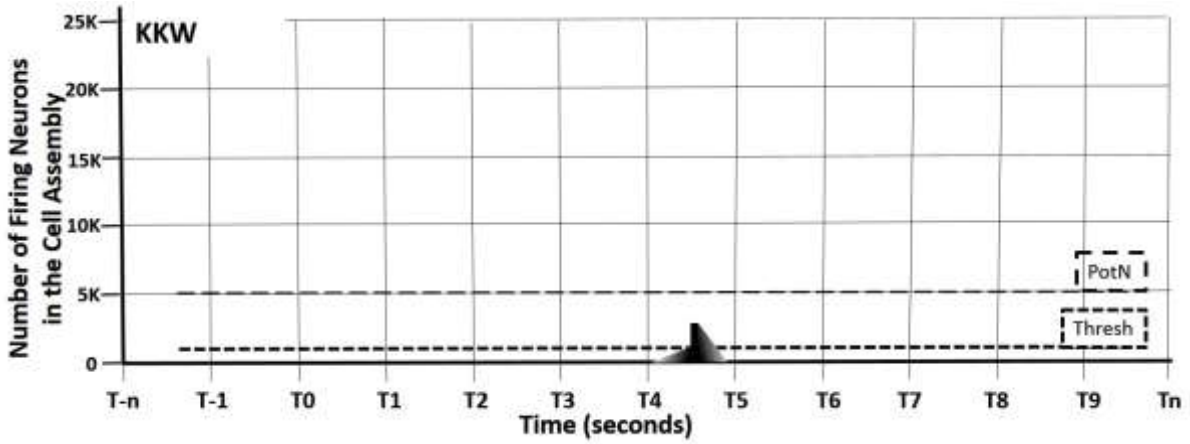
INPUTS: CA: COGNITIVE – Lift Kettle (CLK).

OUTPUTS: *motor behaviour …*

Well primed (P50% - IgTIg = 0.2 seconds) because this is a highly practiced task, and with a low threshold (PotN 5K, Threshold 1k), there is an initial ballistic lift which then comes under kinaesthetic negative feedback control from KKW, which adjusts the rate of the upwards lift, and then close behind this under visual negative feedback control (VLK) via CLK, which starts to orientate the kettle by turning the right wrist clockwise.

The CA is not explicitly extinguished because it segues into the next motor operation, moving the kettle to the sink (MMKS), without a pause, but with a deceleration in the kettle's post-lift trajectory, presumably so that the kettle's path over the drainer can be determined.

26 CA: KINAESTHETIC –Kettle Weight (KKW)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
KKW	5	1	3	3	4.2	4.4	4.5	4.6

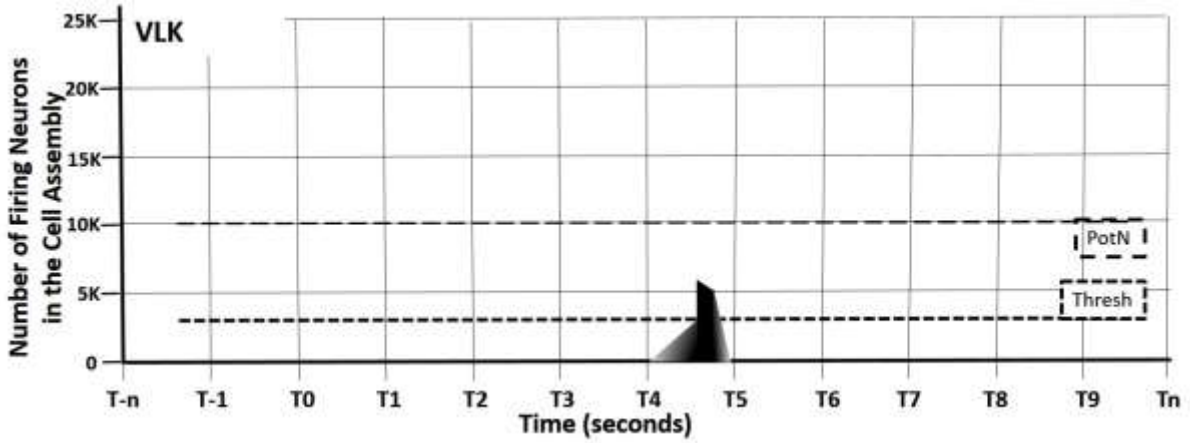
INPUTS: CA: COGNITIVE – Lift Kettle (CLK).

OUTPUTS: CA: COGNITIVE – Lift Kettle (CLK)

People have an expectation about the weight of objects before they touch them and this is easily demonstrated by the under- or over-lift people produce when such expectations are violated. While this kinaesthetic CA is undoubtedly used whenever objects are lifted, it is particularly germane here as the kettle gives no indication of how much water remains in it until it is lifted. The CA rarely has a conscious representation unless the kettle is unusually full, when, against general house policy, this signals poor energy conservation.

The CA is small (PotN 5K) and easily ignited (Threshold 1K). In this model the CA does not persist, i.e. the kettle's weight is represented in CLK.

27 CA: VISUAL – Lift Kettle (VLK)



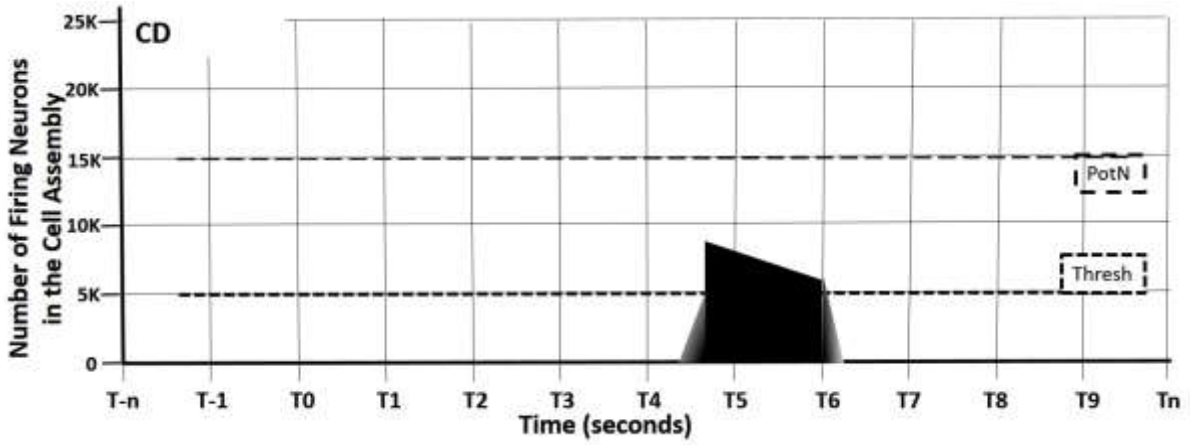
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VLK	10	3	6	5	4.3	4.5	4.6	4.7

INPUTS: CA: COGNITIVE – Lift Kettle (CLK).

OUTPUTS: CA: COGNITIVE – Lift Kettle (CLK).

The kettle comes more into view when it is lifted above the cluttered hot water area (it is initially also obscured by the right hand and forearm). The CA takes over from KKW providing negative feedback to CLK and starts the control of angling the kettle to the right. It is small for a visual CA (PotN 10K) as it involves object tracking and, under movement, a poor percept of the kettle itself.

28 CA: COGNITIVE – Drainer (CD)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CD	15	5	8	6	4.5	4.6	6.0	6.1

INPUTS: CA: COGNITIVE – Lift Kettle (CLK),

CA: VISUAL – Drainer (VD).

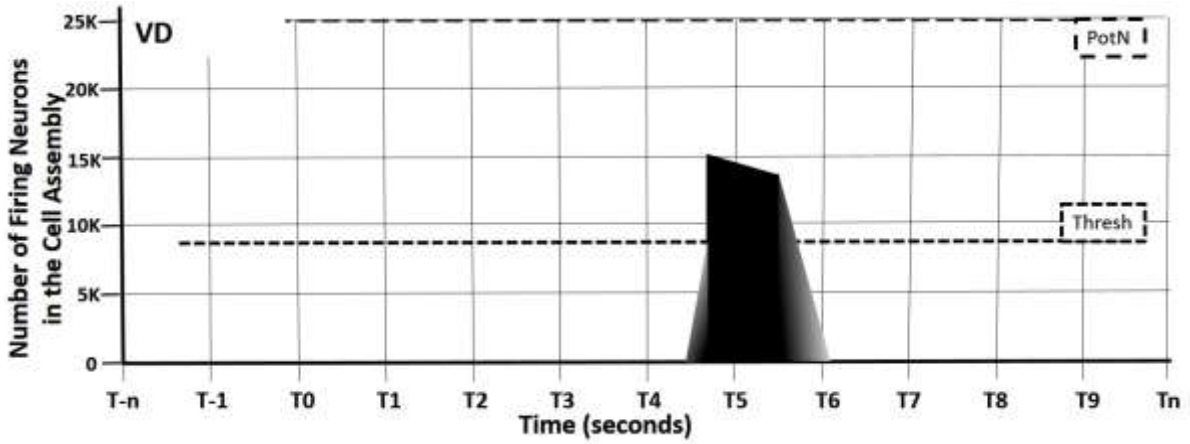
OUTPUTS CA: VISUAL – Drainer (VD),

CA: COGNITIVE – Move Kettle to Sink (CMKS).

The steel wire drainer is the most variable object associated with the task because it may be empty or it could be full of washed objects. It is 50cm in depth and 32cm along the draining board, which is the length of the kettle's path over this potential obstacle. Empty, the drainer is 10cm high but the largest pot that is regularly used has a 28cm diameter and this pot's lid, upright but at an angle in the plate rack, also has a maximum height of 28cm.

This is quite a large CA (PotN 15K) to reflect the complexity of a variable object, although the critical information extracted by CMKS is the height at particular depths over which the kettle must pass. N.B. There are other CAs concerning the drainer that are used in other tasks, such as when washing up or when putting dried objects away. The CA is ignited before CLK extinguishes and accepts the final, angled orientation of the kettle effected by CLK.

29 CA: VISUAL – Drainer (VD)



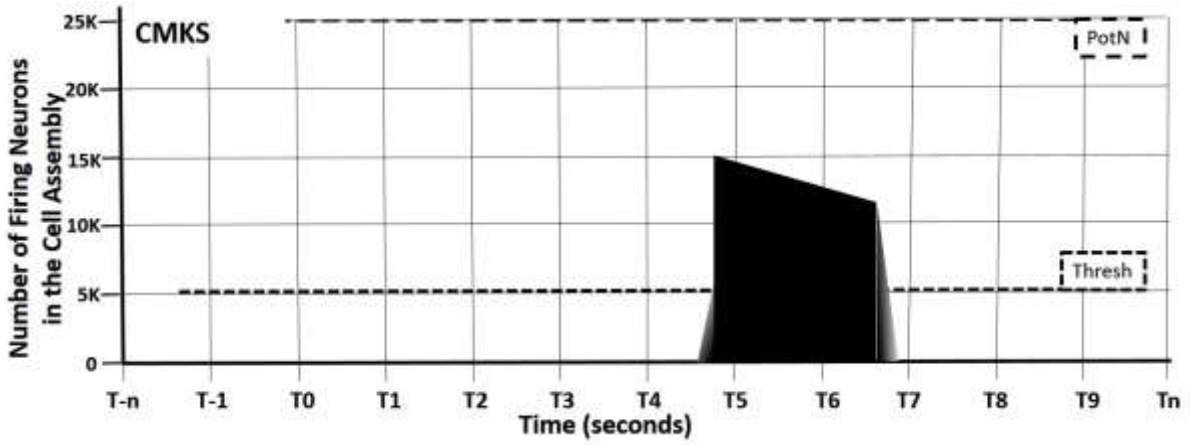
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VD	25	8	15	13	4.6	4.7	5.5	5.8

INPUTS: CA: COGNITIVE – Drainer (CD).

OUTPUTS CA: COGNTIVE – Drainer (CD).

The drainer's visual CA is equivalently large (PotN 25K) to its cognitive CA (PotN 15K). As explained below (CMKS), it does not directly feed the moving the kettle to the sink CA, except via CD. It extinguishes quite early as visual attention switches to the kettle's arrival over the sinks.

