



Perceiving and Remembering – Converging Views from Neuroscience and Early Buddhism

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SPEAKERS

Rick Maddock

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I'd like to start by saying a little bit more about my background for those of you who don't know me, although it's nice to see familiar faces on the screen today. My professional training has been as a neuroscientist and a medical doctor and a psychiatrist. I had a clinical practice of psychiatry for about 35 years primarily seeing patients with anxiety and depression. I've retired now from clinical practice, but I'm still on the faculty at the University of California Davis, where I've been for close to 40 years. And I teach psychopharmacology and psychotherapy and neuroscience. And I'm still involved in brain research, which I've been doing for over 50 years. And the type of research that I've been doing primarily... Well, since the 1980s, late 80s, when MRI scanners became widely available, I've been using brain imaging methods to look at and study what's happening in the brain and what might be wrong when people who have psychiatric disorders come and seek treatment, and are willing to be research volunteers. And so it's been a journey of learning about how to relate the sort of basic anatomy and physiology and neuroscience of the brain to the human experience. I also have had a practice in Buddhism, I was first interested in it and had a meditation practice in my early years, but when I went to medical school that seemed to sort of disappear in the hustle and busyness of training and early academic career. So it's really the last 15 or 20 years that I've come back to a serious commitment, and studying this tradition and practicing in this tradition. And as I've done that, as I did that, having spent those years studying the brain and the mind from other perspectives, I realized that I developed this kind of bilingual feeling for the subject matter, I would sit in a dharma talk, and I would hear what people were saying. And I'd say, well, that's just like this principle from neuroscience. Or I would be reading a neuroscience article or listening to a talk. And I would think, Oh, that's just like something the Buddha talked about in this sutta when he was teaching us about how the mind works and how to be skillful in terms of, of having a human mind, and all the little pitfalls built into it. So this has been a very useful and enriching synergy for me and, and so I want to try to share that perspective with you on a couple of topics. That in today, that would be how memory works, and how people perceive the world. Using both the language from neuroscience and the language from the early Buddhist tradition. I guess the other thing that it's done for me as it's really increased my level of confidence in both traditions, since they seem to be pointing at kind of the same basic facts about the nature of the mind. I also want to communicate a caveat: even though I'll be using a



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lot of the metaphors and language of neuroscience, I don't mean to imply a materialistic metaphysics in doing that. I think science has a valid claim to being useful, as do many other traditions of knowledge. But that's not the same as having a valid claim to the ground truth or the basic reality in which we find ourselves. So please don't extrapolate. If I show pictures of brains and nerve cells that I think this is ground truth, I just think it's a very useful way of framing what's going on in our bodies.

I'm going to be doing sharing my screen a lot. Some of the things I want to talk about are fairly visual. So I will rely on you to tell me if that's not working. If you're not seeing the screen right, interrupt me please. I'd like to start with a quote that I really like from the 10th century Chinese Zen Master Yunmen. When he was quite old, he was asked, "What is the fruit of a lifetime of practice?" And he replied "An appropriate response." An appropriate response. I've always found this terse and pithy quote to be very useful because it highlights the reality that one of the most important fruits of dharma practice is a transformation of how intentions and actions arise in our mind and in our heart. And the freedom that the Buddha spoke about was, in large measure freedom from the effects of greed and hatred and delusion. And when the heart is free of those things, the way we respond to what's happening around us has been transformed and has a bass note of benevolence about it, but is customized to the situation. So an appropriate response I think, captures a lot of what the Buddha was pointing at. And the Buddha talked about intention and how intentions arrive, arise in our mind, in a lot of ways, and one of the ways was with the concept of karma or kamma, and Pāli. You know, in the West, this idea sometimes misunderstood as, as some form of cosmic justice, where people who do bad things eventually get punished for it. But the Buddha had something much more sort of simple and direct in mind, although subtle, which is that whenever we act in the world, there are intentions behind them. And, and sometimes we're not really clearly aware of what they are, we'd rather not know and we tell ourselves our intentions are one thing, but really, they were something else- but it's the actual intentions behind our actions that influence our future life. That's the way that the Buddha generally meant his teachings about karma. It's not some kind of force in the universe or force outside of us. It's the simple relationship of what activates in our minds and motivates actions and then who we are in the future. What we intend now shapes who we are in the next mind moments and in the next days, and weeks and months. I'm going to share my screen and just show you a couple of suttas that illustrate this.

