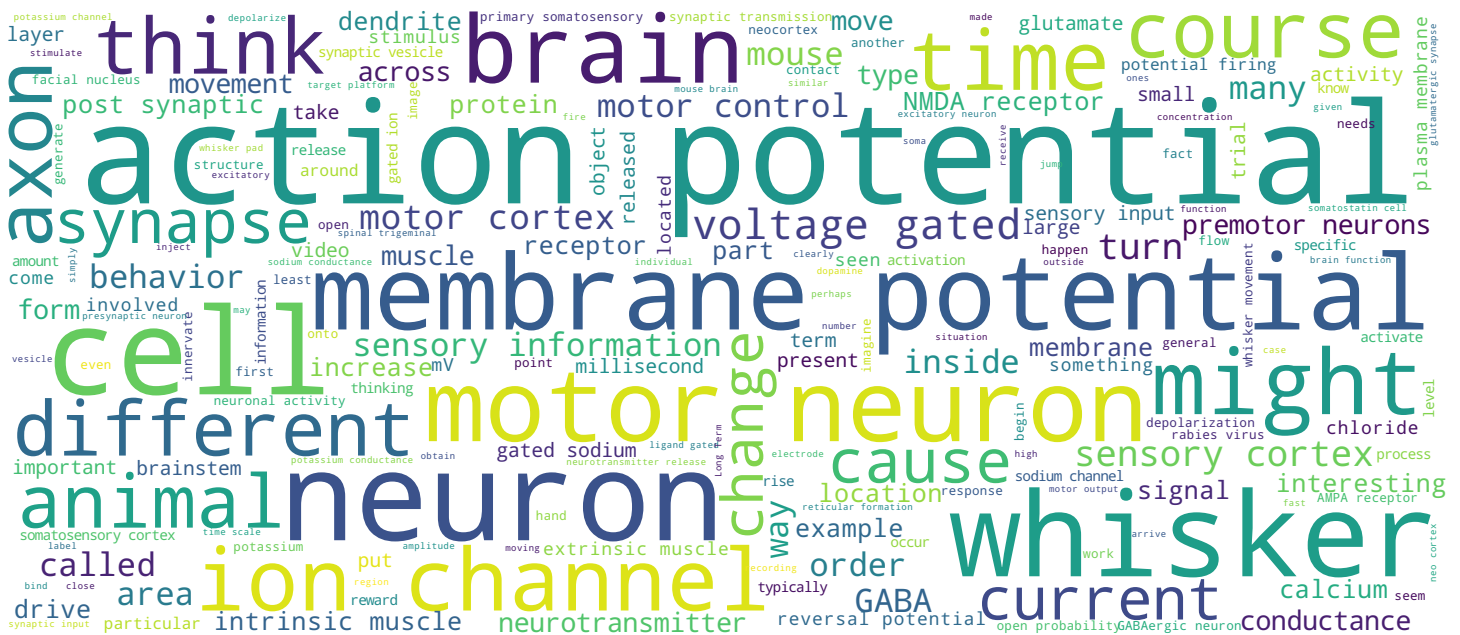
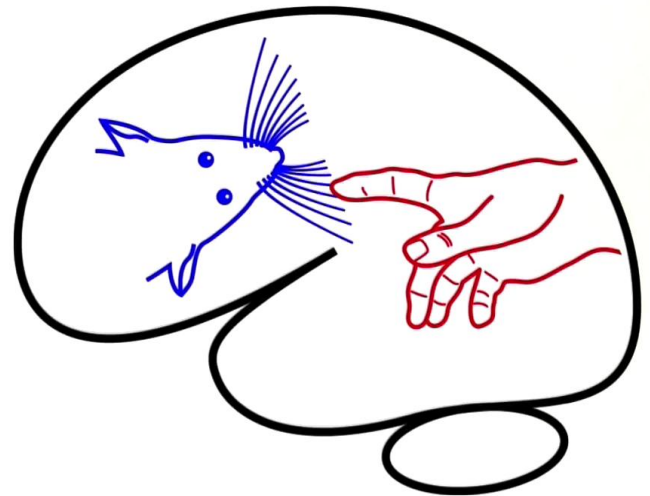


Cellular Mechanisms of Brain Function

Prof. Carl Petersen



Active sensing



Cellular Mechanisms of Brain Function

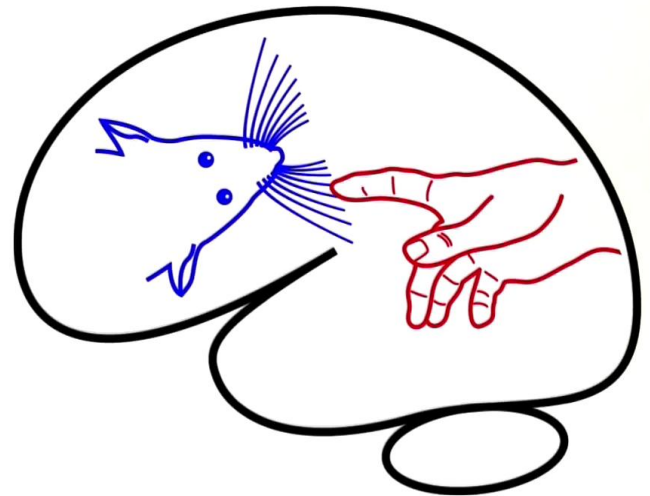
Welcome to the final week of cellular mechanisms of brain function. We've come a long way since we began this course where we discussed lipid membranes and protein ion channels until last week when we discussed the methods for studying the mouse brain during behavior. As we think about behavior, it becomes apparent that we need to understand motor control. Behavior is nothing but muscle contractions and the control of those muscular contractions is the movement that we call behavior. And so, now we'll begin thinking about motor control and as we think about motor control it becomes apparent that sensory input to motor control is one of the major impacts. We govern our lives, our movements, our behaviors by thinking about the incoming sensory information. And so, sensory input to motor control centers is a key way that determines behavior. Equally important is to think about the converse that motor control affects sensory input to the brain. So, for example, if we think about how we look at the world around us we make head and eye movements and we select regions of interest in the visual field that we'd like to pay attention to.

Notes

Summary



0m 05s



Cellular Mechanisms of Brain Function

And so, as a first order approximation we choose the visual information, that falls on the retina and that flows into the brain. Equally, if we think about our sense of touch, it's very obvious that the way that we move our hands and our fingertips determines the tactile sensory information that we obtain, so in order to get the information about the texture of an object we need to stroke that object with our fingertips and it's the movement of the finger that generates the flow of sensory information. So the sense of touch and vision are dominated to a large extent by self-generated movements that form the so-called *basis of active sensing* where we select the type of sensory information we want to obtain by making specific goal-directed movements.

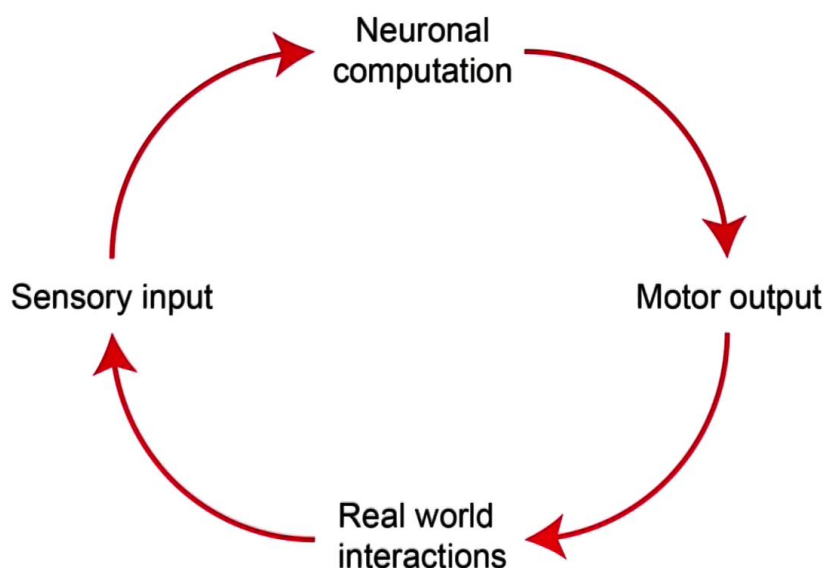
Notes

Summary



1m 26s

Sensorimotor loops



Cellular Mechanisms of Brain Function

So we can think of the basis of behavior as a sensorimotor loop which neither has a beginning nor an end but we can enter it at any point we want. We can think about neuronal computations that, of course, are influenced by sensory information that's been gathered and that generates motor output behavior and that motor output, of course, interacts with the real world. We might move our hands against an object or move our eyes and then the visual field will change and give rise to different sensory input that then, in turn, influences the neuronal computation. And in that way we have sensorimotor loops that are the most important determinants of behavior.