30 CA: COGNITIVE – Move Kettle to Sink (CMKS)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CMKS	25	5	15	12	4.7	4.8	6.6	6.7

INPUTS: CA: COGNITIVE – Lift Kettle (CLK)

CA: COGNITIVE – Drainer (CD),

CA: VISUAL – Move Kettle to Sink (VMKS).

OUTPUTS: CA: VISUAL – Move Kettle to Sink (VMKS),

CA: MOTOR – Move Kettle to Sink (MMKS)

CA: MOTOR – Left Hand Track Kettle Lid (MLHTKL)

CA: KINAESTHETIC – Left Hand track Kettle Lid (KLHTKL),

CA: MOTOR – Shuffle Body to Sink (MSBS),

CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL).

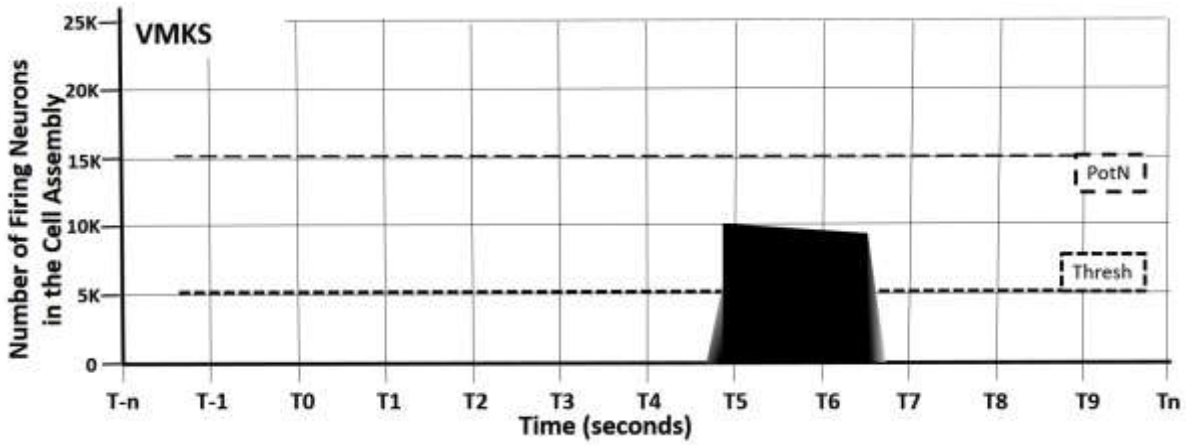
CA: COGNITIVE – Sink (CS).

If the kettle were an aircraft, then it would be one with terrain following radar so as to maintain height-above-ground. The kettle is flown over the drainer in a smooth path that varies in height, and to a lesser extent depth, depending on what, if anything, is in the drainer. What does not happen is that the kettle is flown around the drainer and not over it as this would require a step to be taken back, away from the hot water area, whereas CMKS involves a shuffle to the right so that the body is closer to the sink.

How much the kettle's flight path is "calculated" in advance and how much is under visual negative feedback control is moot. Performance is fast and, perhaps surprisingly, error free, i.e. objects on the drainer are never hit by the kettle even though it may be only a few centimetres above draining objects. The subjective impression following detailed observation for this research is that perhaps one course correction is made mid-flight over the drainer and a second, once that is cleared, to bring the kettle above the main, right most sink.

The CA is large for a cognitive one (PotN 25K) and with a low threshold (5K) because its ignition continues the initial kettle lift (CLK). The kettle's weight information is transferred from CLK to CMKS. At a lower level of analysis this CA might be described by a number of interacting CAs, e.g. concerning open versus negative feedback control and the varying, three dimensional accelerations applied.

31 CA: VISUAL – Move Kettle to Sink (VMKS)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VMKS	15	5	10	9	4.8	4.9	6.5	6.6

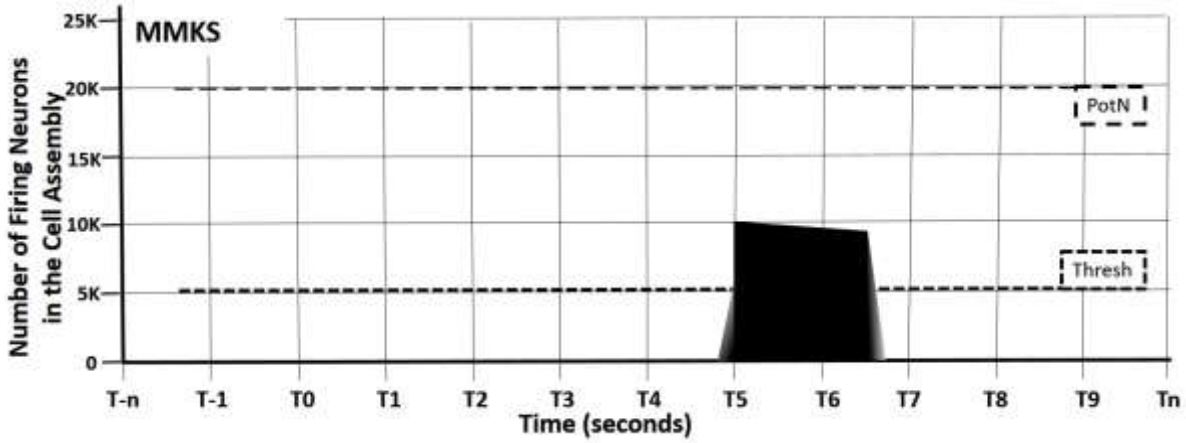
INPUTS: CA: COGNITIVE – Move Kettle to Sink (CMKS).

OUTPUTS: CA: COGNITIVE – Move Kettle to Sink (CMKS).

Like the visual CA for lifting the kettle (VLK), this CA is quite small as it really only signals the base of the kettle over the drainer (PotN 15K) and then the general location of the kettle over the sink.

As with CMKS, at a lower level of analysis this CA might be described by several, interacting ones.

32 CA: MOTOR – Move Kettle to Sink (MMKS)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MMKS	20	5	10	9	4.9	5.0	6.5	6.6

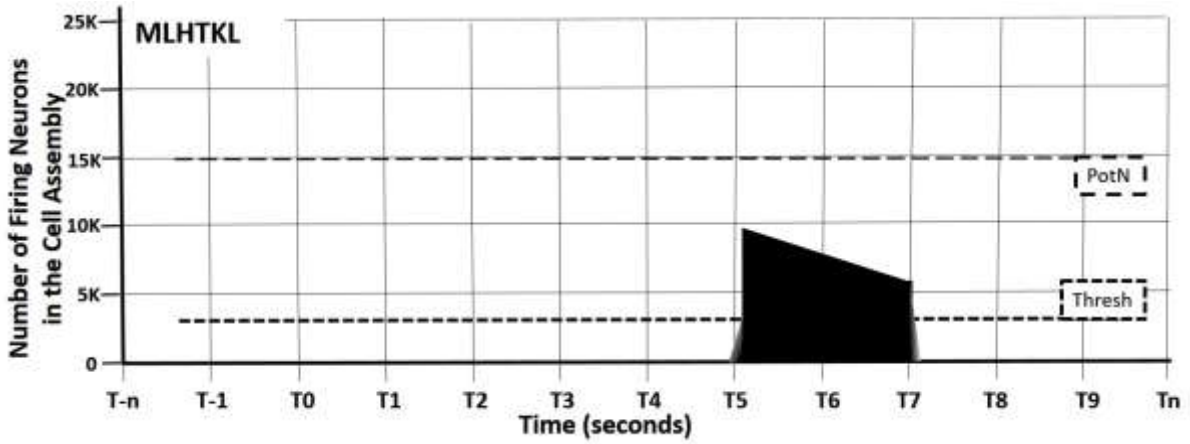
INPUTS: CA: COGNITIVE – Move Kettle to Sink (CMKS).

OUTPUTS: *motor behaviour …*

The complex motor behaviour is probably carried out by a single CA and illustrates the advantage of using a CA-based model rather a symbolic computational one, that CAs are capable of flexible learning. The CA is modelled as having several general flight paths, e.g. for when the drainer is empty, has a few low height objects, or some big ones draining, and then adapts to specific conditions to quickly and safely fly over the draining board using visual negative feedback via CMKS.

The CA is large for a motor one (PotN 20K) and perhaps only half these neurons will be involved in any particular ignition (IgMax 10K). The CA is explicitly suppressed by CMKS when the kettle is over the main sink; the actual location need not be very precise as the sink is a large target relative to the kettle.

33 CA: MOTOR – Left Hand Track Kettle Lid (MLHTKL)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MLHTKL	15	3	9	6	5.0	5.1	7.0	7.0

INPUTS: CA: COGNITIVE – Move Kettle to Sink (CMKS),

CA KINAESTHETIC – Left Hand Track Kettle Lid (KLHTKL).

CA: VISUAL – Visual Left Hand (VLH).

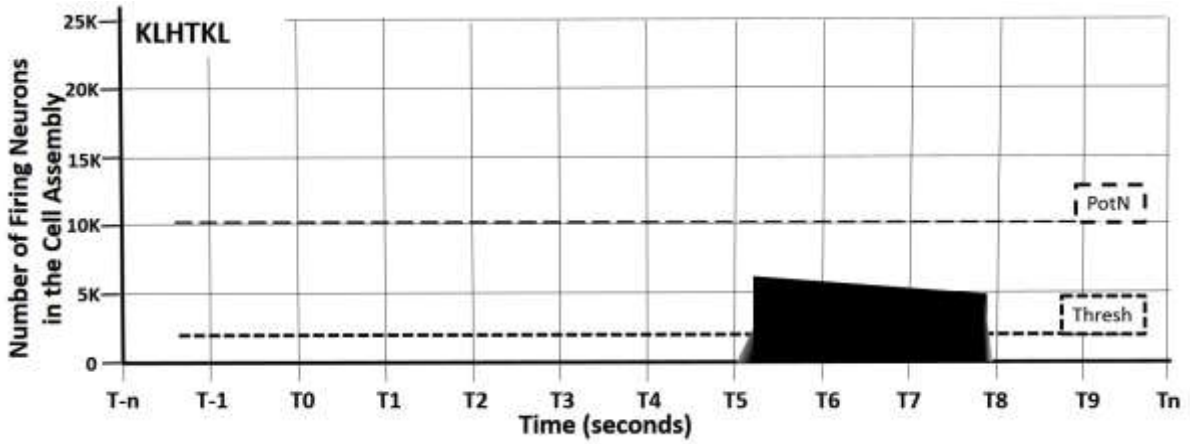
CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL).

OUTPUTS: CA: KINAESTHETIC – Left Hand Track Kettle Lid (KLHTKL).

The left arm/hand has not so far featured in this task, being used for general balance. Out of sight, the left hand is accelerated towards, and then tracks, the kettle's lid so that the left hand is close to it when it appears (VLH). The left hand/wrist will commence to orientate to meet the kettle lid.

The CA is quite large for a motor one (PotN 15K), although we model it as a single CA because the behaviour is continuous. It has additional input once the left hand appears (VLH) and so there is then both kinaesthetic and visual negative feedback to control the final fractions of a second before the kettle lid handle is gripped, at which point this tracking CA is suppressed by CLHRKL. Ignition and visual input comes from CMKS which probably also provides kinaesthetic input about the right hand's location and movement as it grips the kettle.