This is a sutta called the Penetrative Sutta and it's much longer than this, but this excerpt is just pithy and I enjoy it- that the Buddha says, "Intention, I tell you, is kamma. Intending one does kamma by way of body, speech, and intellect." The karmic results are not from the outcome of our actions. If a surgical patient dies in spite of a surgeon's best efforts to save them, this doesn't produce bad karma for the surgeon. If the surgeon had been careless or neglectful or even malicious in his actions, then that's bad karma. It's the intention, not the outcome. The intention is what arises in the mind and leaves a trace that influences us in the future. There's another way that the Buddha taught about the importance of the intentions behind our actions of body speech and mind. The sutta on the two kinds of thought, (a mendicant, by the way, is a monk if you're not familiar with this usage) "Whatever a mendicant frequently thinks about and considers, becomes their hearts inclination. If they often think about and consider malicious thoughts, their mind inclines to malicious thoughts. If they often think about and consider cruel thoughts, their mind inclines to cruel thoughts. Whatever a mendicant thinks about and



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considers becomes their hearts inclination. Think about and consider thoughts of goodwill, the mind inclines to thoughts of goodwill. If they often think about and consider thoughts of harmlessness, the mind inclines to thoughts of harmlessness." Yeah, so this principle, (I'm gonna stop sharing for a moment) is very similar to a fundamental principle in neuroscience, which is summarized as neurons and brain cells that fire together, wire together. What this means is that whenever an intention of body speech or mind is activated in the brain, it strengthens the connections between the neurons that embody those intentions. And by strengthening those connections, that type of intention or similar intentions will be prioritized, they'll be stronger, there'll be more likely to show up in a similar situation.

Actually have another sutta I want to show you. The Buddha also spoke about the importance of the practice of reflection. And how that can affect our intentions. This is one of several suttas where the Buddha was instructing his son Rahula. Here he's asking him, "What do you think Rahula? What is a mirror for?" And he answers, "For reflections, Sir" "In the same way, Rahula, bodily actions, verbal actions and mental actions are to be done with repeated reflection. Whenever you want to do a bodily action, you should reflect on it, this action I want to do would it lead to self affliction, the affliction of others or to both? While you're doing a bodily action, reflect on it, is it leading to self affliction, affliction of others or to both? Having done a bodily action, you should reflect on it: did it lead to self affliction? Did it lead to the affliction of others or to both? Thus, Rahula, you should train yourself I will purify my bodily actions, verbal actions, mental actions through repeated reflection. That's how you should train yourself."

Excuse me. So the Buddha teaches that one can purify one's actions through repeated reflection. And one reason for this, of course, is that when you think about it, and think about if it's harming yourself or others, it might bring closer to conscious awareness, you know, that maybe what you're doing isn't a good thing to be doing, and it will change your motivation. But there's another thing here that is particularly interesting from the point of view of neuroscience that he talks about after an action has been carried out after you've done something, remembering it and reflecting on it can actually change the memory trace for that action, intention, and can change its influence on future experience and future actions and intentions. And I want to talk about how this is sort of fundamental to the way people think about memory now, particularly in the context of psychotherapy, and helping people overcome the effects of past experiences. But before I expand on that, I want to bring in a related Buddhist idea, which is that of the Alaya, and now this is not from the earliest Indian Buddhist tradition, it's an Indian Buddhist tradition from but it's from about 700 years later, after the time of the Buddha, from a school of Buddhism called Yoga Chara. And they introduced this somewhat more explicit way of thinking about karma, based on the idea of the Alaya consciousness. The word Alaya means store or storehouse. And it's a word that we're familiar with in the West because of the mountain range the Himalayas, that's part of the word that names that mountain range: "him" means snow, and the Himalayas are "where the snow is stored." But in the, in the yogacharya tradition, it's where the traces of past experience are stored in the mind. They call it the Alaya consciousness. To the best of my understanding, because they called everything consciousness. So, just like they call vision "eye consciousness." They call this memory storehouse the "alaya consciousness." So in its simplest forms, it's a place in the mind where traces of our past experiences are stored in a dormant or latent state. and they can reappear in present moment experience when conditions trigger them as to arise. And in the latent state the