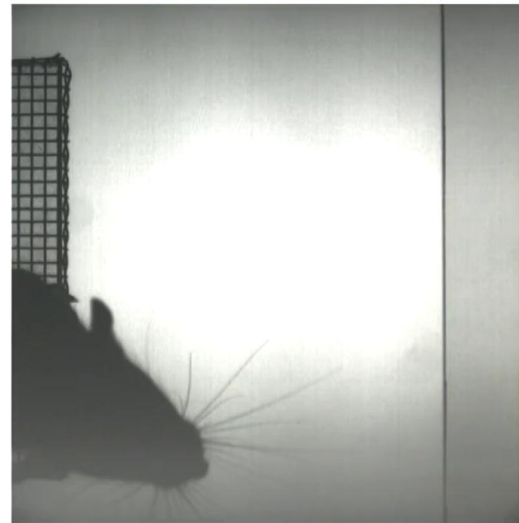
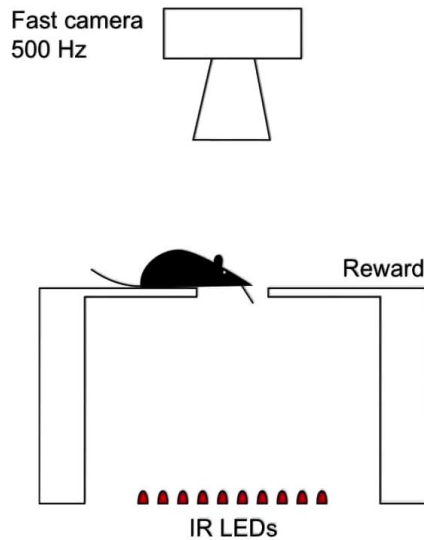
Notes

Summary



2m 20s

Active whisker sensing



Petersen, 2007

Cellular Mechanisms of Brain Function

In this video we'll consider the Mouse Whisker System which is one of the key systems being analyzed at the moment for active sensing. Mice are nocturnal animals, they live in tunnels and one way in which they can obtain spatial information about their immediate surroundings is by using their whiskers which they actively move around to explore their environment. And the first thing I'd like to show you is a behavioral paradigm where we can see just how they use their whiskers to get special information. In the so called gap crossing task that was developed by Hutson and Masterton a mouse is placed on an elevated platform. It's in the dark under infrared illumination and what the mouse needs to do is to identify the location of a target platform, where it needs to jump over and then when it does so, it receives a reward. The gap between this two platforms is so large that the only way that the mouse can identify the location of this target platform is by using its whiskers to reach across this gap. We're gonna look at a movie where we'll film from above and we'll see the silhouette of the mouse with its whiskers stands on one platform and reaches across space to touch a target platform where it needs to jump to to obtain its reward.

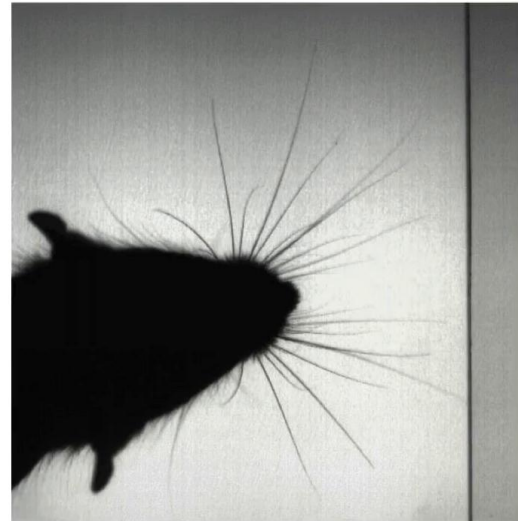
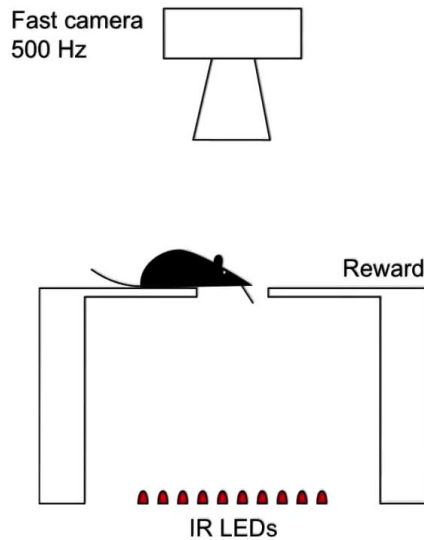
Notes

Summary



3m 04s

Active whisker sensing



Petersen, 2007

Cellular Mechanisms of Brain Function

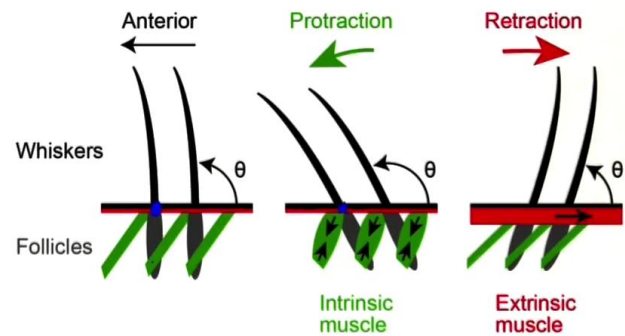
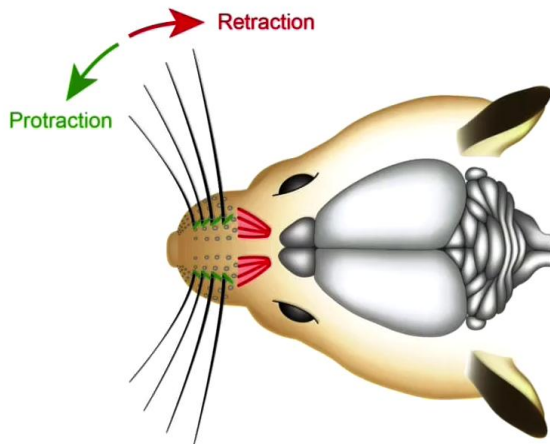
So, here you see the mouse touching the target platform and when it's built up sufficient confidence, it jumps and now it's enjoying its snack. now that all happen rather quickly, so, let's look at that slowed down twenty times and zoomed in on this area where the animal's whiskers are contacting the target platform. Now the individual movements of the whiskers become obvious and you'll see that most of the time the whiskers move at the same time both left and right and they move in concert with each other but sometimes they become out of phase and they move individually and if one begins to quantify the movements of the individual whiskers you can actually see that each whisker is individually under its own motor control. So, clearly, if we're gonna understand how the animal perceives its environment here and gets sensory information under these conditions it becomes important to look at the mechanisms driving motor control.

Notes

Summary



Muscles driving whisker movements



Petersen, 2014

Intrinsic muscles

Extrinsic muscle
nasolabialis

Cellular Mechanisms of Brain Function

Notes

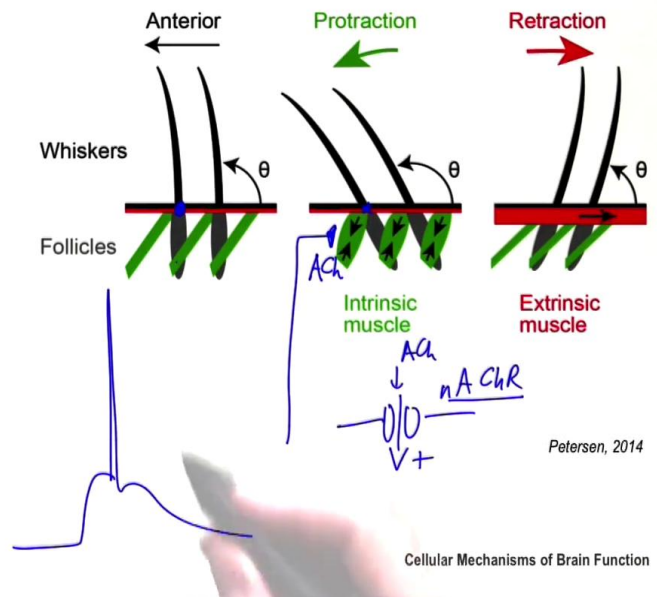
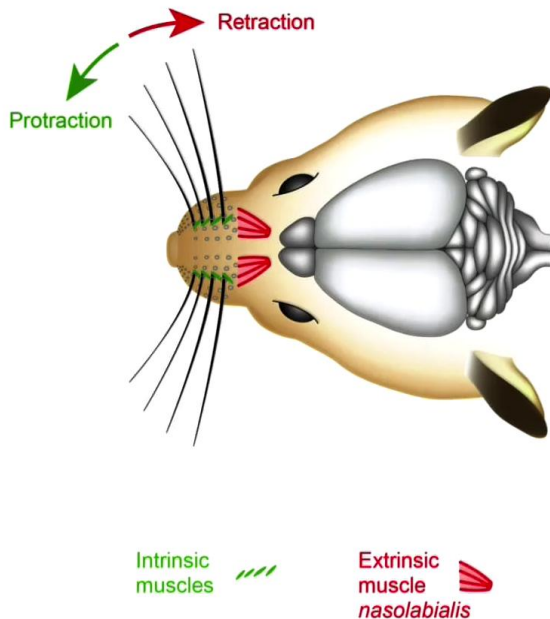
So, how *does* the mouse control its whisker movements? There are two important sets of muscles that are involved in generating whisker movements. There are so-called intrinsic muscles shown here in green that are located entirely within the whisker pad and attached to each whisker is its own individual intrinsic muscle, it attaches at the base of one follicle and at the whisker behind it at the top. When this muscle contracts the whisker pivots around its insertion point here in the skin and is rotated anteriorly in a protraction movement, so the whisker moves forwards through the contraction of this intrinsic muscle and is pivoting around its insertion point. So, the intrinsic muscle here, drives whisker protraction as the animal reaches out in front of it to touch an object. The other important group of muscles are the so-called extrinsic muscles that are anchored onto bone outside the whisker pad and when they contract they pull the whiskers backwards. So, this extrinsic muscles here are relatively superficial in the whisker pad, when they contract they pull the whiskers backwards causing whisker retraction. So, we have intrinsic muscle that generates protraction and we have extrinsic muscle that generates retraction of the whisker.