34 CA: KINAESTHETIC – Left Hand Track Kettle Lid (KLHTKL)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
KLHTKL	10	2	6	5	5.1	5.2	7.8	7.8

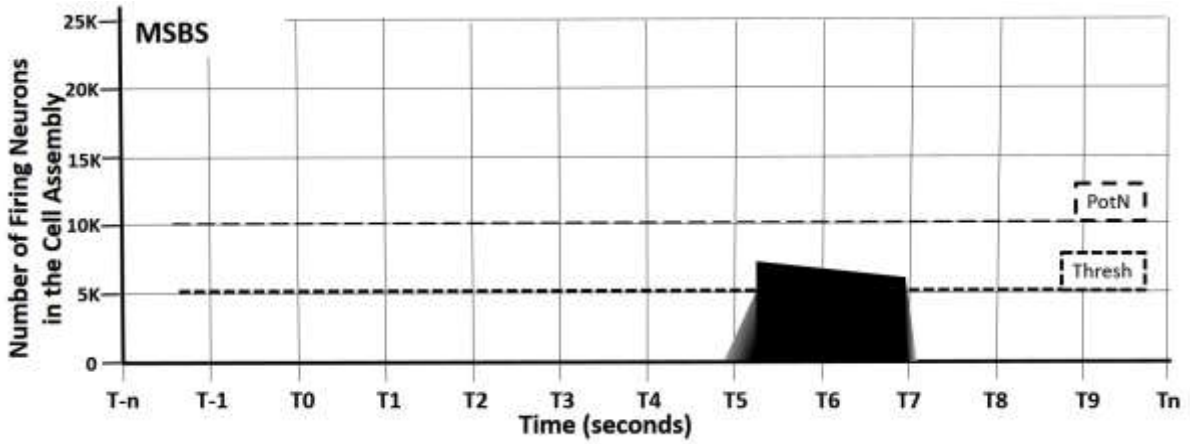
INPUTS: CA: COGNITIVE – Move Kettle to Sink (CMKS),
CA: MOTOR – Left Hand Track Kettle Lid (MLHTKL),
CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL),
CA: MOTOR – Replace Kettle Lid Left Hand (MRKLLH).

OUTPUTS: CA: MOTOR – Left Hand Track Kettle Lid (MLHTKL),
CA: COGNITIVE – Left Hand remove Kettle Lid (CLHRKL),
CA: MOTOR – Replace Kettle Lid Left Hand (MRKLLH).

There must be all sorts of kinaesthetic feedback involved in the left hand tracking the kettle lid, then touching and gripping it, before the lid is replaced (CRKLLH). The CA is ignited by CMKS and provides negative feedback cycles to MLHTKL and other motor CAs: CLHRKL before CRKLLH. Unlike MLHTKL, it is not supressed but decays away once motor inputs terminate.

Kinaesthetic CAS are generally on the small side because of the quality of their output, but this one is quite large (PotN 10K) and with a low threshold (2K) and little decay (IgMax 6K, IgFat 5K) because, persisting for over two seconds, fatiguing neurons will be replaced from those so far not used within PotN.

35 CA: MOTOR – Shuffle Body to Sink (MSBS)



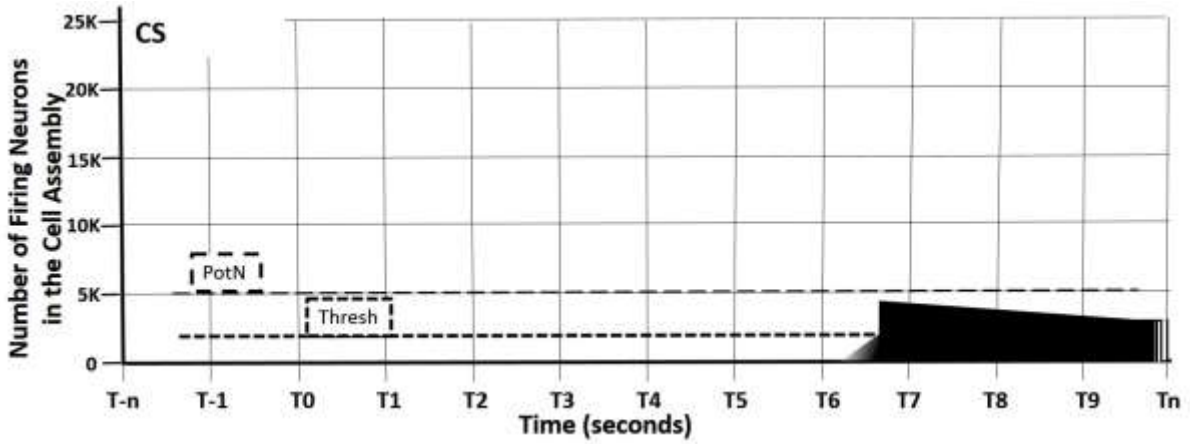
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MSBS	10	5	7	6	5.1	5.3	6.9	7.0

INPUTS: CA: COGNITIVE – Move Kettle to Sink (CMKS).

OUTPUTS: *motor behaviour …*

This may be a super-practiced task but the movement of the body from the hot water corner to the sink is ungainly and variable, and although irrelevant, the subject isn't normally conscious of this behaviour. The knees are close to the under sink cabinets so the move to the sink involves the hips and a sideways stretch of first the right and then the left foot and then some small foot corrections, although occasionally the final position is one where most of the body weight is on the right foot. The shuffle may continue for some time after the kettle has reached the sink, i.e. in parallel with the next sub-task of removing the kettle's lid.

36 CA: COGNITIVE – Sink (CS)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CS	5	2	4	3	6.5	6.7	-	-

INPUTS: CA: COGNITIVE – Move Kettle to Sink (CMKS),

CA: VISUAL – Sink (VS).

OUTPUTS: CA: VISUAL – Sink (VS),

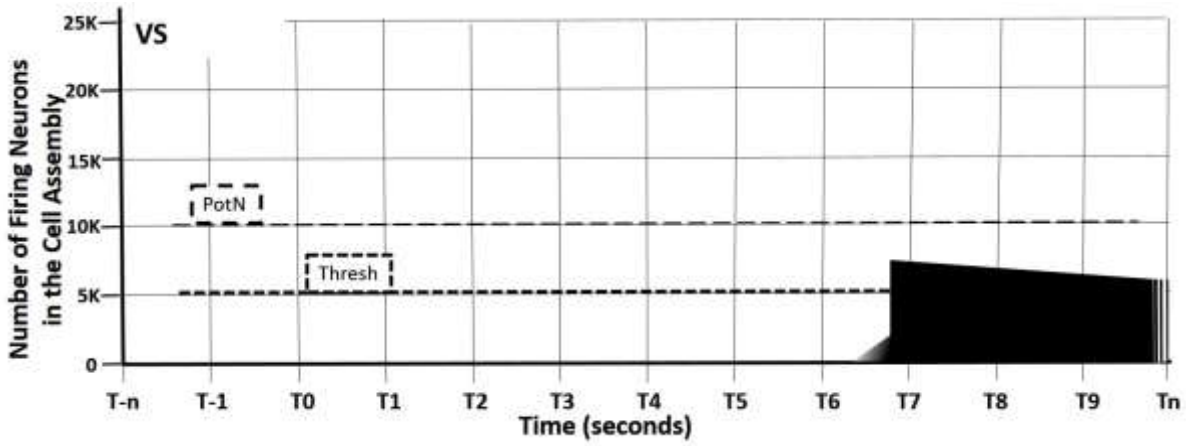
CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL).

The sink here is the larger, rightmost of the pair and it is usually empty; if it is not empty then, like CKEC at the start of this analysis, other CAs would be ignited to assess the sink's state and decide how to orientate the kettle so it can still be filled.

Empty, the sink's cognitive representation here need not be large (PotN 5K) as it is a large target relative to the kettle, which only needs to be centred above the sink so that it can be emptied.

This CA and its associated CA (VS) are assumed to persist beyond the analysis as they provide, albeit perhaps weak, context information to the following CAs (not shown on the CAAR diagram, Figure 9).

37 CA: VISUAL – Sink (VS)



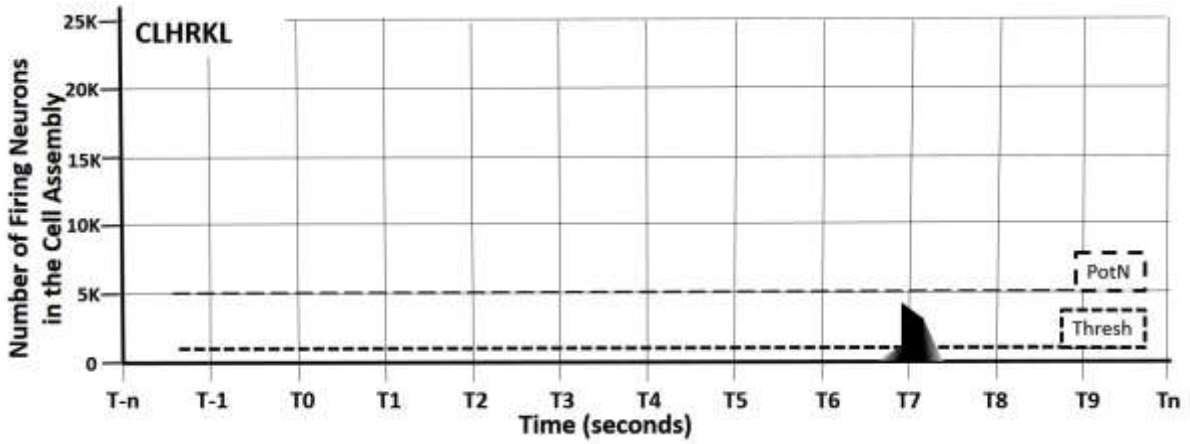
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VS	10	5	7	6	6.6	6.8	-	-

INPUTS: CA: COGNITIVE –Sink (CS).

OUTPUTS: CA: COGNITIVE – Sink (CS).

Made of brushed steel, the visual representation of the sink is fairly simple (PotN 10K) as it is relatively featureless and colourless (N.B. In the human visual system there would be many low spatial frequency components; and in computational terms standard compression algorithms of a photograph would be particularly effective).

38 CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CLHRKL	5	1	4	3	6.8	6.9	7.2	7.3

INPUTS: CA: COGNITIVE – Move Kettle to Sink (CMKS)

CA: COGNITIVE – Sink (CS),

CA: KINAESTHETIC – Left Hand Track Kettle Lid (KLHTKL),

CA: VISUAL – Kettle Lid (VKL)

CA: VISUAL – Left Hand (VLH),

CA: VISUAL – Kettle Without Lid (VKWL).

OUTPUTS: CA: KINAESTHETIC – Left Hand Track Kettle Lid (KLHTKL),

CA: VISUAL – Kettle Lid (VKL)

CA: VISUAL – Left Hand (VLH),

CA: MOTOR – Left Hand Remove Kettle Lid (MLHRKL),

CA: VISUAL – Kettle Without Lid (VKWL),

CA: COGNITIVE – Empty Kettle (CEK).

CA: MOTOR – Left Hand Track Kettle Lid (MLHTKL).

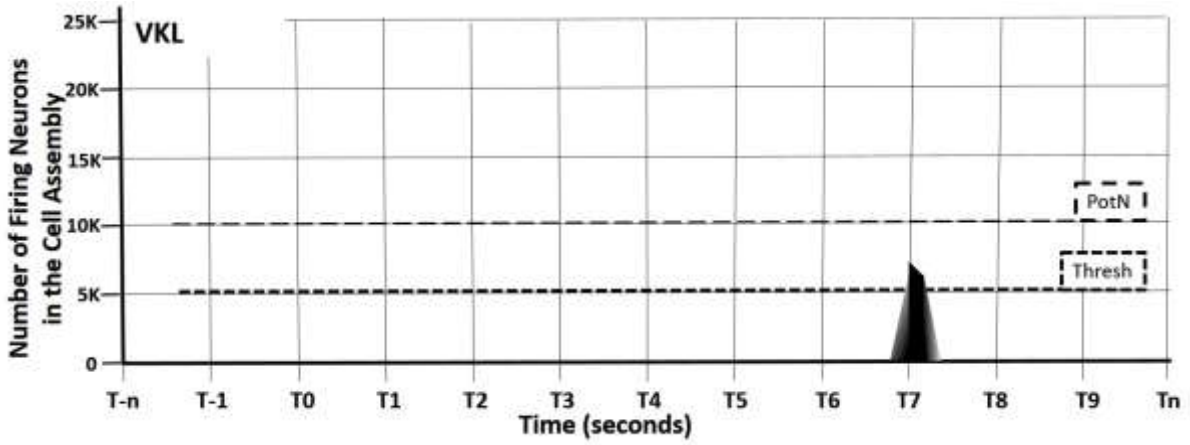
On the adage that the act of doing a TA improves, by method iteration (Section 1), even the earliest analysis stages, then this CA provides a good example. Initially the subtask seemed remarkable for its speed (say a third of a second) and accuracy (it virtually never fails on the first attempt); it took careful, further observation for this research to be able to model it. The initial problem was that the first analysis only included the left arm/hand once it came into operation to remove the kettle's lid. Further observation showed that the left hand was tracking the kettle's lid soon after the kettle starts moving towards the sink (CMKS) and that the lid is closely tracked by the left hand (MLHTKL and KLHTKL) during its flight over the drainer.