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Yoga Charas call it the seeds, the karmic seeds in the Alaya. And when it showed up in the present, because it was triggered by something that was the ripening of the fruit of karma. Now, I gather that in later Mahayana traditions, the Alaya consciousness has other types of meanings and I'm honestly not very familiar with them. And I gather it's sometimes used to explain the mechanics of multiple lives. But I'm not talking about anything that goes that far, just the basic concept of a storehouse for the traces of our past experiences. The other thing that's a little different about the Yoga Chara view of the Alaya is that it doesn't focus exclusively or primarily on intentions, it focuses on all aspects of experience, which is much like the way neuroscientists would think about memory. And really, biologists in general are very happy with the concept of a storage system for latent information that can come back when needed, because this is basically what DNA is. It's our evolutionary karma. And we're all stuck, we all inherit a raft of it. And it's very active while we're growing as embryo and fetus. And many of our genes become latent, as when we're fully grown and developed, but they don't go away and they can be reactivated. And this happens all the time. You know, if the weather gets really cold, certain genes wake up, and they do things to help you generate warmth. If you make a transition from a sedentary lifestyle, to a lifestyle with a lot of exercise, certain genes turn on and there's they deal with that, they cope with that extra demand. And I'm sure you know this, but that's good for you. This happens even with meditation practice, certain things get turned on when when one adopts a new regular practice, certain potentials that were latent, become activated. So this is a very agreeable concept to biologists. But for neuroscientists and psychiatrists and psychologists, the thing about memory and for our experiences of our life, especially our early life, and feelings, and beliefs, and things that happened to us, not just from our own intention, although that's very important, but sometimes things happen to us that have nothing to do with what we intended, and they affect us. And, and basically, neuroscientists call this neuroplasticity, of which memory is the sort of common sense expression of it. And I want to talk about how that's embodied. And I'm going to share my screen again.

So this is a sketch of an embryonic brain of a human. And it has, the brain has the part above the spinal cord. So there's the hind brain, a little bulge in the midbrain, another bulge, and then the forebrain, which has two subunits. And (excuse me.) ...then as the human develops and grows into maturity, the brain looks like this, and the forebrain in the human has become very large, the midbrain stays very small. And the hind brain grows a bit. And it sort of looks like this. And while this embryonic brain on the left, looks actually not that different from the embryonic brain of a salamander, or a fish, or any vertebrate, it's what happens during development that makes the difference. And in so in fish, the hind brain stays the largest and in birds, the midbrain becomes as big or bigger than the forebrain. But in mammals we're a very forebrain oriented branch on the tree of life, of animal life. But the point I want to make is that each of these sort of sub brains is has the capacity to sense and perceive what's happening in the world, has some capacities for that, for knowing how to care about it: Is this good or bad? What's happening? And doing something about it- responding- generating intentions: from the most primitive unconscious intentions to fully conscious aware intentions from the cerebral cortex. So these are functioning subunits that cooperate, to create a useful organ for governing our behavior. And all of these different circuits in the brain and many sub-circuits within these different elements of the brain are capable of remembering. And they remember in different ways, in the forebrain, we have a lot of conscious memories; in the in the midbrain and hindbrain and deeper parts of the forebrain, the diencephalon, memories are not conscious. Some parts of the brain are like active