Summary



5m 29s

Muscles driving whisker movements



These muscles are under neuronal control. So, each muscle is innervated by an axon from the so-called motor neuron and these motor neurons release neurotransmitter onto the muscle. And so, the junction between neurons and muscle is a synapse, a chemical synapse very similar to the synapses we've been thinking about within the central nervous system. At the neuromuscular junction the neurotransmitter that's being released is called acetylcholine. And acetylcholine is released from synaptic vesicles just like in the nervous system and it acts upon postsynaptic ligand-gated ion channels so called nicotinic acetylcholine receptors. So the acetylcholine is released from the motor neuron axon, it activates the ligand-gated ion channel, the nicotinic acetylcholine receptor. That causes an influx of cations, Sodium importantly, causes a postsynaptic depolarization and muscle is also excitable. So in fact, the muscle gets depolarized and fires an action potential. Just like a neuron would. That action potential in the muscle causes a rise in cytosolic calcium concentration and that rise in calcium is what then drives the biochemical reactions that cause muscular contraction.

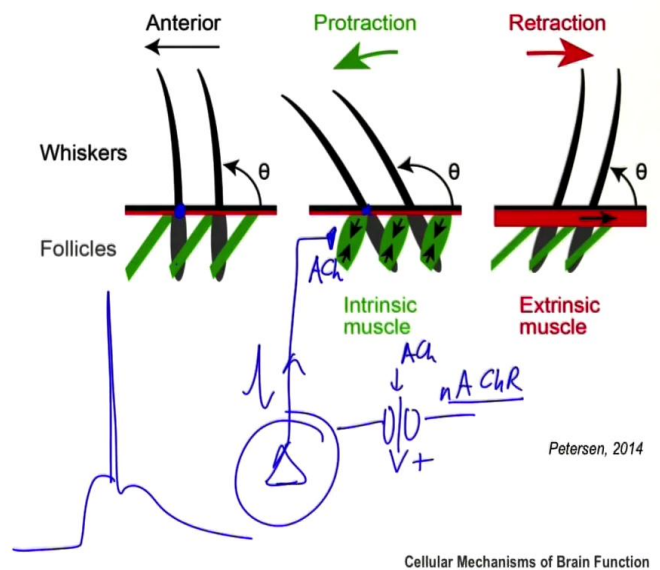
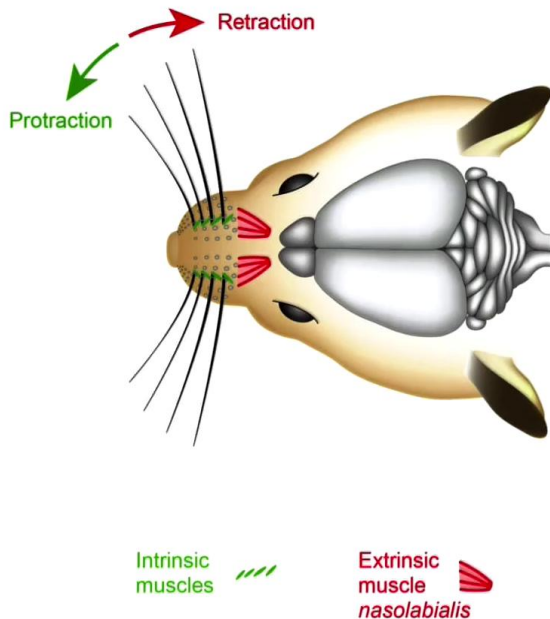
Notes

Summary



6m 59s

Muscles driving whisker movements



So, action potentials here in the motor neurons drive muscle contraction and can then move the whiskers forwards or backwards and of course the same is true across all the muscles in our body. Acetylcholine is the neurotransmitter at the neuromuscular junction. So now in order to understand how these whiskers are moved we then clearly need to know where the neurons are that innervate these muscles.

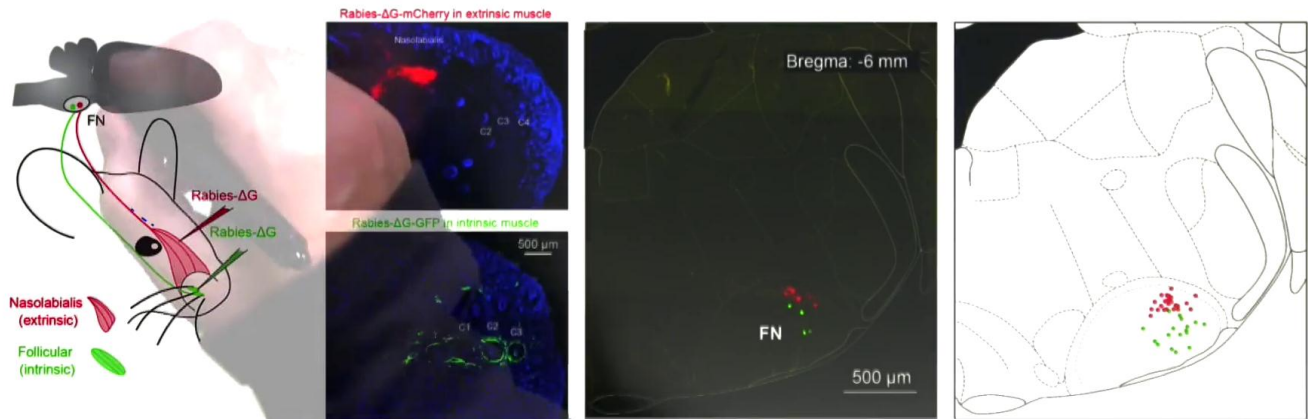
Notes

Summary



8m 23s

Motor neurons driving whisker movements



Sreenivasan, Karmakar, Rijli and Petersen, 2015

Cellular Mechanisms of Brain Function

In order to localize where these circled motor neurons are, the ones that directly innervate muscle, we can use viral tools, highly genetically engineered viruses like the rabies virus here that's been modified through genetic engineering by Ian Wickersham and Ed Callaway. If we inject a red variant of rabies virus, expressing so called mCherry fluorescent protein into the extrinsic muscle, that then gets taken up by the axonal junctions, retrogradely transported along the axon and then it labels the locations of the neurons that project here where the motor neurons are. We can also inject rabies virus into the intrinsic muscle and label then the motor neurons that innervate the intrinsic muscle. We can have two different variants. We can have a red one for the extrinsic, a green one, G green fluorescent protein injected into intrinsic muscle, so these are the pictures here: the whisker pad, the injections of virus here into the whisker pad labelling the axons here of the motor neurons and here into the extrinsic muscle labelling again the motor neurons. If we now cut sections here of the brainstem, we can then see the location of where the motor neurons are.

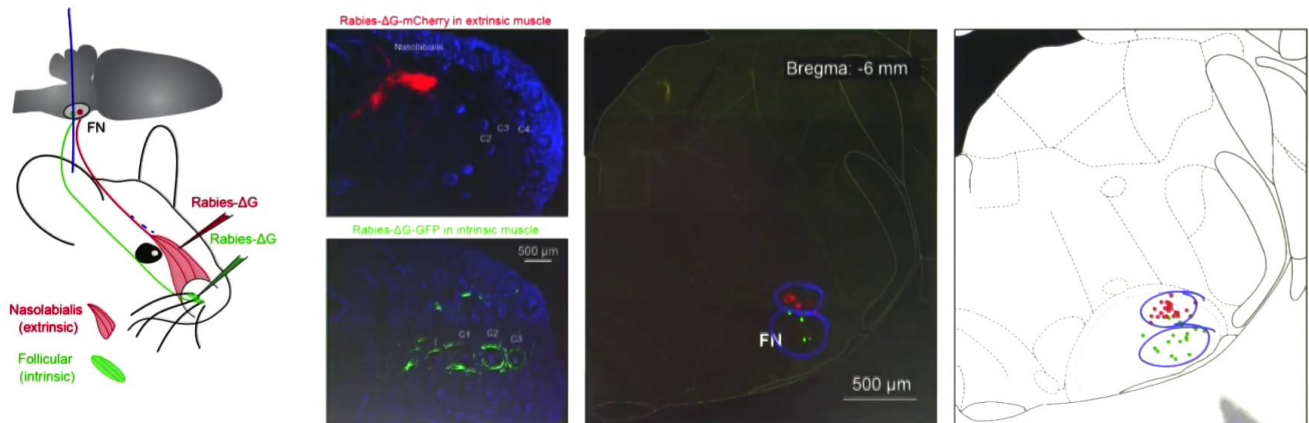
Notes

Summary



8m 51s

Motor neurons driving whisker movements



Sreenivasan, Karmakar, Rijli and Petersen, 2015

Cellular Mechanisms of Brain Function

So here's one of these coronal sections here taken through the brainstem and here ipsilateral to the same side where the muscles are we see the locations of the cell bodies of the motor neurons. So these are now cholinergic neurons so they release acetylcholine here onto the muscle and this is the cell body and also, of course, they have dendrites all around here that are more difficult to see. You can also see that the location of the motor neurons for the extrinsic muscle are in a slightly different location to the motor neurons for the intrinsic muscle. And this is an individual example and this is a group representation of where in general we find the extrinsic and the intrinsic groups of motor neurons. So here you can see one of the general principles of organization of motor neurons. And that is that the motor neurons that innervate a given muscle type are located close to each other, in a cluster. So these motor neuron pools innervate different muscles and that's typical throughout the spinal cord and brainstem. That the cholinergic motor neurons that innervate a given muscle are located close to each other in a tightly segregated region.