Like the right hand approaching the kettle (CRHA), it must start with a ballistic movement as the left hand is not in view and then it must come under visual negative feedback control for

the fingers to grip the kettle lid's handle, which can be at any angle on top of the kettle, but this is far less variability than exists in the hot water area.

This CA and its associates could be analysed in much greater detail than is provided at the level of analysis we've chosen. In the analysis offered the CA is small (PotN 5K), with a low threshold (1K), and, being highly specialised, IgMax is proportionally high (4K). In an alternative CAA this CA could be larger or, as we suspect, there are many component CAs that we have not modelled in our analysis.

39 CA: VISUAL – Kettle Lid (VKL)



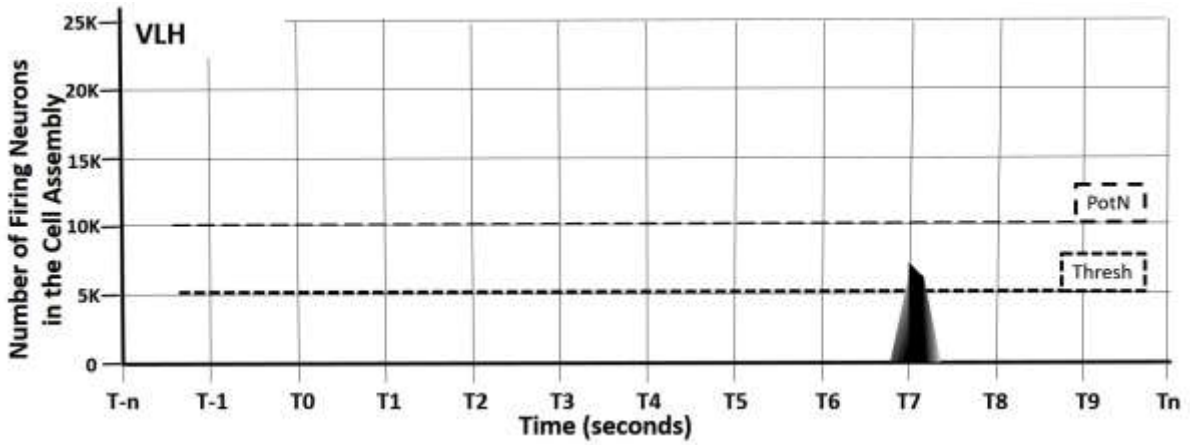
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VKL	10	5	7	6	6.9	7.0	7.1	7.2

INPUTS: CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL).

OUTPUTS: CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL).

The kettle lid is a black/dark grey plastic with an inverted dished top and a simple sold bar across this to act as the handle. What the CA needs to represent is the angle of the handle and the three dimensional location of the lid on the top of the kettle; the latter is no doubt determined by binocular parallax (the different images in the eyes caused by the eyes' horizontal separation). It doesn't need to be large for a visual CA (PotN 10K).

40 CA: VISUAL – Left Hand (VLH)



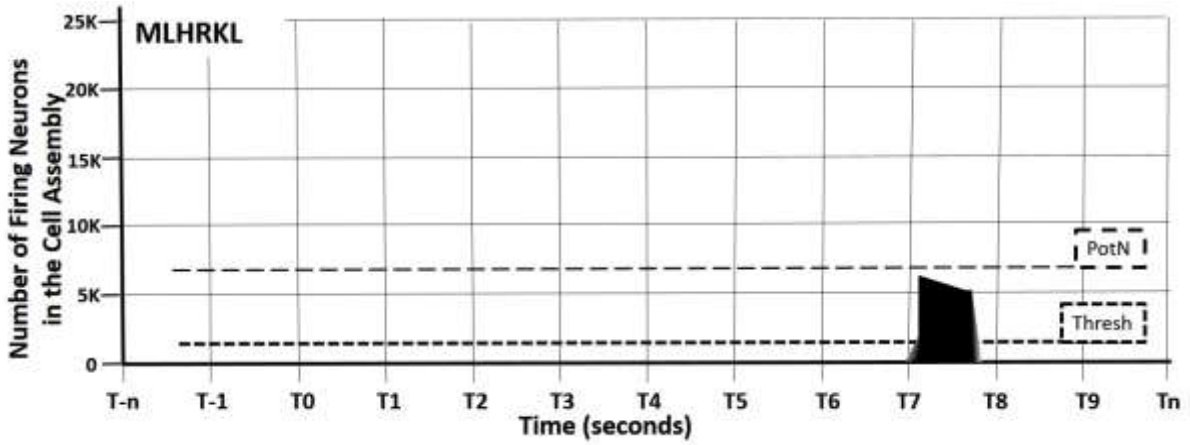
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VLH	10	5	7	6	6.9	7.0	7.1	7.2

INPUTS: CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL).

OUTPUTS: CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL).

This doesn't need to be a big visual CA (PotN 10K) as its purpose is only for control of the left hand's final approach to the kettle's lid. It is also assumed, because of the speed and accuracy (see CLHRKL), that the CA is not that large.

41 CA: MOTOR – Left Hand Remove Kettle Lid (MLHRKL)



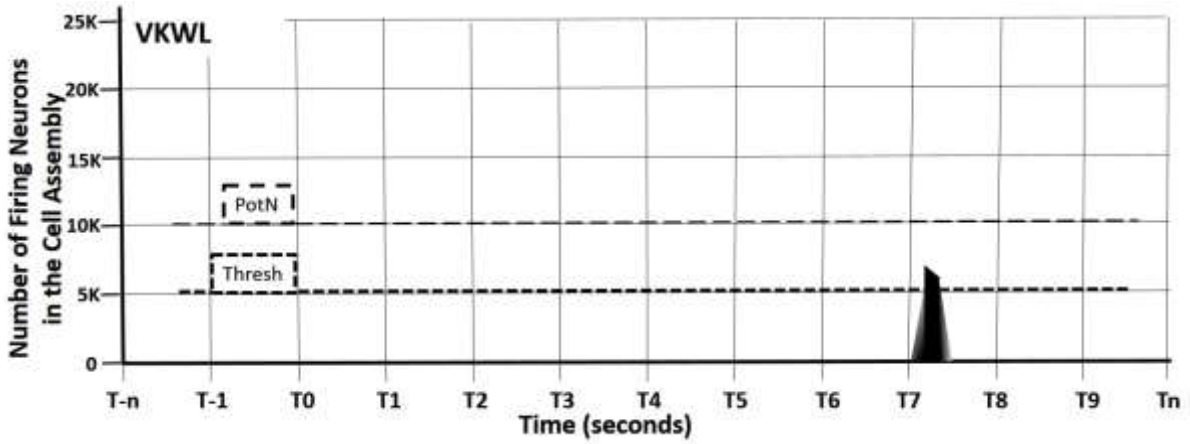
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MLHRKL	7	2	6	5	7.0	7.1	7.7	7.7

INPUTS: CA: COGNITIVE – Left Hand Remove Kettle Lid (MLHRKL).

OUTPUTS: *motor behaviour …*

This is a snatch, hold and move away action which in this analysis is modelled by a single CA (PotN 7K) because, again, of the speed of the initial behaviour, although at a more detailed level it might be treated as compound behaviour involving several CAs. On the other hand, a single CA, as here, seems equally plausible, with it smoothly combining the component behaviours. The CA remains ignited, holding the lid away from the kettle, until the lid is replaced about half a second later (CRKLLH and MRKLLH).

42 CA: VISUAL – Kettle Without Lid (VKWL)



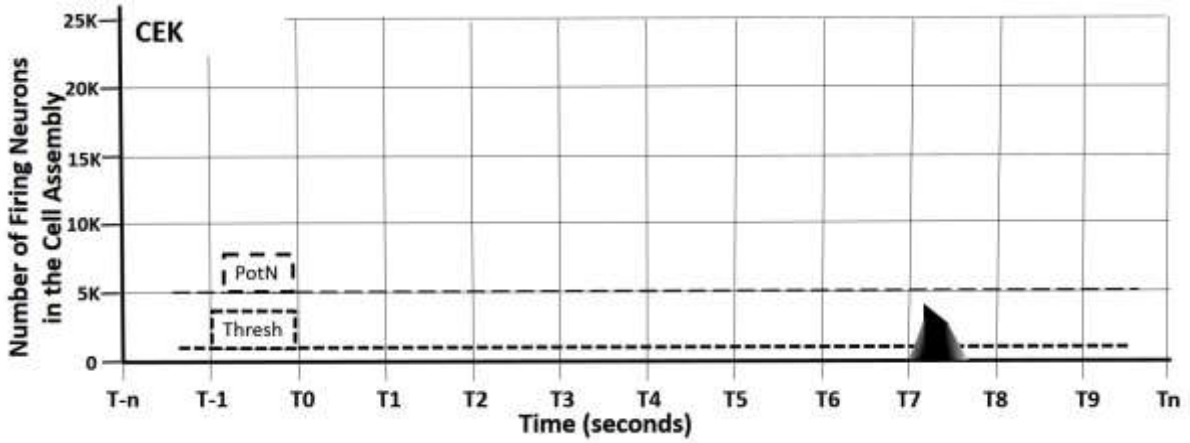
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VKWL	10	5	7	6	7.1	7.2	7.3	7.4

INPUTS: CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL).

OUTPUTS: CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL).

This is a small (PotN 10K) visual CA that confirms the kettle's lid is off. It provides feedback to CLHRLK which then allows the ignition of CEK to empty the kettle.

43 CA: COGNITIVE – Empty Kettle (CEK)



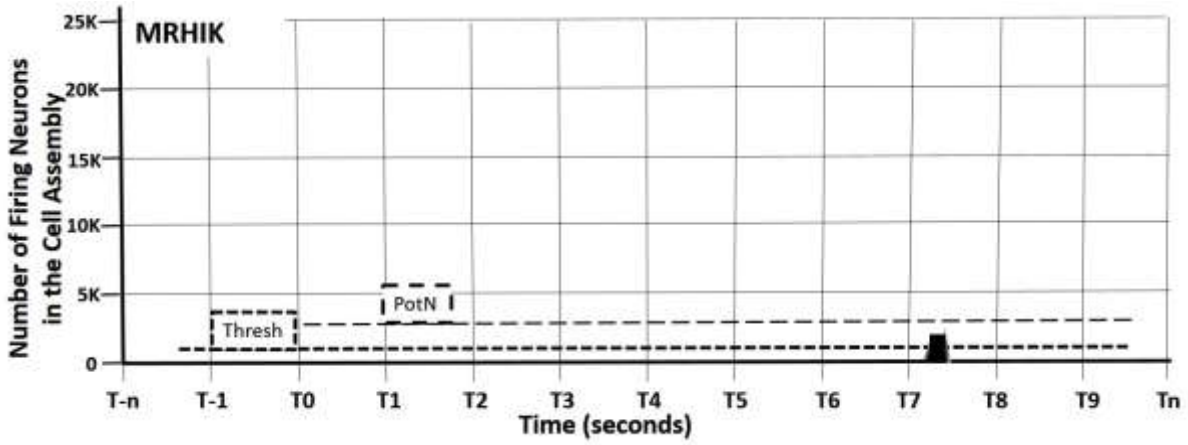
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CEK	5	1	4	3	7.1	7.2	7.4	7.5

INPUTS: CA: COGNITIVE – Left Hand Remove Kettle Lid (CLHRKL),
CA: VISUAL – Kettle Empty (VKE).

OUTPUTS: CA: MOTOR – Right Hand Invert Kettle (MRHIK),
CA: VISUAL – Kettle Empty (VKE)
CA: COGNITIVE – Kettle Empty (CKE).

Residue water in the kettle is never re-boiled. The kettle is emptied very rapidly by turning the kettle upside down; there is a brief physical delay as the water falls out. Inverting the kettle, however, involves a single, fast right wrist rotation to the left. The CA is small (PotN 5K) with a low threshold (1K).