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all the time. Other parts of the brain are sort of waiting to be needed. They have different neurotransmitters and the dynamics of their memories are really different. So there isn't one set of rules that governs memory for all these regions. But, we know there are many different kinds of memory and that's related to the different manifestations of brain tissue in our system. And the ones on the left here, declarative explicit, these are memories that we are fully conscious of, we can put them into words. That's why they call it declarative, you can say, you know, what just happened, your immediate working memory, or what happened last week, or what you know about the world, your semantic memory. These implicit memories are not declarative, they're hard to talk about: how to ride a bicycle. This is sort of the motor muscle memory of procedural memory. Perceptual memory: learning to discern differences in what you see and hear, you know, a musician has developed, has a lot of perceptual memory for shades of difference in musical tones, conditioning, etc. They're all different. But what I want to talk about is episodic memory, also called autobiographical memory that primarily involves the hippocampus and the thalamus and cortex. And what I'll say about it, it's not going to be true in detail for all these other types of memory, but the general principles I think, will be the same.

So what episodic memory is, is memory for the specific episodes of our experience. So if I asked you, what did you have for breakfast this morning, your mind could go back and recreate that situation, hopefully? And you'd know the answer to that if I asked you, where was your favorite vacation in the last decade, that should pop up in your mind. And the characteristic, the defining characteristic of episodic memories is that they are situated. That is they have an autobiographical context, who was there, where it was, when it was, how you felt about it. It's a rich, sort of elaborated memory scene. And this is different from, for example, semantic memories. If I were to ask you, what's the capital of Canada, you might know it's Ottawa without ever having been there. So there's no autobiographical context, you probably don't remember when, in fifth grade, you learned that, you know, it's not autobiographical. It's really factual. It's abstract, it's cognitive. So some basic principles about episodic memories. And this actually applies, as far as I know, to all forms of memory, is that, as the memories are formed, they're shaped by things we already know, things that are already part of our Alaya, if you will, or how the brain (and this is in a grown person) is shaped by internal information. It's also true that episodic memories and all memories didn't evolve to accurately record the past, they evolved to meaningfully guide our behavior going forward. So they're not archives, they're guidebooks. And if the meaning of an event, an episode that's been remembered in this kind of memory, if that meaning changes, the memory itself changes. And if one reframes or changes the perceived context of a remembered event, its meaning can change.

So I'd like to illustrate a couple of features of episodic memory and I'm not going to actually ask you to take this memory test, but I'm just going to tell you what it would be like if you did, and a lot of studies like this are done on college sophomores. So I'd ask people to listen to a list of 15 words without writing them down, and then when the list is finished, have them write them down. And I would read the words from the list: "bed, rest, awake, tired, dream, nap, snooze, blanket, dose slumber, snore, wake, peace, yawn and drowsy" then I (I know this might not be the best word list to use in the Zoom talk where you don't want people to fall asleep, but anyway) if you were to give that word list and then wait about 15 seconds and have them do something to distract them from just saying the words over and over again in their mind, and then that is another words entrusted that material to episodic memory, not just hold it inactive working memory,