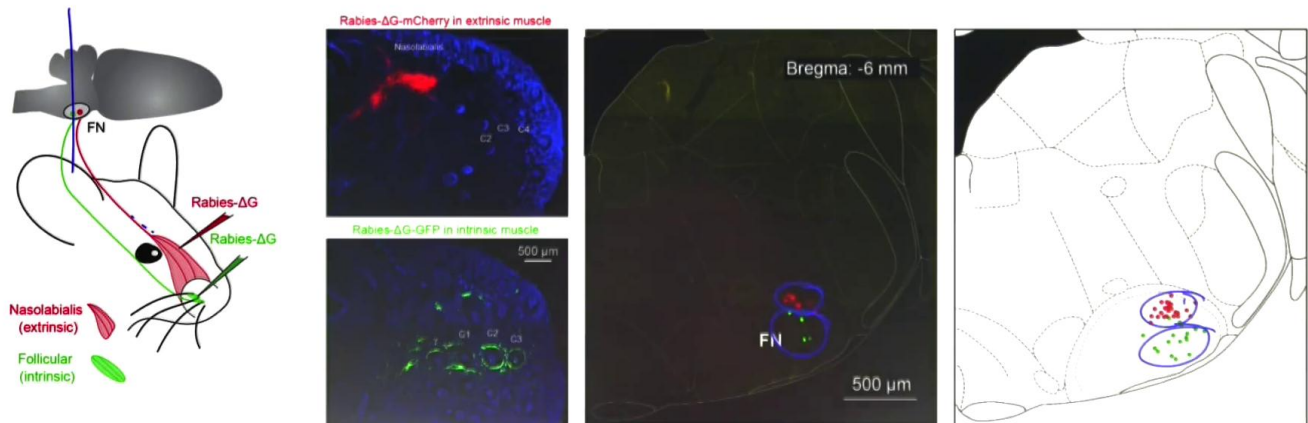
Notes

Summary



10m 12s

Motor neurons driving whisker movements



Sreenivasan, Karmakar, Rijli and Petersen, 2015

Cellular Mechanisms of Brain Function

And here the two different muscles that cause retraction or protraction of the whisker are located in different areas of the brainstem, in the facial nucleus, where all the motor neurons are that govern facial movements. Now, in order to understand what controls action potential firing in these motor neurons, we need to look and see where do they receive their synaptic inputs. So, like all other neurons, they have dendrites and they receive glutamatergic and GABAergic and glycinergic input distributed across their somatodendritic arborization and the reason that these guys fire action potentials is because of the synaptic input that they receive. So we need to know what are the presynaptic neurons to these motor neurons.

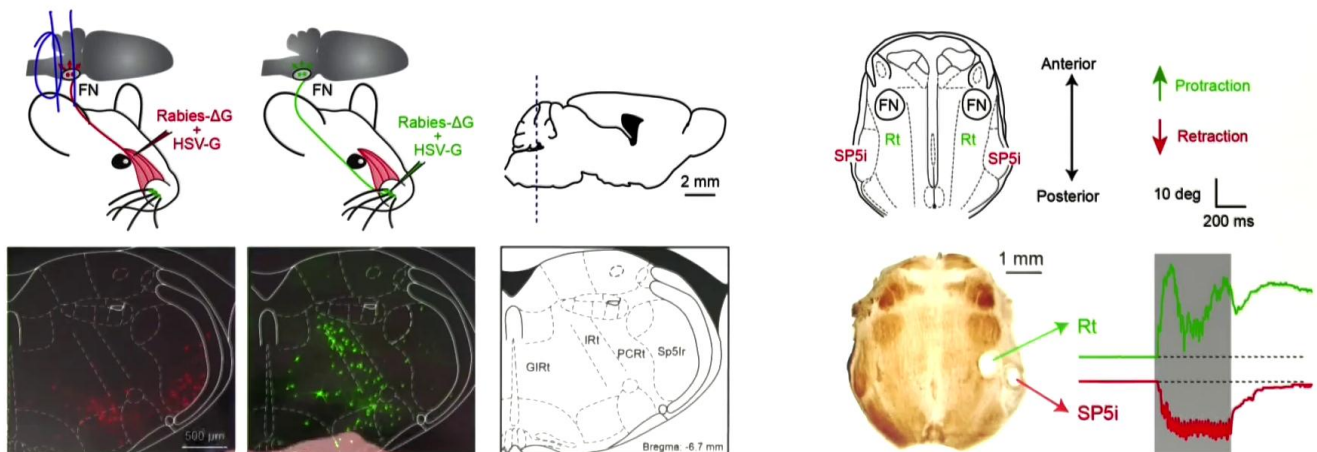
Notes

Summary



11m 27s

Mapping premotor neurons



Sreenivasan, Karmakar, Rijli and Petersen, 2015
Matyas, Sreenivasan, Marbach, Wacongne, Barsy, Mateo, Aronoff and Petersen, 2010

Cellular Mechanisms of Brain Function

And the presynaptic neurons to motor neurons are called premotor neurons. These are the ones that give synaptic input onto motor neurons. And we can use a trick with the rabies virus to label the presynaptic neurons of the motor neurons. So, as before, we inject the rabies virus to infect the motor neurons and then we complement them with the missing factor that allows them to jump just one synapse back and then that labels the neurons that send synaptic input onto the motor neurons. And it turns out that premotor neurons are widely distributed across the brain in many different brain regions. And that's true for the whisker system but it's true for all of our muscles. There are many presynaptic neurons to any given motor neuron. One of the hotspots for the location of premotor neurons is hidden here, immediately behind the facial nucleus where the motor neurons are located. And here we see a couple of sections in coronal sections, immediately posterior to the facial nucleus. And you'll see that the red dot here correspond to the locations of cell bodies of premotor neurons that innervate the extrinsic muscles of these, generate retraction movements.

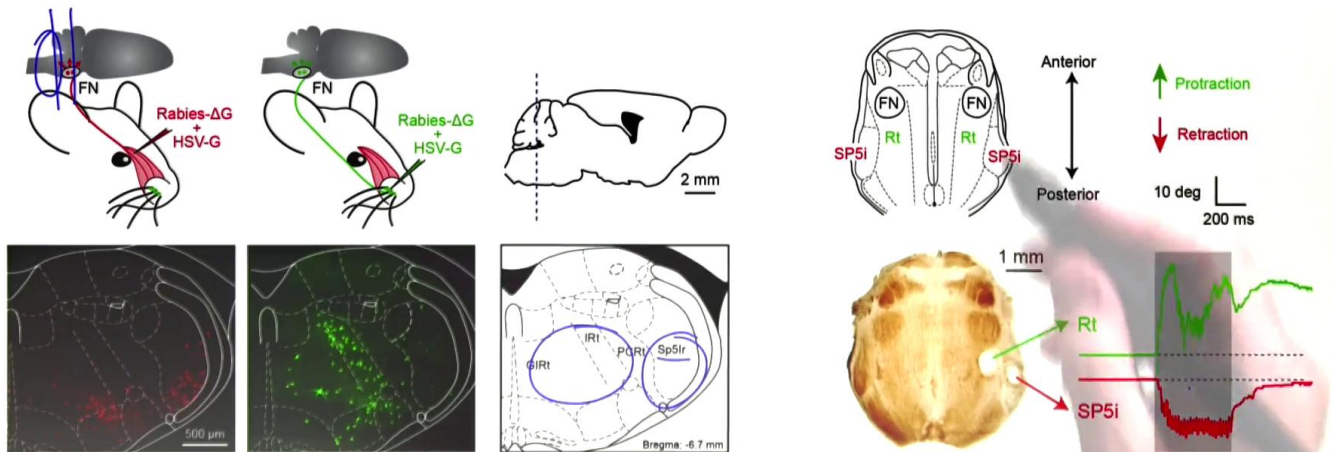
Notes

Summary



12m 13s

Mapping premotor neurons



Sreenivasan, Karmakar, Rijli and Petersen, 2015
Matyas, Sreenivasan, Marbach, Wacongne, Barsy, Mateo, Aronoff and Petersen, 2010

Cellular Mechanisms of Brain Function

And here we've injected the rabies virus into the intrinsic muscle and these are then the premotor neurons that drive protraction, contraction of the intrinsic muscles and forward movement of the whiskers. And you'll see there's an obvious difference in the lay out of the neurons innervating the retraction and the protraction whisker muscles. The retraction premotor neurons are located here in the spinal trigeminal nucleus, whereas the neurons that innervate the motor neurons that give rise to protraction movements, are set in here, in the reticular formation of the brainstem. And so there are two separate locations for where premotor neurons are located. So one would expect then that if we stimulated these neurons that would drive action potential firing in the facial nucleus motor neurons that innervate the extrinsic muscle and cause retraction of the whisker. And so if we now put a stimulation electrode here into the spinal trigeminal nucleus and we drive current through that, it turns out indeed, it does cause a retraction of the whisker. This is now a horizontal section through the brain somewhere around here where we see the horizontal section through the reticular formation and spinal trigeminal here, more laterally.