44 CA: MOTOR – Right Hand Invert Kettle (MRHIK)



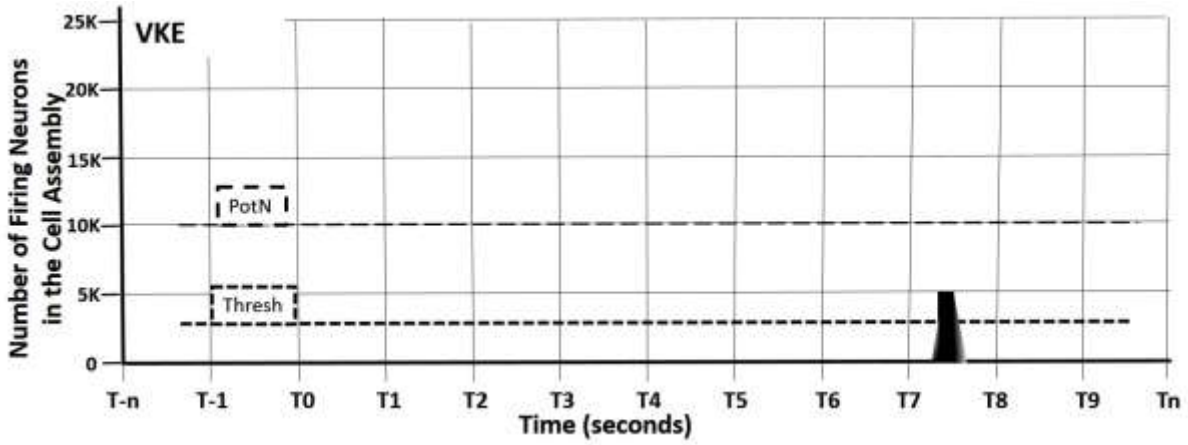
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MRHIK	3	1	2	2	7.2	7.3	7.4	7.4

INPUTS: CA: COGNITIVE – Empty Kettle (CEK).

OUTPUTS: *motor behaviour …*

This is a really small CA (PotN 3K) as the right wrist is rotated to the left (anticlockwise) to its maximum extent. Mostly it is open loop control, although there is probably kinaesthetic negative feedback control, which isn't modelled in this analysis, and might involve the right elbow and shoulder which, starting to lift as the wrist rotation approaches its maximum, may contribute to the CA extinguishing.

45 CA: VISUAL – Kettle Empty (VKE)



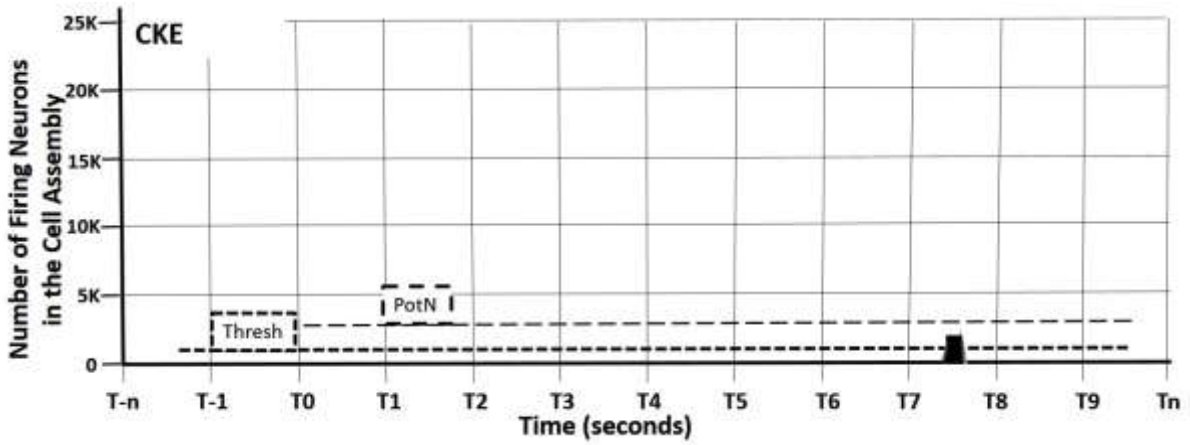
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VKE	10	3	5	5	7.3	7.4	7.5	7.6

INPUTS: CA: COGNITIVE – Empty Kettle (CEK).

OUTPUTS: CA: COGNITIVE –Empty Kettle (CEK).

The water falls out of the kettle in a lump; the splash remains within the sink; the critical thing for the CA is that the event has ended. The CA ignites CKE via CEK.

46 CA: COGNITIVE – Kettle Empty (CKE)



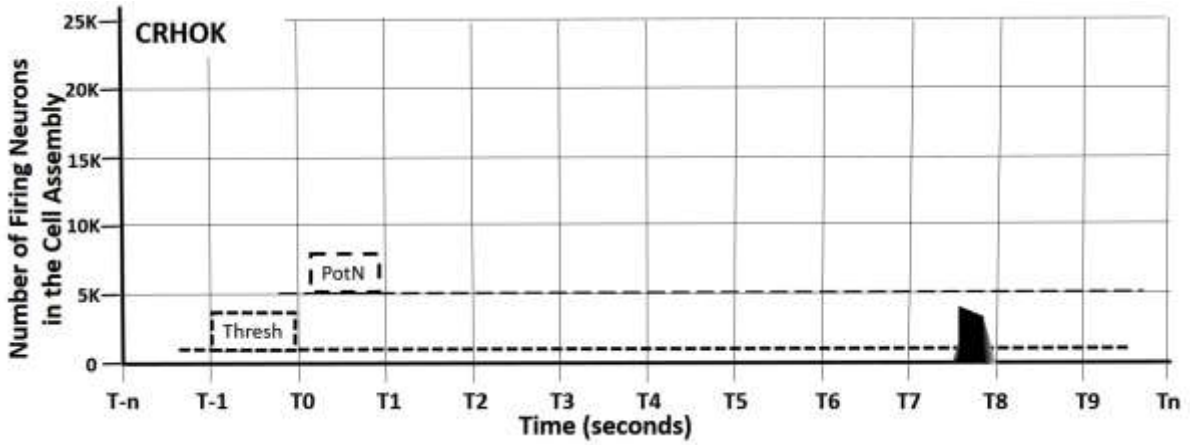
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CKE	3	1	2	2	**7.4**	7.5	7.6	7.6

INPUTS: CA: COGNITIVE –Empty Kettle (CEK).

OUTPUTS: CA: COGNITIVE – Right Hand Orientate Kettle (CRHOK).

Primarily concerned with signally that the kettle is empty, rationally this CA ought to exist, but in the CAA described it really only functions as a place marker that ignites CRHOK. An alternative CAA could equally plausible have CRHOK ignited by VKE. It is modelled as a very small CA (PotN 3K) and transient, lasting 100ms or less.

47 CA: COGNITIVE – Right Hand Orientate Kettle (CRHOK)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CRHOK	5	1	4	3	7.5	7.6	7.8	7.9

INPUTS: CA: COGNITIVE – Kettle Empty (CKE),

CA: VISUAL – Right Hand Orientate Kettle (VRHOK).

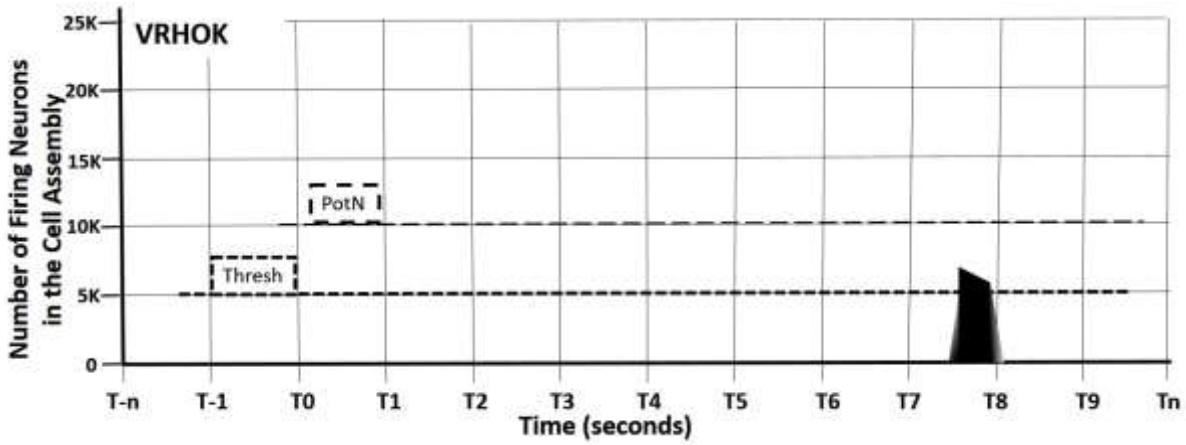
OUTPUTS: CA: VISUAL – Right Hand Orientate Kettle (VRHOK)

CA: MOTOR – Right Hand Orientate Kettle (MRHOK),

CA: COGNITIVE – Replace Kettle Lid with Left Hand (CRKLLH).

This is the opposite of inverting the kettle (CRHIK) and involves a right wrist rotation of about 100 degrees so that the kettle is returned to being upright and roughly angled towards the filtered water tap. It is a small CA (PotN 5K) and visual negative feedback control (VRHOK) primarily concerns the end of the rotation and halting its motor CA (MRHOK)

48 CA: VISUAL – Right Hand Orientate Kettle (VRHOK)



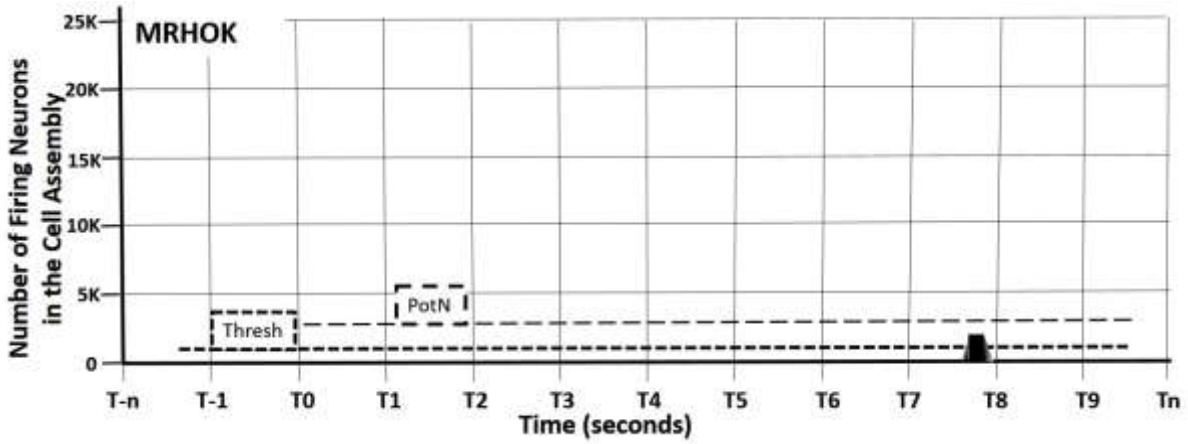
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VRHOK	10	5	7	6	7.5	7.6	7.9	8.0

INPUTS: CA: COGNITIVE – Right Hand Orientate Kettle (CRHOK).

OUTPUTS: CA: COGNITIVE – Right Hand Orientate Kettle (CRHOK).

Since the previous visual target was the emptied, inverted kettle, then visual attention is already directed to the kettle. The initial wrist rotation is fast but as it decelerates to a halt then this CA provides the final control that orientates the kettle and then leads to the suppression of MRHOK via CRHOK.