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and then write them down after it's gone through the little bit of filtering, that episodic memory does. About half of people would write down that they remembered hearing the word sleep, even though it's not on the list. Now, you can see that the word sleep is very strongly suggested by the gist of this word list. And episodic memory is most interested in the meanings of things, the gist of an episode that's prioritized. And the longer this material is processed in these episodic memory circuits that I'll talk about in a little more detail the stronger, that tendency to prioritize meaning becomes and in fact, if you do this memory test on people, and then have them go home and sleep through the night, and come back in the morning, the percentage of people who remember the word sleep is even greater. And that's because one of the things that happens during sleep is our memories are sort of refined and enhanced and consolidated, and compressed a little bit. And this meaning principle, is a bigger part of what we're left with. So these memories, and people at first call this a false memory. But I think that people don't do that so much anymore, because that implies that there are some kinds of memories that are accurate. But that's not true. All memory is about meaning it's not about archiving. That doesn't mean that memories are not useful, that you can't rely on them, they are useful. It's just they're not, there's always something that's wrong in any detailed memory. It's just not what it's prioritizing. So it's better to call this a memory illusion. And it just illustrates how memory works. There's nothing wrong with us for having these memory illusions. And it's sort of helpful, it's a little bit freeing to sort of know this. Another kind of episodic memory is called a flashbulb memory. It's not really a different type of memory. It's just episodic memories that are really vivid, and strong, and usually rich with emotional meaning. And people say they remember them really well. And a classic example is the events of September 11 2001. A number of memory researchers studied how folks remembered those experiences. And 97% of Americans said that a year later said that they remembered exactly where they were and what they were doing, the moment they heard about the attacks. I remember that exactly as well. So what makes some episodic memory, so vivid and clear, and produces a sense of such great confidence that you've remembered it exactly as it happened? The emotional arousal associated with it, the meaningfulness of it. And if it's a memory that one has frequently recalled, and I know many people spoke about the events of September 11, and other important life events get talked about and recalled. And those three factors together can lead to a feeling of very clear memory. One of the memory research groups that studied this, interviewed some undergraduates within a week of the attacks, and wrote down everything they said about where they were, who they were with what they were doing, and then got them back in the lab again and ask them those same questions a year later. And their descriptions agreed a little over 60% of the things they said were the same as what they said the first time or or similar enough to sound like the same memory. But you know, it's a little under 40% of the things they said had changed during that time, and, you know, this is how memory is, especially memories that are recalled frequently talked about, you know, you went over to your best friend's house, and you talked about it, and they said what they were doing. And things start to get a little muddled, and the memory changes. So, how does this happen? How do memories change over time and often become less accurate than we subjectively think they are. And I think, a good explanation for this or good way of thinking about it comes from current thinking about what happens in the circuits of the brain, as memories are formed and reformed over time. And I'm going to go through that in a little bit of detail. But there are three principles that I would like to underscore: one is (I don't mean three principles, I mean three phases of memory.) The first phase is when things are happening, the present moment experience. The second phase, immediately after, and up to a



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couple of weeks, is a period when the memory traces labile, it can be easily updated, especially in the first hour or two, and modified and, and crystallized and consolidated and gradually becomes a stable store. And in the stable store for episodic memory, it doesn't change for long periods, unless it's retrieved, or there's a gradual decay of forgetting. A different way of thinking about these three phases, graphically: present moment experience, all of the mental content, our actions, our feelings, our perceptions of the present moment experience, are continually recorded by the labile storage circuits of the brain, which is basically the hippocampus for episodic memory. And in this short term store, this labile store can be updated. But a process occurs that that translates it into a stable store that is not labile and is resistant to change except for forgetting.

Important point is that, if you take this stable memory, that stable memory that's resistant to change, but you retrieve it, you're making it labile again, and it's only the labile traces that can be updated or modified or changed in a way that enhances its useful meaning. So I'm going to just show you a little bit how this happens. And I'm going to use some sort of cartoon illustrations of what's going on in the brain. So an ongoing experience, present moment experience. Neuroscientists think about this as being represented as patterns of activation in brain areas, especially cortical modules for conscious experience. And so the areas that are bright are areas that are processing this visual area, the person is probably seeing something, they might be hearing something in this auditory area, they're, you know, thinking about what they might do in this action planning region. So all these regions, these different things are activated in a moment of experience. And retrieving a memory involves sort of recreating or stimulating that pattern of activation, if you produce the same activation at a lower level, you'll have a memory of the original experience. So one of the key things is knowing which things were activated, and how to connect them. So they activate at the same time, and the hippocampus: that's its job. It's really, it's a unique part of the forebrain. It's kind of always recording- the recording button is always on in the hippocampus. And it stores codes of what's happening now, what happens next, and what pattern of activation is there, and it's connected widely to the cortex and can simulate the pattern of activation that was present, you know, an hour ago when you were doing whatever you were doing. And it creates kind of a code to simulate that pattern. And it uses that to retrieve a recent memory, a fresh memory. And that code kind of expires after about a month, it really never lasts longer than about four weeks. The hippocampus needs the space to keep track of what you're doing now. So it transfers that memory to the cortex. And it has to teach the cortex, how to how to simulate that pattern of activation itself.