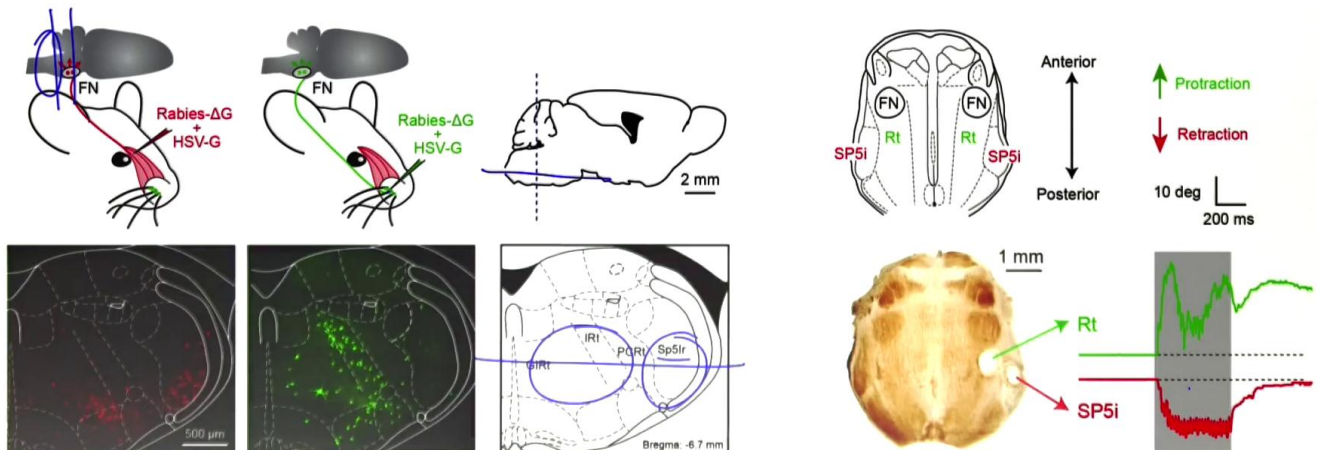
Notes

Summary



13m 33s

Mapping premotor neurons



Sreenivasan, Karmakar, Rijli and Petersen, 2015

Matyas, Sreenivasan, Marbach, Wacongne, Barsy, Mateo, Aronoff and Petersen, 2010

Cellular Mechanisms of Brain Function

We would expect that stimulating this area here might cause whisker protraction. There are many cells here, premotor neurons that innervate the intrinsic motor neurons that drive protraction of the whisker. And indeed, if we put a stimulation electrode here in the reticular formation and stimulate it electrically we see that the whisker indeed moves forwards. Compatible with our premotor mapping.

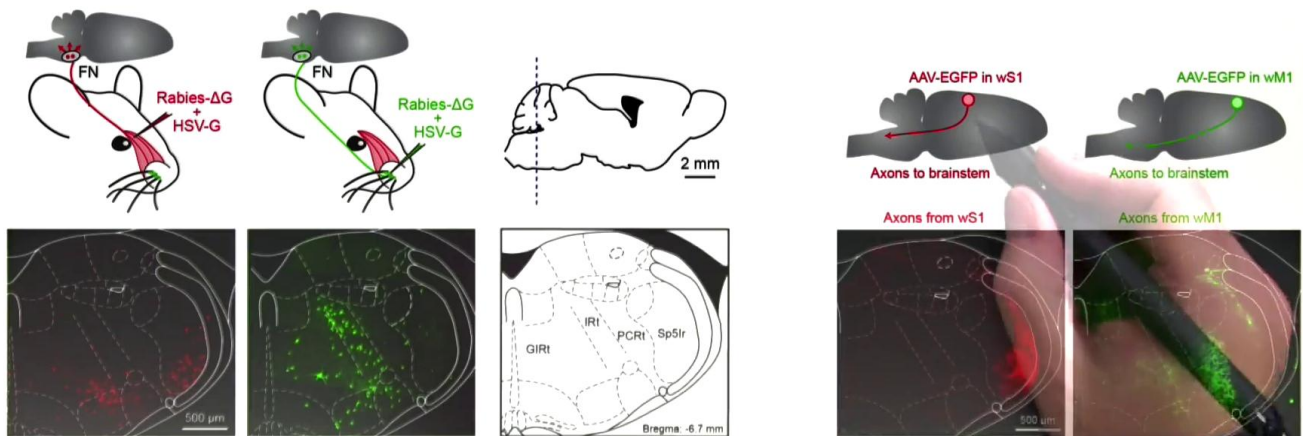
Notes

Summary



14m 51s

Cortical projections to brainstem



Sreenivasan, Karmakar, Rijli and Petersen, 2015

Cellular Mechanisms of Brain Function

Now, there are many sensory motor loops at the level of the brainstem. So sensory information, both from the whisker system and from many other types of sensory inputs impinge upon these premotor neurons. And in general, there's a great deal of local circuitry in the brainstem and the spinal cord that gives rise to reflex movements and even more complex sensorimotor contractions. However, if we're interested in volitional movement then typically this is something that results from cortical activity. So, if we're thinking about volitional control of whisker movements we might be interested in the cortical inputs to these premotor neurons. In general, cortical neurons don't connect strongly to motor neurons and most of the impact of the neo cortex upon movement is indirectly through complex brainstem and spinal cord circuits through interacting with the premotor neurons. So here, we then introduce an anterograde label for the axons into the whisker sensory cortex and into the whisker motor cortex. Two areas that we think are intimately involved in processing and generating whisker movements. If we inject this virus into the sensory cortex, we can see the axons down here in the brainstem.

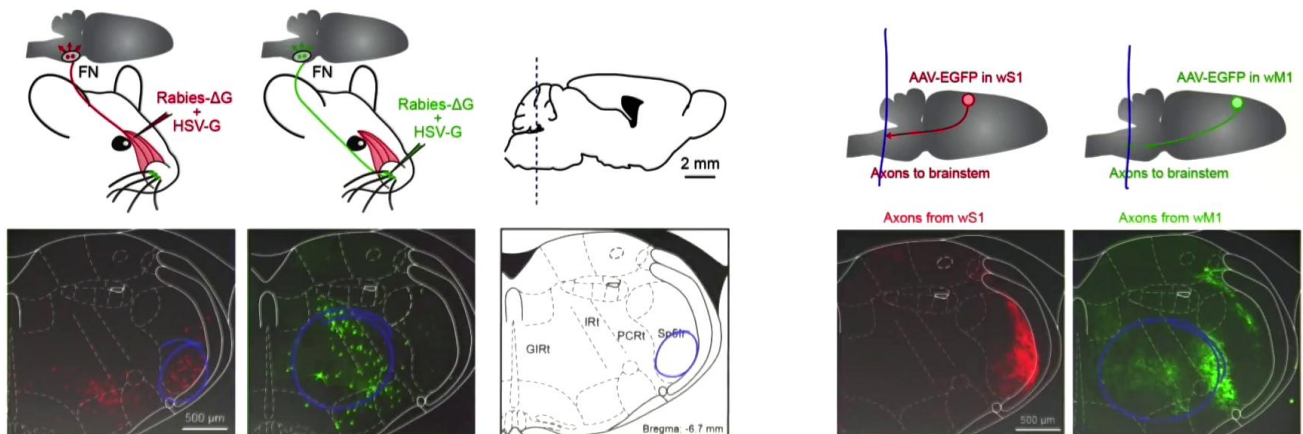
Notes

Summary



15m 14s

Cortical projections to brainstem



Sreenivasan, Karmakar, Rijli and Petersen, 2015

Cellular Mechanisms of Brain Function

If we cut a coronal section then, we can look and see that the axons are coming in here from the sensory cortex and largely innervating this spinal trigeminal interpolaris region, exactly where the extrinsic premotor neurons are located. So you might imagine then that if we stimulate sensory cortex that would release glutamate in this area, stimulate these neurons here and that should then cause a retraction of the whiskers. If we now put the virus to label the axons into the motor cortex, we then cut sections here in the brainstem and we look and see in these sections where the axon's terminating, we see that there's a great deal axon that's terminating here, in the reticular formation. And that's where there's a high density of neurons that are involved in protracting whiskers. So you might imagine that stimulating this area of motor cortex might then cause the whisker to move forwards.

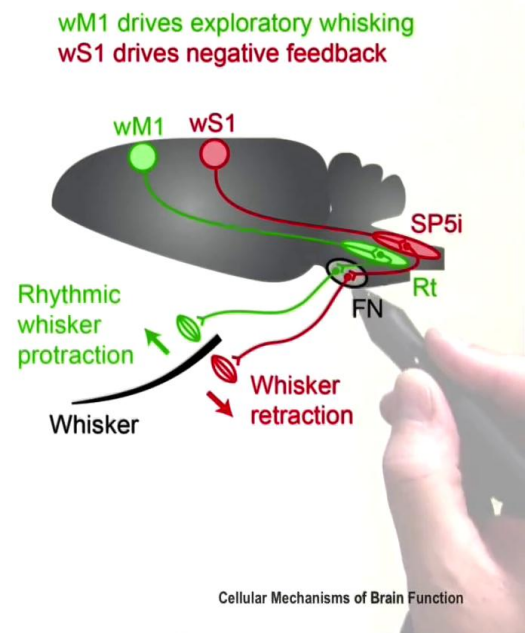
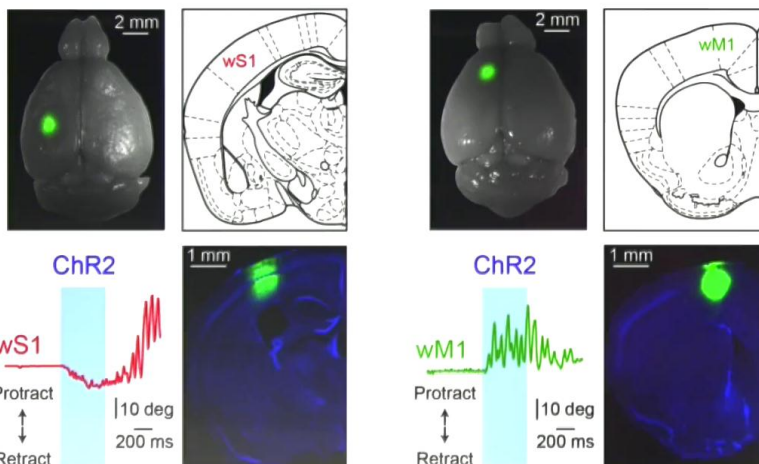
Notes

Summary



16m 37s

Cortical control of whisker movement



Sreenivasan, Karmakar, Rijli and Petersen, 2015
Matyas, Sreenivasan, Marbach, Wacongne, Barsy, Mateo, Aronoff and Petersen, 2010

So we can test this hypothesis by putting channelrhodopsin in these two different brain areas. Here we've injected a virus to express channelrhodopsin in the sensory cortex. Here we've injected channelrhodopsin into the motor cortex. This is now the fixed brains that have been removed from the animal after diffusion. While the animal was alive, we put blue light onto this spot of the cortex and saw that indeed generated a whisker retraction. So stimulation of sensory cortex causes the whisker to move backwards while stimulation of motor cortex causes the whisker to move forwards, but it does so in a more complex way, it's a rhythmic forwards and backwards movement. Very much like what we saw during the movie when the animal was performing the gap crossing task. It's this exploratory rhythmic palpation of its surroundings. So as a summary when we think about whisker motor control by the cortex, we can see that the sensory cortex sends axons down to the brainstem, innervates spinal trigeminal interpolaris nucleus. That has premotor neurons that innervate facial nucleus motor neurons. And those facial nucleus motor neurons are the ones that are involved in retracting the whisker.