49 CA: MOTOR – Right Hand Orientate Kettle (MRHOK)



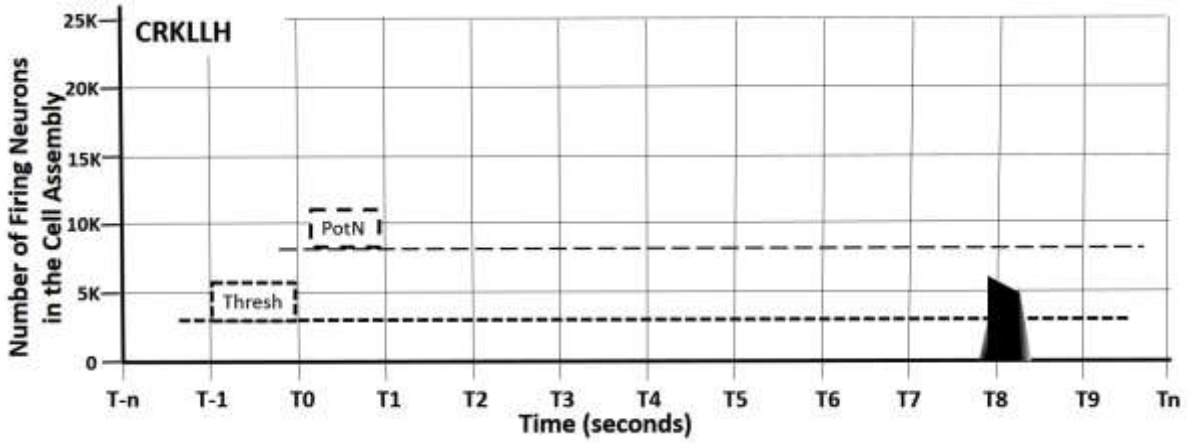
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MRHOK	3	1	2	2	7.6	7.7	7.8	7.9

INPUTS: CA: COGNITIVE – Right Hand Orientate Kettle (CRHOK).

OUTPUTS: *motor behaviour …*

A small motor CA (PotN 5K), it is ignited and then supressed by CRHOK. Like MRHIK, there is probably kinaesthetic feedback which is not modelled here.

50 CA: COGNITIVE – Replace Kettle Lid with Left Hand (CRKLLH)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CRKLLH	8	3	6	5	7.8	7.9	8.2	8.3

INPUTS: CA: COGNITIVE – Right Hand Orientate Kettle (CRHOK),
CA: VISUAL – Replace Kettle Lid with Left Hand (VRKLLH).

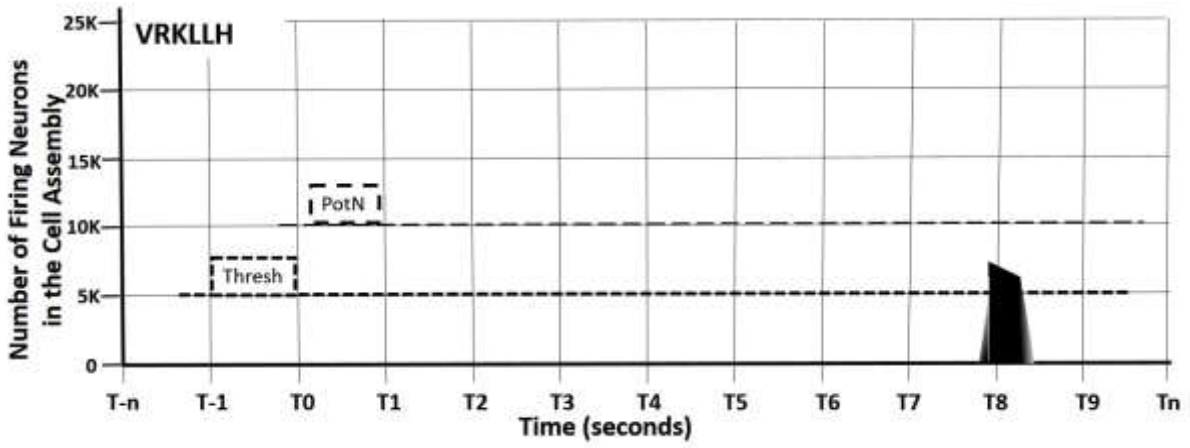
OUTPUTS: CA: VISUAL – Replace Kettle Lid with Left Hand (VRKLLH)
CA: MOTOR – Replace Kettle Lid with Left Hand (MRKLLH),
CA: COGNITIVE – Move Kettle to Tap (CMKT).

The kettle is filled through its spout so its lid is replaced by the left hand before filling. The lid has been held in roughly the correct position, slightly above the top of the kettle. The lid is nearly always accurately inserted into the kettle in a single motion under visual negative feedback control.

A slight wobble from the left wrists ensures the lid is correctly located in the final few tens of milliseconds. Whatever kinaesthetic feedback from left, and right, hands is not modelled being too fast and at too low a level of detail. In any case, bringing the hands together, with or without an intervening object, are expert skills everyone learns very early in life. Similarly, we have not modelled audio inputs, but there is a "click" when the lid locates, although this is only noticeable in its absence, e.g. when the washing machine is making so much noise that such quiet noises cannot be detected.

The CA ignites its motor component (MRKLLH) and then explicitly supresses it on confirmation that the lid is correctly in place.

51 CA: VISUAL – Replace Kettle Lid with Left Hand (VRKLLH)



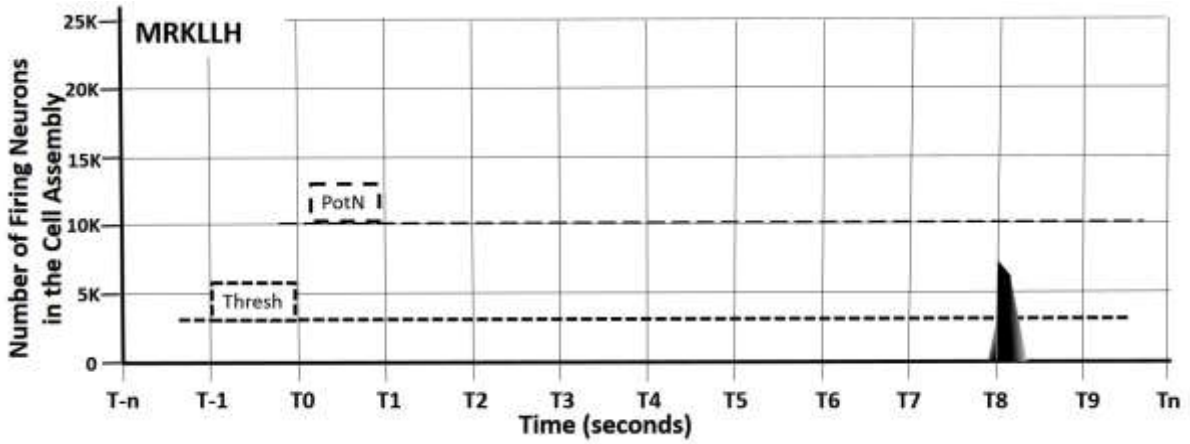
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VRKLLH	10	5	7	6	7.8	7.9	8.2	8.3

INPUTS: CA: COGNITIVE – Replace Kettle Lid with Left Hand (CRKLLH).

OUTPUTS: CA: COGNITIVE – Replace Kettle Lid with Left Hand (CRKLLH).

This is a straightforward, short distance, tracking task for the visual system. It's part of the vast suite of potential CAs involved with manipulating objects with our hands.

52 CA: MOTOR – Replace Kettle Lid with Left Hand (MRKLLH)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MRKLLH	10	3	7	6	7.9	8.0	8.1	8.2

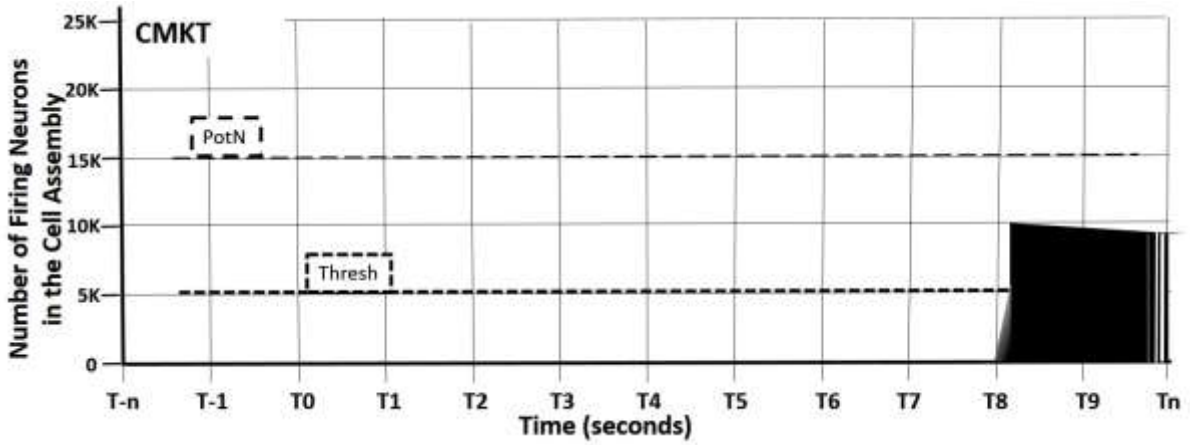
INPUTS: CA: COGNITIVE – Replace Kettle Lid with Left Hand (CRKLLH),

CA: KINAESTHETIC – Left Hand Track Kettle Lid (KLHTKL).

OUTPUTS: CA: KINAESTHETIC – Left Hand Track Kettle Lid (KLHTKL).

Ignited by CRKLLH it is then supressed by it once the kettle's lid is located. Once ignited it establishes a negative feedback loop with KLHTKL. The CA has three motor components: the movement to the kettle; a wobble to locate the lid securely; and the final operation is to move the left hand away and leave it hovering before the next behaviour, moving the left hand to operate the filter water tap's switch. Thus, the CA is relatively large (PotN 10K).

53 CA: COGNITIVE – Move Kettle to Tap (CMKT)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CMKT	15	5	10	9	8.1	8.2	-	-

INPUTS: CA: COGNITIVE – Replace Kettle Lid with Left Hand (CRKLLH),

CA: VISUAL – Tap (VT)

CA: VISUAL – Kettle (VK).

OUTPUTS: CA: VISUAL – Tap (VT)

CA: VISUAL – Kettle (VK),

CA: MOTOR – Move Kettle to Tap (MMKT).

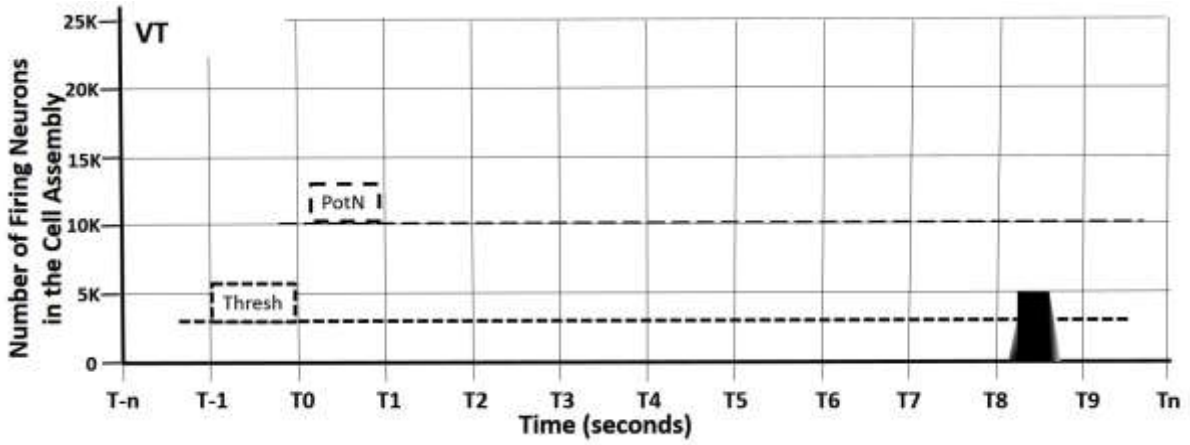
CA: MOTOR – Hold Kettle to Tap (MHKT),

CA: COGNITIVE – Move Left Hand to Tap Switch (CMLHTS)

While similar to moving the kettle to the sink (CMKS), the flight path here is only short, say 15cm, and unobstructed given the sink's usual, empty state. It is a complex behaviour in that the kettle needs some small, careful rotations under visual negative feedback control so that the kettle's spout is accurately located directly under the water filter's spout, preferably without the two touching. Hence a PotN of 15K.

The CAs final operation is to supress the movement of the kettle (MMKT) and to hold the kettle still (MHKT) while the kettle is being filled. It ignites CMLHTS to move the left hand to the filtered water's tap switch.