So I'll just walk you through that again: if you don't have a hippocampus, your fresh memories are very weak, and someone who has damaged the hippocampus, the things that have happened in the last week to four weeks, they just can't remember at all. And not in an episodic memory sense. You need the hippocampus early on. And then as time goes by, and a lot of this happens during sleep, when when the brain is not otherwise busy, the hippocampus is teaching the cortex about what happened when you were awake. And it takes time. And over the course of up to four weeks, the hippocampus is no longer needed to represent that pattern of connections.



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I'd like to illustrate this a different way, everybody has different preferences for how they input information. So in terms of a block diagram, you know, present moment experience: our sense, gates are letting in information about the world. And we have all the skandhas are active: our intentions, our feelings, our perceptions, our consciousness. And it goes into this labile short term store in the hippocampus, and the first couple of hours are the most flexible. You know, we all have this experience where something unusual happens. And like shortly after we're saying "What just happened?" You know, and we're going over it again. And it's coming from the labile store back into the present moment. And we're looking at it and trying to figure it out and put it back in the short term memory. So a lot of changes that occur early on in memory, in coding. And then there's a less highly labile phase, but still not stable, where things are consolidated. And especially after the first night's sleep, the memory becomes a little bit less easily modified less malleable. And then by four weeks, it enters the stable store of long term memory. But at any point, we can retrieve it we can retrieve memories from a month ago, we can retrieve memories from a week ago, we can retrieve memories from five minutes ago. And whenever we do, they're present moment experience. And this whole cascade begins again, especially if the retrieval was part of something meaningful. You know, we talk to our best friend about something that happened two weeks ago, that really mattered to us that episode of retrieving it and discussing it and thinking about and reflecting on it.

This is what reflection is: it re-activates makes labile again, something that was in a fixed state as a karmic seed, and it becomes alive again. And it can be modified by virtue of the reflections that occur or the meaning that's created in this present moment experience. And this maps very well onto the way the the Alaya metaphor talks about this, these are the stable stores of the karmic seeds. Retrieval, reactivation, remembering is the karmic fruit. It's when these karmic seeds ripen, those are the times they're susceptible to being exhausted or destroyed in the metaphorical language of the Alaya. And from the point of view of like psychotherapy, when memory traces are reactivated and present experience, they can be reframed in a way that actually modifies the long term store of that memory. The meaning changes, the memory is changed. Quite commonly, memory traces are reactivated, even troublesome ones ones that cause distress. They're reactivated but in the language of the Alaya, they're replanted unchanged, people just react the same way. And that, if anything, solidifies the seed. If it changes, a new stable trace, slightly modified, replaces the old one and overtime can completely change. This doesn't happen like with one setting. Often it takes many repetitions. But this is one way I think about this: sort of the karmic metaphors versus the psychology and neuroscience metaphors. Karmic seeds are in the long term store, they ripen when something triggers them, and they're either replanted largely unchanged, or there's a mindful and compassionate reflection that's occurring and this modifies them even to the point of exhausting them- destroying those seeds completely- when they're reconsolidated with a fundamentally different meaning. So you can see see that this has some implications for dharma practice for well-being certainly for psychotherapy, if you happen to be in that business. When karmic seeds of difficult experiences, arise are triggered and ripen, that's a challenge for people. And often, they just get replanted without much change, the same reactive reactivity pattern arises. But, so it's not necessarily bad- because it's only when reactivation occurs, there's even the possibility of changing the long term store or the seed form of these traces. But it requires reflection and reframing- really penetrating the meaning that's been taken and seeing if that's really the right meaning for that experience. So it's a time of opportunity. And, you know, when I was treating