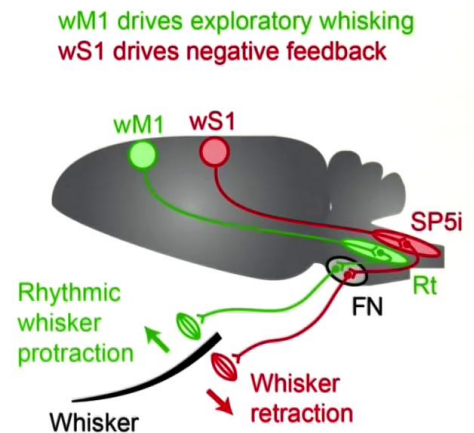
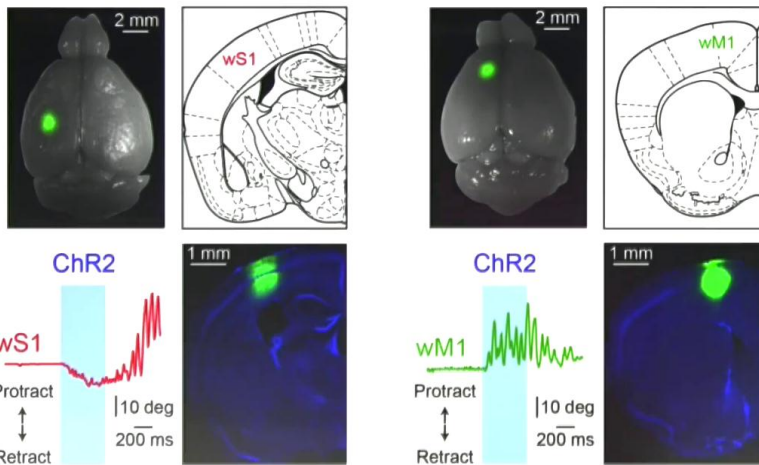
Notes

Summary



17m 30s

Cortical control of whisker movement



Sreenivasan, Karmakar, Rijli and Petersen, 2015
Matyas, Sreenivasan, Marbach, Wacongne, Barsy, Mateo, Aronoff and Petersen, 2010

Cellular Mechanisms of Brain Function

So, activity in the sensory cortex causes the whisker to move backwards and that could be viewed as a negative feedback signal. And perhaps, that's useful if we think about, say ourselves that are exploring a dark room, we're moving our arms around and when we contact the wall the first thing we might want to do is to stop moving our hand forwards. We can't bring that hand through the wall, so we need a negative feedback signal that prevents or stops that movement. So that might be one of the purposes of the sensory signals and sensory cortex, is to cause a feedback signal to driving whisker retraction. On the other hand, the whisker motor cortex does the opposite, it tries to get more sensory information and moves the whiskers forwards to try and get more sensory information to flow in. And the way it does that is by its axons that project down to the reticular formation, here there are complex neuronal circuits that probably act as central pattern generators that then innervate the rhythmic whisker protraction neurons that are the motor neurons for the intrinsic muscle that then drive the whisker to move forwards and backwards. So, frontal cortex is involved in trying to get more sensory information and the sensory cortex seems to be involved in a negative feedback signal. So there are two distinct types of cortical control signals for whisker movements.

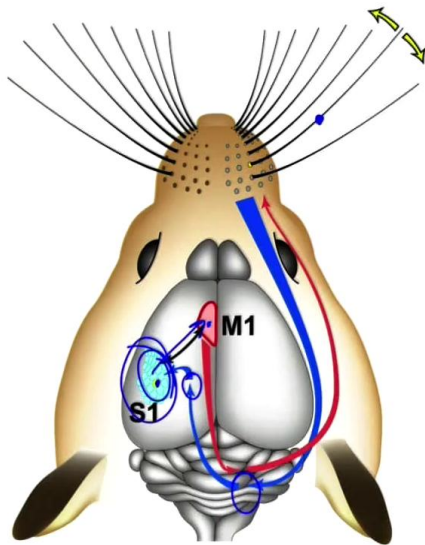
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Summary

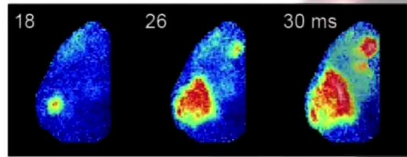
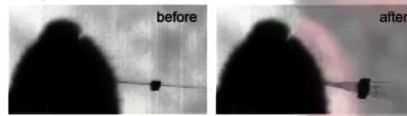


18m 41s

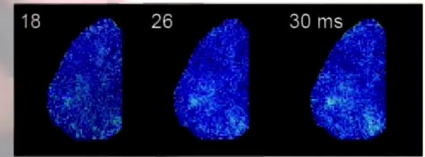
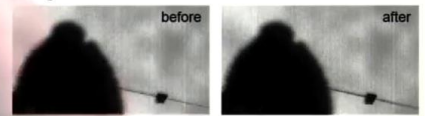
A cortical sensorimotor loop



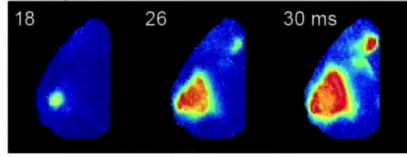
Single trial



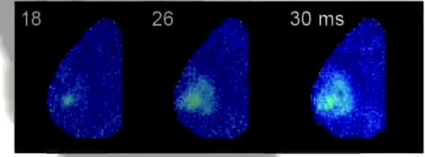
Single trial



Averaged trials



Averaged trials



Ferezou, Haiss, Gentet, Aronoff, Weber and Petersen, 2007

Cellular Mechanisms of Brain Function

So, having seen what the cortex can do when we artificially stimulate it, it's also interesting to see what types of signals occur from the periphery and whether we can follow through sensorimotor loops. And in particular here, what we do is we deliver a stimulus onto one particular whisker. The C2 whisker we have a piece of metal attached to this and there's a magnetic coil underneath. We can generate a brief one-millisecond pulse onto this whisker that then activates the signalling pathway. First, glutamatergic synapse in the brainstem. Second, glutamatergic synapse in the thalamus. Then the information is processed here in the primary somatosensory cortex. After we deliver a whisker stimulation, some tenths of a millisecond later, we can see the activity here in S1, it spreads within S1, and it also sends a signal here to the motor cortex. And we believe that's a direct monosynaptic projection from somatosensory cortex to motor cortex. What you see here is that we're also filming the behavior of the animal while we measure the activity in the brain here, with the voltage sensitive imaging technique that we've described before.

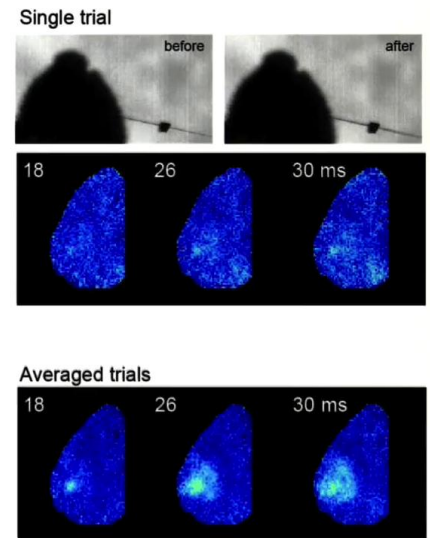
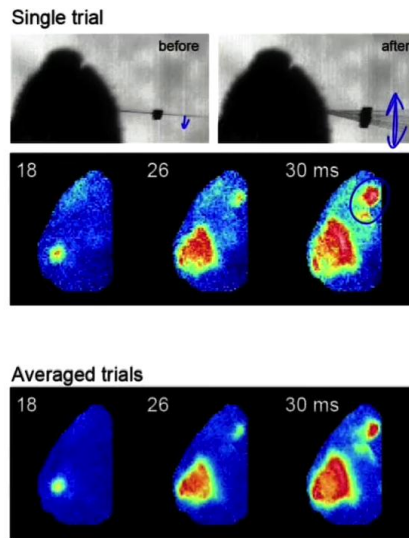
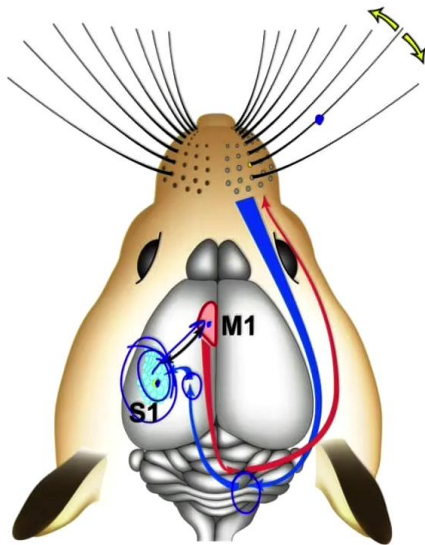
Notes