54 CA: VISUAL – Tap (VT)



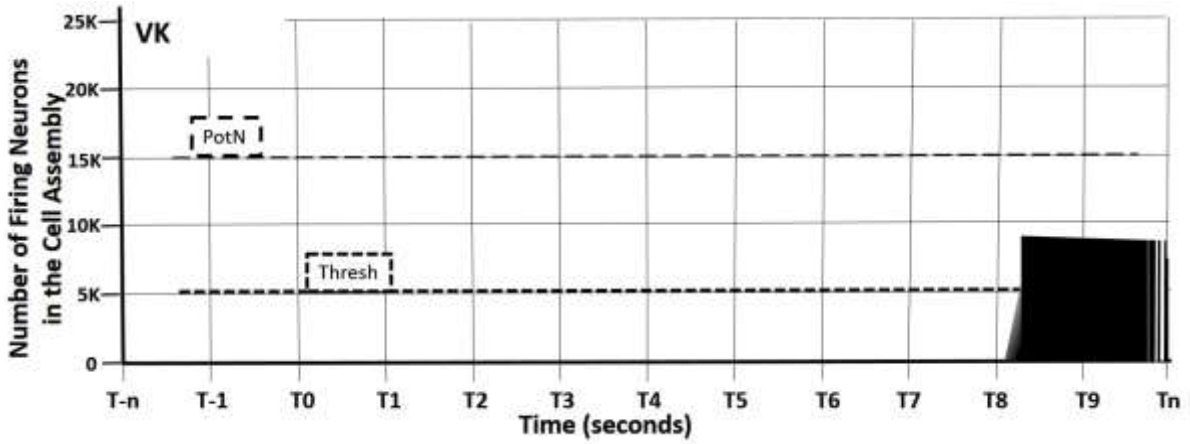
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VT	10	3	5	5	8.2	8.3	8.6	8.7

INPUTS: CA: COGNITIVE – Move Kettle to Tap (CMKT).

OUTPUTS: CA: COGNITIVE – Move Kettle to Tap (CMKT).

The filtered water tap consists of a tubular spout that rises beside the sink and turns 180 degrees vertically so that water flows down into the far right corner of the sink; the tap and spout are in a fixed position that does not change. Such invariance, unlike even in the hot water area, means that a large visual CA is not necessary (PotN 10K).

55 CA: VISUAL – Kettle (VK)



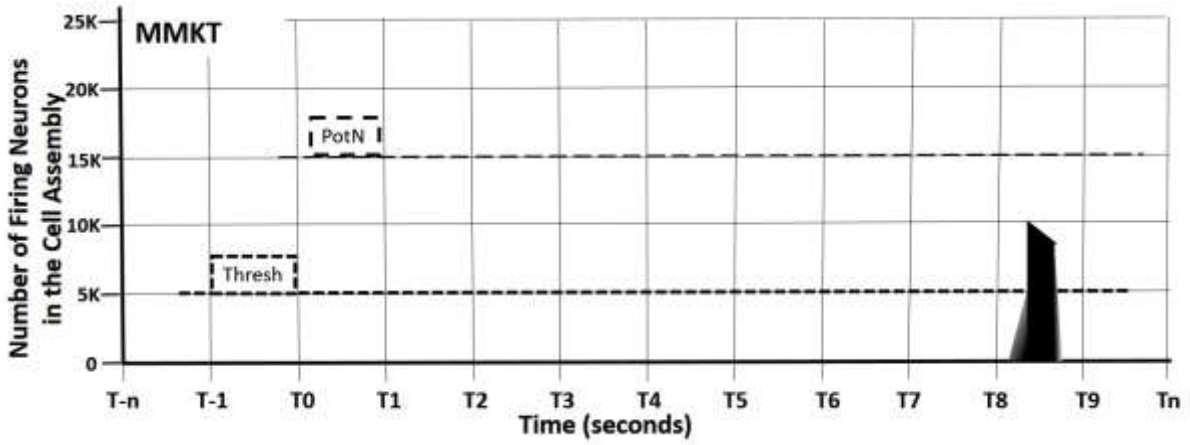
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VK	15	5	8	7	8.2	8.3	-	-

INPUTS: CA: COGNITIVE – Move Kettle to Tap (CMKT).

OUTPUTS: CA: COGNITIVE – Move Kettle to Tap (CMKT).

Visual attention is primarily on the kettle's spout and its three dimensional location with respect to the fixed location of the filtered water's spout, which is a small silver coloured target against a similarly coloured background, the sink. Visually fiddly but highly practiced, it has a PotN of 15K.

56 CA: MOTOR – Move Kettle to Tap (MMKT)



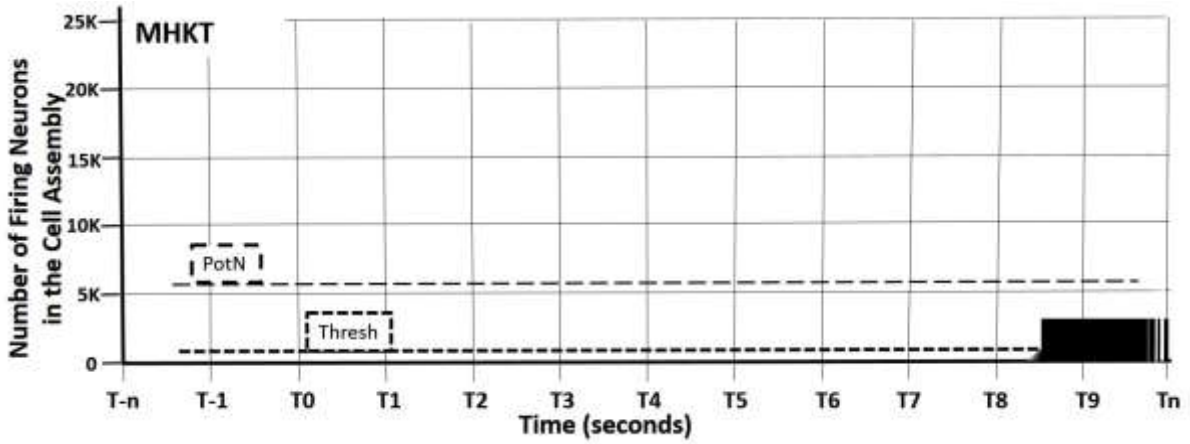
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MMKT	15	5	10	8	8.3	8.4	8.6	8.6

INPUTS: CA: COGNITIVE – Move Kettle to Tap (CMKT).

OUTPUTS: *motor behaviours …*

Involving hand, wrist and arm movement is relatively complex and requires accuracy if the kettle and tap spouts are not to make contact (PotN 15K). It is ignited by CMKT and then extinguished by CMKT so that the kettle can be held in its final, filling location (MKHT).

57 CA: MOTOR – Hold Kettle to Tap (MHKT)



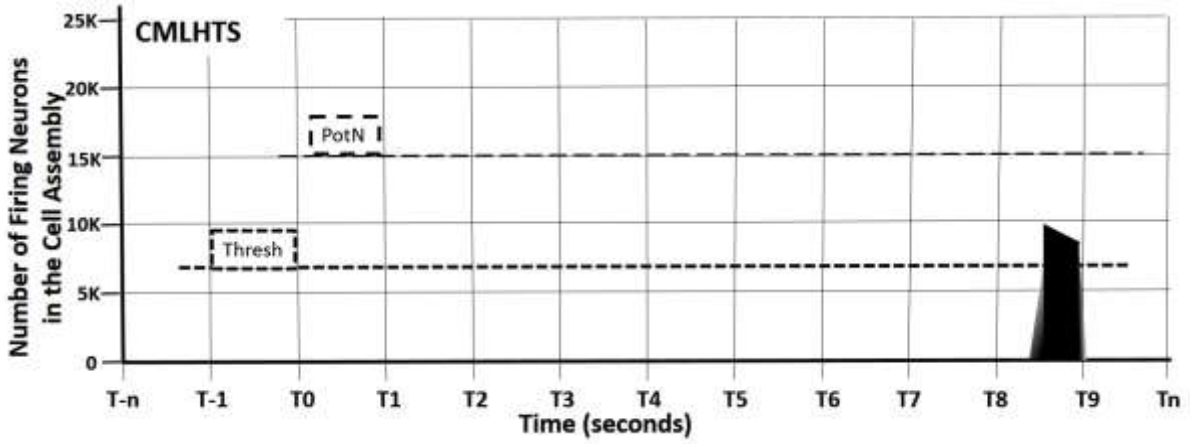
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MHKT	6	1	3	3	8.4	8.5	-	-

INPUTS: CA: COGNITIVE – Move Kettle to Tap (CMKT).

OUTPUTS: *motor behaviours …*

This is a small CA (PotN 6K) that is of a stationary class involving maintaining the position of an object. It is easily ignited (Threshold 1K) and can maintain itself indefinitely, i.e. neurons firing as other fatigue, indeed, the muscle fibres similarly fatigue and rotate contraction amongst themselves.

58 CA: COGNITIVE – Move Left Hand to Tap Switch (CMLHTS)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CMLHTS	15	7	10	8	8.3	8.5	8.9	9.0

INPUTS: CA: COGNITIVE – Move Kettle to Tap (CMKT),

CA: VISUAL – Left Hand to Tap Switch (VLHTS)

CA: VISUAL – Tap Switch (VTS),

CA: TOUCH – Left Hand on Tap Switch (TLHTS).

OUTPUTS: CA: VISUAL – Left Hand to Tap Switch (VLHTS)

CA: VISUAL – Tap Switch (VTS),

CA: MOTOR – Move Left Hand to Tap Switch (MMLHTS)

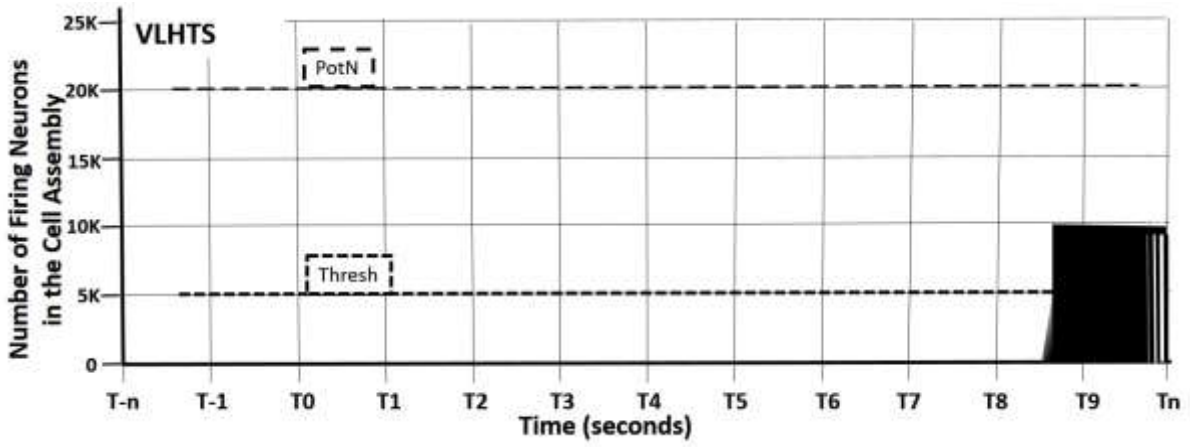
CA: TOUCH – Left Hand on Tap Switch (TLHTS),

CA: COGNITIVE: Fill Kettle (CFK).

The left hand has been hovering, waiting for the kettle to start to move towards the filtered water tap (CMKT). The hand loosely follows behind the top of the kettle and then the elbow and wrist have to make adjustments for the left hand's awkward reach behind the tap to the tap's switch. It's quite a large cognitive CA (PotN 15K) to reflect the movement's complexity and has a high threshold (7K) to reflect the variability of when the CA ignites and the reaching behaviour starts (IgTIg – P50% = 0.2 seconds, i.e. perhaps nearly half a second of priming).

With detailed observation it seems about 10% of the time the left hand takes an alternative route, in between the tap and the kettle, rather than behind both, and this seems to be determined by how close are objects behind the tap switch (an area used to stack things waiting to be washed-up) that might interfere with the left fingers. Thus, a decision is made early on by this CA as to which path the left hand will follow.