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people with anxiety disorders, like agoraphobia, for example, some people would be in a situation that triggered their fears and it was very unpleasant for them. But what they discovered over time with cognitive behavioral therapy, that if they stayed in the frightening situation, the fear would eventually subside. And when that happens, the meaning of that experience is different than it had been in the karmic seed and gradually, a new set of memories would replace the memories of the fear memories that were triggered by certain situations. And, you know, some people who were making really good progress began to feel a sense of mastery and a sense of, like, wanting another fear to be triggered, so that they could work with it. You know, it started to seem like, 'Oh! Yeah, are there any more of these? What else? What else have you got? You know, let's see it and let's see if the meeting can change.'" Now, I don't want to make it sound too easy. But the key, of course, is meeting experience with with mindfulness and compassion and wisdom. And it really, it's not something that you just do with strangers, you know, you do it with yourself with self compassion, or you do it with a trusted mentor or therapist.

I think there's another implication of these metaphors about episodic memory, and memory in general. And that is, I found this really striking for me personally. Sometimes we have things that happen that aren't troublesome, but in fact, they're profound and deeply affecting and deeply meaningful. And sometimes this happens with with meditation practice, or just in life. I think it's wise to treat them with special care, especially when they're fresh. And I know I felt this way instinctively, as a young person not to talk about things too soon. Because the wisdom in the mind that has nothing to do with our personalities, knows how to settle these things down. And I guess I had the experience of talking too soon about something with someone who wasn't really interested. And it just sort of diminished it, it replanted a different seed that wasn't a good one. So it's wise to allow these things to settle. And I think this is relevant in psychotherapy practice where sometimes a person is really touched on something important. And then the hour is over. And I sometimes would suggest if they don't have to go right back to work, to spend some time just letting things settle. Because this process is a wise process. And it's not something that you can do a better job of by talking about it except in very special settings. Well, I think that's all I've got to say about memory and if people have questions, I'd be happy to respond to them. You can just raise your zoom hand...Where did Paul go?

That's okay. Let's let Wayne go first, and then I'll go later. Thank you so much.

Questioner

Hi. I am 64 years old, and I had a stroke in the hippocampus, I'm told, of my brain about 30 years ago, and it was a rare part of the brain to have a stroke. And I know the hospital put me in touch with some people from UC Davis and I saw three people at the Veterans Hospital somewhere halfway between Davis and where I lived. And I'm just, I wonder, like, I now teach autistic middle schoolers. And I have six students in one of my class, you know, and I've been with them now for three months, but I list their names on the wall so that I can remember six names. Because sometimes I just forget them. And but there's a part of me that in terms of my practice, I just kind of will go, Well, shit, it's hopeless. I can't remember anything. And I'm just wondering if you can comment. You know, one other interesting thing is these three researchers



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I saw said, I was the first person they'd met that had a stroke in this part of the brain that wasn't blind in half of each eye. So very fortunate.

Rick Maddock

Yeah, that does sound like an unusual presentation. I'm sorry that you've had to go through that. Well, you know, I talked about this episodic memory, which the hippocampus is super important for, but there are many other kinds of memory and, you know, our, our practice shapes who we are and how we respond going forward. Even without having conscious episodic memories. We are shaped in other ways. emotional memories, procedural memories, often called muscle memory, but it's more than just learning how to ride a bike or throw a Frisbee. It's learning sequences. What you know, this follows this, follows this, follows that, that kind of thing that's not, quote, "episodic" be hard to verbalize. But one learns to act in different ways in situations through that kind of sequencing memory. Relationships, the way one conducts oneself in relationship is a different kind of learning and memory than episodic. So there are many other avenues of transformation through memory. And, you know, what we do in our present life. I don't know if that's responsive to your question.

Questioner

Yeah, yeah, it's helpful. I am trying, I mean, when I said I think, you know, I just think something. This is helping, because at least it nothing else It relieves anxiety and calms me down and makes at school, I'm much less likely to get reactive to one of the 700 middle schoolers doing crazy things.

Rick Maddock

Yes, thank you, Nancy.