Summary



20m 07s

A cortical sensorimotor loop



Ferezou, Haiss, Gentet, Aronoff, Weber and Petersen, 2007

Cellular Mechanisms of Brain Function

The animal's sitting still at the beginning of the trial, when we deliver the stimulus but by the time we've seen this activity in sensory and motor cortex, afterwards the animal in this trial is moving its whisker, and what we think it's happening is that the animal is sitting here waiting, waiting and suddenly there's this unexpected sensory input that arrives on the whisker. And the animal might wonder "what was it in my environment that touched my whisker?" and so it stops moving its whisker around actively trying to explore, looking for the stimulus that arrived on its whisker. And of course, there is none because it's an artificial magnetic stimulus that we've delivered. And it seems that the underlying neuronal activity at least at the level of the cortex, is a large response in sensory cortex that might drive a small whisker. Retraction followed by activation of motor cortex that might then drive forwards and backwards movements as the animal actively explores its environment looking for what stimulated it. Now it turns out that there's considerable trial to trial variability especially in the neo cortex.

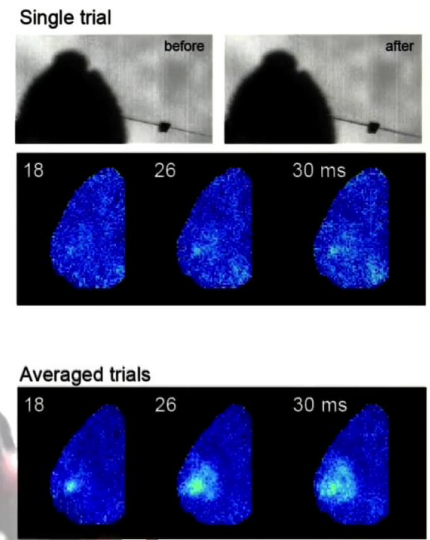
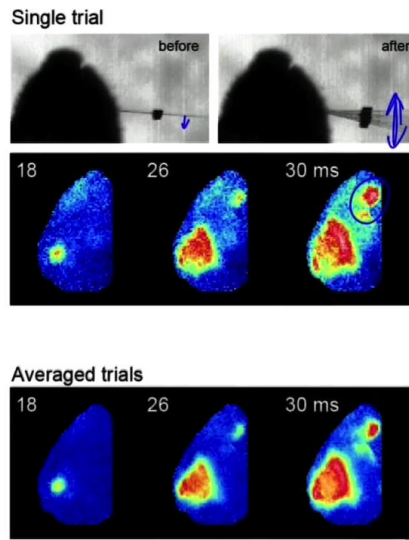
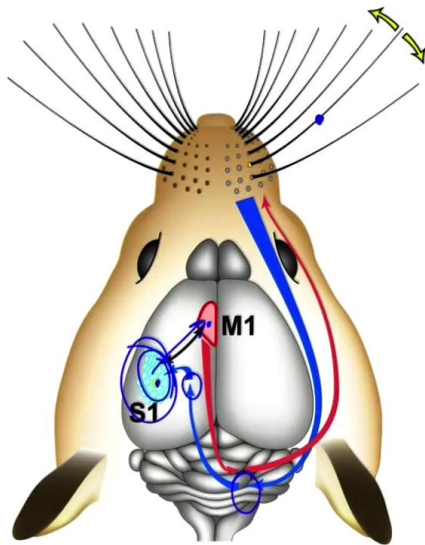
Notes

Summary



21m 17s

A cortical sensorimotor loop



Ferezou, Haiss, Gentet, Aronoff, Weber and Petersen, 2007

Cellular Mechanisms of Brain Function

So even though one gives the same sensory stimulus time after time again, each time there's a slightly different response on the neo cortex. And probably that relates to context-dependent processing of sensory information. So here is another trial where we stimulate the animal sitting still at the beginning of the stimulus but in this case, the animal doesn't make any exploratory self-generated movement afterwards. It simply ignores the stimulus and sits still. If we now look and see what happened in the brain on this trial, we'll see that there's actually a relatively small response. There's a little bit that happens here in the sensory cortex and nothing in the motor cortex. These are just two individual trials but we can select for all trials where the animal makes a sensory evoked whisker movement, and we can select for all trials where the animal makes no movement and we can see in general how the pattern of neuronal activity occurs. And you'll see that on the trials where the animal begins to move its whiskers and explore its environment, that's accompanied by large activation in sensory cortex and also substantial activation here in the motor cortex.

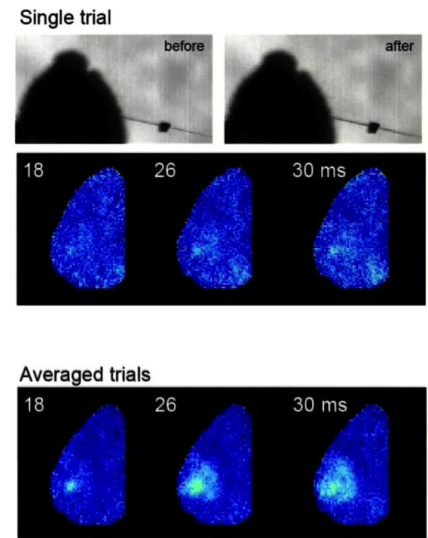
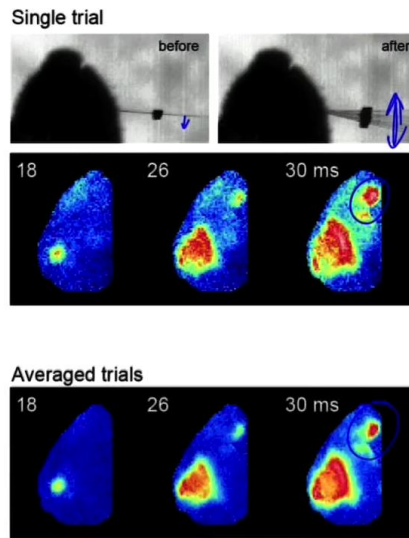
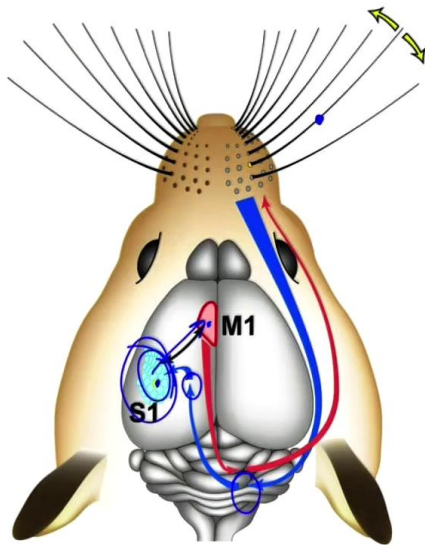
Notes

Summary



22m 21s

A cortical sensorimotor loop



Ferezou, Haiss, Gentet, Aronoff, Weber and Petersen, 2007

Cellular Mechanisms of Brain Function

Whereas on trials where the animal doesn't make any movements, it just simply ignores the stimulus, we'll see that there's a sensory response in primary somatosensory cortex, it's smaller in amplitude, and there's nothing activating the motor cortex. So, at least at the level of correlations, we can see that there's sensorimotor activity when the animal begins to actively explore its environment driven by a sensory stimulus and there's other trials where the animal ignores that stimulus and that's accompanied by very little activity in the neo cortex.