59 CA: VISUAL – Left Hand to Tap Switch (VLHTS)



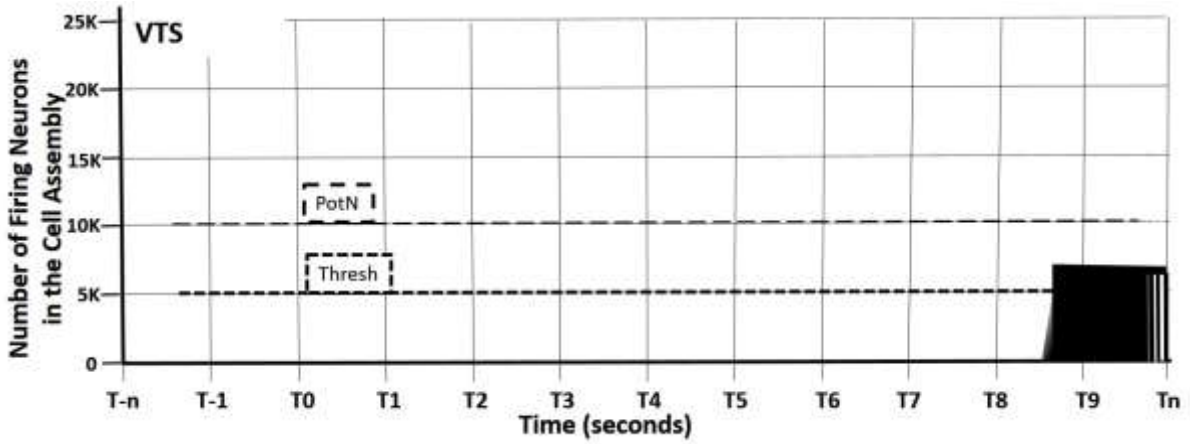
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VLHTS	20	5	10	7	8.5	8.6	-	-

INPUTS: COGNITIVE – Move Left Hand to Tap Switch (CMLHTS).

OUTPUTS: COGNITIVE – Move Left Hand to Tap Switch (CMLHTS).

The CA is larger than one might initially expect (PotN 20K) because of the awkwardness of the movement, first tracking the kettle top and then providing feedback to control adjusting the hand to reach behind the tap to the switch.

60 CA: VISUAL – Tap Switch (VTS)



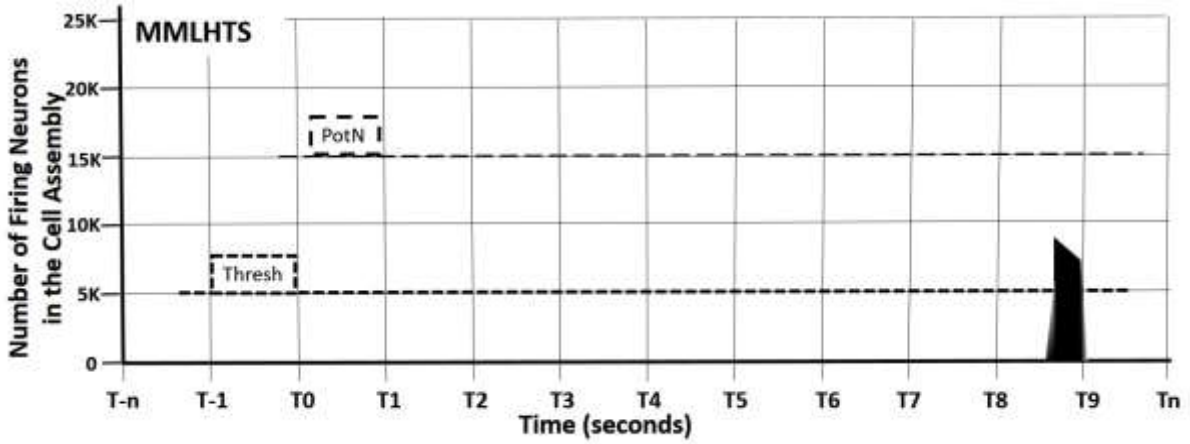
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
VTS	10	5	7	6	8.6	8.7	-	-

INPUTS: COGNITIVE – Move Left Hand to Tap Switch (CMLHTS).

OUTPUTS: COGNITIVE – Move left Hand to Tap switch (CMLHTS).

The invariance of the filtered water tap's location means that this is small for a visual CA (PotN 10K). Indeed, while this CA rationally needs to exist, one might suggest that its effect on behaviour is limited and perhaps, if the tap switch were absent (broken off), then CMLHTS and MMLTS would still ignite and the hand reach the switch before its absence was discovered, perhaps even discovered kinaesthetically (TLHTS).

61 CA: MOTOR – Move Left Hand to Tap Switch (MMLHTS)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MMLHTS	15	5	8	7	8.7	8.7	8.9	9.0

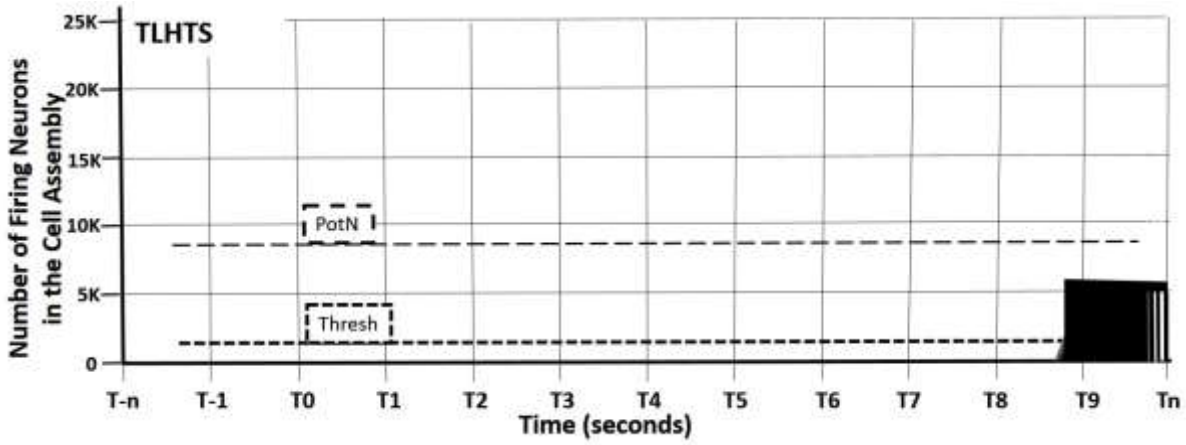
INPUTS: COGNITIVE – Move Left Hand to tap Switch (CMLHTS).

OUTPUTS: *motor behaviour …*

With a PotN of 15K, this is a relatively large motor CA to reflect the compound nature of the behaviour. At a lower level of analysis this CA might be broken into several tightly bound

ones, although some CAA models might still prefer a single CA as used here. It is ignited and then extinguished by CMLHTS. The latter based on touch feedback (TLHTS).

62 CA: TOUCH –Left Hand on Tap Switch (TLHTS)



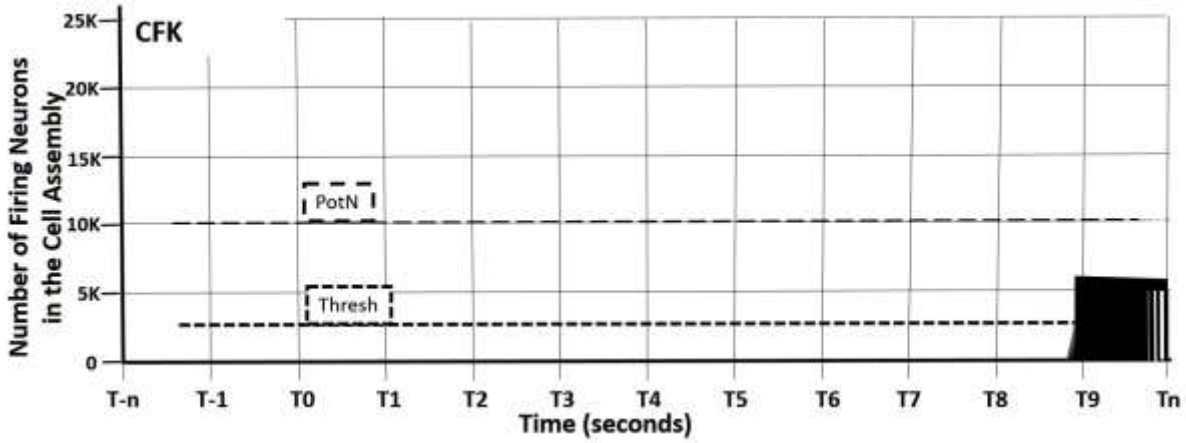
ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
TLHTS	8	2	6	5	8.7	8.8	-	-

INPUTS: COGNITIVE – Move Left Hand to Tap Switch (CMLHTS).

OUTPUTS: COGNITIVE – Move left Hand to Tap switch (CMLHTS).

The left hand's final approach behind the tap switch target might be described as a fumble; whether it's the first two or the middle pair of fingers which come to rest under the switch appears to vary across task performances. An alternative description is that this CA is one of a common class of small ones (here PotN = 8K) that are used in fixed environments, are highly practiced, and use only limited visual feedback for approximate control, instead relying on a final fumble and negative feedback from touching the target object (putting one's coffee mug down on one's desk while still looking at the computer screen might be a particularly common example).

63 CA: COGNITIVE – Fill Kettle (CFK)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
CFK	10	3	7	6	8.8	8.9	-	-

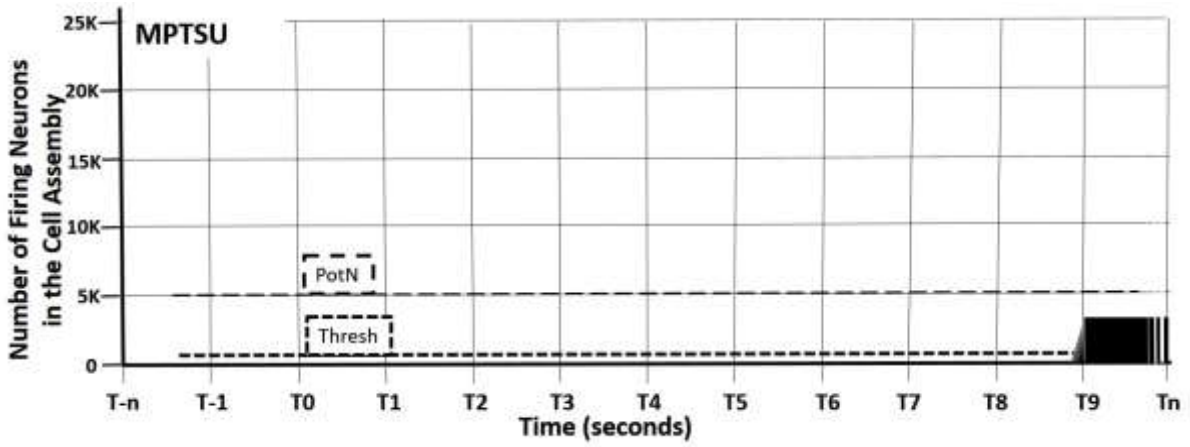
INPUTS: CA: COGNITIVE – Move Left Hand to Tap Switch (CMLHTS).

OUTPUTS: CA: MOTOR – Pull Tap Switch Up (MPTSU),

CA: COGNITIVE – Make Coffee (CMC).

Ignition of this CA starts the first of three long pauses in the making a mug of coffee task; the other, longer two, are (1) boiling the kettle; and (2) waiting for the coffee to filter into the mug. It doesn't have to be a large CA (PotN 10K) as it needs only to ignite MPTSU to start the kettle filling process and then to reignite CMC.

64 CA: MOTOR – Pull Tap Switch Up (MPTSU)



ID	PotN	Thresh	IgMax	IgFat	P50%	IgTIg	IgTEx	D50%
MPTSU	5	1	3	3	8.9	9.0	-	-

INPUTS: CA: COGNITIVE – Fill Kettle (CFK)

This involves a simple flick of the fingers upwards under open loop control (PotN 5K). After this flick the left hand may or may not be removed from the tap switch, immediately or at some later time during the filling process; this depends on other mental activities during the filling time.

03 CA: Cognitive – Make Coffee (CMC) …

This is the end of the 'First Steps to Making Coffee' analysis. At this point there remains ten ignited CAs:

CRHH & MRHH – The right hand is holding the kettle by its handle.

CS & VS – The sink is still a major feature of the task environment.

CMKT & MHKT – The kettle is held to the tap as the kettle fills.

VK – The kettle remains a major object in the task environment.

TLHTS, CFK & MPTSU – The left hand may make a variety of movements, including none, after the end of the analysis period.