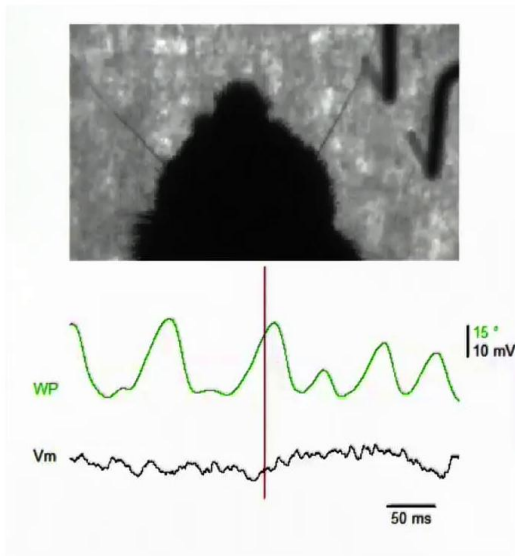
Notes

Summary

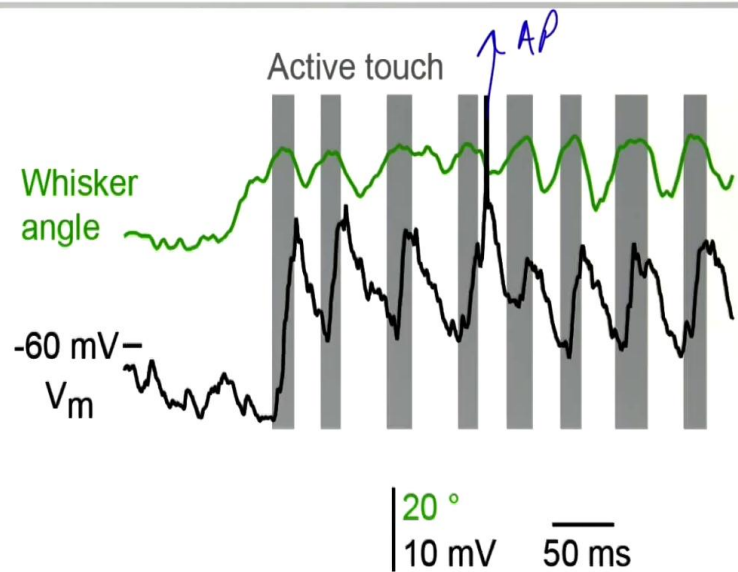


23m 27s

Active touch



Crochet, Poulet, Kremer and Petersen, 2011



Cellular Mechanisms of Brain Function

We can also go and see what happens from the other perspective. See what happens as the animal moves its whisker and contacts an object. So, here we're tracking whisker position and looking at membrane potential, below in black, and at some stage there's gonna be a drop of this pole, it drops down and then the animal's whisker is now contacting that object and as it contacts the object, there are obvious membrane potential fluctuations that correlate with sensory responses as the animal touches repeatedly this pole that's been put in its way. And if the animal needs to localize where this pole is, clearly it needs to take into account the motor position of where the whisker is as well as the timing of that contact in order to extract the position of where that pole is. Here is another example of a different cell recorded where each time the whisker is touching an object it's shaded in gray and you see every gray shaded area here correlates with a membrane potential depolarization in the cell that's being recorded. And here there are some action potentials that are being fired in response of this particular contact here. So we can see that there's active encoding of each individual touch response in the primary somatosensory cortex of the mouse. So there's a clear signal in the brain that corresponds to each active touch as the animal contacts its environment.

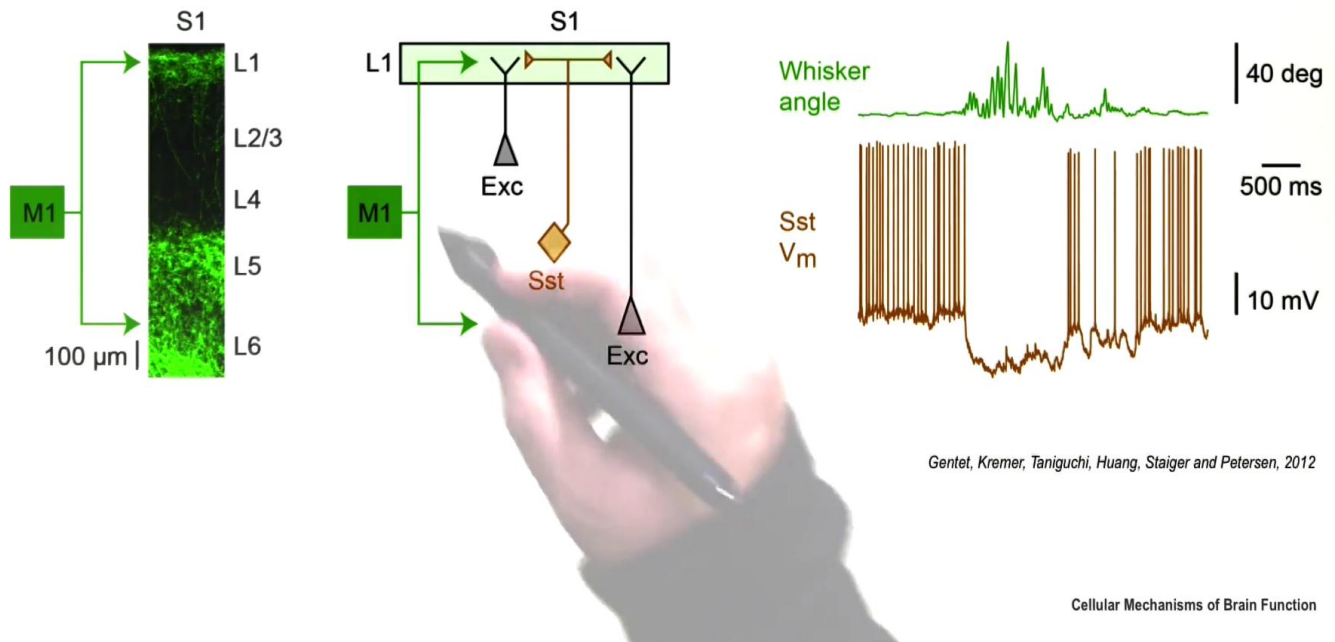
Notes

Summary



23m 58s

Cortical sensorimotor integration



Now we need to be able to put those sensory and motor signals together in order, for example, to extract the position of the object. So it's interesting to note that there's a substantial motor input to sensory cortex as well as across the sensory cortex that sends input to motor cortex so they're bidirectionally coupled. Here we just look at one aspect, that the motor control signals arrive in sensory cortex this is the axonal innervation of primary somatosensory cortex. And it seems to come in two layers, There's an upper layer of innervation here that arrives at the surface of the brain in Layer 1 and there's also deeper innervation. If we now focus our attention here, on the superficial innervation of Layer 1 that's particularly interesting because it contacts the distal dendrites of the excitatory neurons in this region and it's actively controlled by the GABAergic inhibitory neuron the somatostatin Martinotti cells that send their axons here into the upper layer of the neo cortex. So the input for motor cortex in terms of its impact upon the dendritic integration here on the excitatory neurons is regulated by how much GABA is being released by the somatostatin cells.

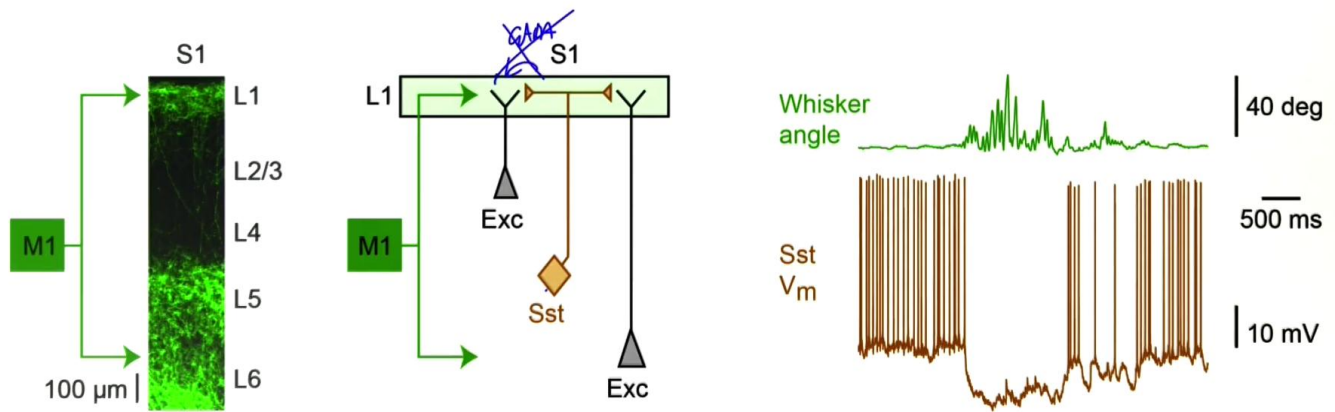
Notes

Summary



25m 27s

Cortical sensorimotor integration



Gentet, Kremer, Taniguchi, Huang, Staiger and Petersen, 2012

Cellular Mechanisms of Brain Function

When the animal's sitting still and not moving its whiskers, these somatostatin cells are firing quite actively. So they are inhibiting these distal dendrites and it may be that the motor input makes relatively little impact upon the excitatory cells. However, when the animal begins to move its whiskers, the somatostatin cells hyperpolarize, they stop firing action potentials and now, the GABAergic inhibition that was strong before, is now taken out and the motor input can now make a substantial input onto the excitatory cells. So, there's an interesting regulation of this distal dendritic input by the somatostatin cells and that then might allow for motor interactions onto the excitatory neurons. That then might help the animal interpret the sensor information coming in during active touch for example, by combining motor signals with the upcoming sensory input that also arrives, of course, in sensory cortex.

Notes

Summary



26m 39s

Sensorimotor interactions



- Understanding motor control is fundamental to understanding any form of behavior.
- Sensory information is essential for guiding motor commands, and sensory stimuli can initiate sensorimotor loops.
- Sensory information is often actively and selectively acquired.

Cellular Mechanisms of Brain Function

So in this video we've seen that if we're interested in understanding behavior, we absolutely need to investigate motor control. Motor control and movements are the very basis of any behavior and so, that's an important starting point. We've seen that sensory input to the motor control systems is extremely important and forms the first way in which our motor output is regulated. We have various sensorimotor feedbacks that drive reflexes for example, and at higher levels we can imagine that sensory input often initiates our movements and certainly helps us guide us through any action that we wish to perform. From the other point of view, our movements and motor control make a big difference to the type of sensory information that we obtain. So we actively touch objects, we make eye movements to select things that we want to analyze in higher resolution. So active processing of sensory information is extremely important both in terms of the information that we obtain and also in terms of selecting for specific types of sensory information. So in this video we've largely looked at what are probably hardwired genetically programmed sensorimotor loops and sensory interactions.

Notes

Summary



27m 38s

Sensorimotor interactions



- Understanding motor control is fundamental to understanding any form of behavior.
- Sensory information is essential for guiding motor commands, and sensory stimuli can initiate sensorimotor loops.
- Sensory information is often actively and selectively acquired.

Cellular Mechanisms of Brain Function

In the next video, we're going to see how we can use reward-based learning to change sensorimotor interactions and drive goal-directed behaviour. And that is essential as a starting point for understanding sensory perception.

Notes

Summary



29m 00s