Questioner

Thank you. Um, gosh, I have so many questions. I'm not sure where to start. I used to be a criminal defense attorney. And a lot of what you're talking about in terms of a memory and how they change over time, certainly makes me think of witnesses that have testified in a number of cases. And how, you know, when witnesses are, well, we call it "interfered" with, but when suggestions are made to them, by any party that can really color what their original memory was. And the other thing I thought is fascinating was when you were talking about the karmic background with intention is that that also plays out in the legal world in terms of mens rea. And that the intention, especially in some of the more violent crimes, like murder, or, for instance, conspiracy, all of those intentions make the crime much more severe. And so it's just an interesting take on what you're talking about today. I do have just a general question about how it is that like, my sister and I grew up in the same household, and I have a really great memory of when we were children, and she has like a non existent memory of when we were children. And how is that? How is it that our brains are so different? That our memories are that different of the same life?

Yeah, yeah, well, yeah, people are really different in the brain is a really complicated organ that starts out as a few cells, you know, and gets built out into this really incredibly complex thing. And the diversity is, you know, it's probably a feature and not a bug, you know, that we get.



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Every generation has very diverse minds and brains in it, even if they're siblings. That's how I think about it. Thank you. Yeah, Sandy.

Questioner

Hi, Good afternoon. I'm a psychotherapist working with highly suicidal teens. So needless to say, I run into a lot of trauma. And what I'm trying to work with, with my clients is- because they want to try to remember everything that happened, and I try to encourage them that it's not important to remember every detail, but rather, how it affects their behavior, how it affects them internally, where do they feel it internally? And, um, my question to you is, when trauma happens to a youth versus an adult, is it the episodic memory that makes them remember it differently? Like I'm finding a lot of the teens, a lot of children don't remember all the details, almost like, it's like the brain is protecting them, because it is so traumatic. And if they felt every essence of what happened to them, they would literally feel like they would explode. whereas adults kind of shut down a little bit, but they do you tend to remember a lot of what happened.

Rick Maddock

Yeah, that's, that's a great question. And I'll start by saying that when I was trained, actually, in the 80s, in psychiatry, think it was a more siloed academic world then, and I was an adult psychiatrist, and I really don't have a lot of experience with children- adolescents and adults, yes, so I can't speak from experience from working with young children who have been traumatized, I just never had that experience. But the principle I think that you articulate is a reasonable one, which is children are more are more likely to wall off memories, I think, because of the potential disruptive, disruptive effect of them. And yet, if someone who's been traumatized wants to, you know, is ready to go over those memories with a safe and trained caregiver, that's a good thing, you know, that usually leads to some resolution, some replanting of different seeds, that are going to be less troublesome going forward and it may take time to remember all the things. I think the best indicator of whether it's essential that all the details are remembered is how much those reactive seeds have been exhausted. If they're exhausted without having to remember exactly what happened first or second, then that's not a problem, you know, but sometimes there are details that that remain like a little source of inflammation and psychological inflammation. And then until they are brought into the present moment, they can't be changed. And so it's a bit of a detective process sometimes, and you know, just the mindful relaxation and reflection eventually will bring to light most of those seeds. Tony,

Questioner

Hey, Rick, I remember the movie Inside Out, which was a cartoon story about internal life of a young girl. And one of the things that was going on in the in the movie was everybody was trying to keep sadness away from recalling the memories that were in that (I don't even know how to describe it in in the movie) but it would have been the Alaya. And when those memories were touched, the sadness, as I recall was blue. And the memory started to turn blue and there was an effort to try to distract that behavior. And I'm wondering whether that's correct neuroscience, it sounds like, but whether whether recalling things when you're feeling joyful or happy, whether that's a good time to explore in mindfulness to call up some of those experiences and recall them if one is feeling mindful, and to intentionally call them up. What do you think?

Rick Maddock



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Yeah, I think there's a time and a place for retrieving and reactivating challenging memories, and feeling good, feeling confident, feeling happy is a nice qualifier for that. But I would also say, having the freedom to not have to cope, you know, take care of your infant child, you know, I mean, if you have some space, it's, that's really important too. So like, I don't remember those details of the movie, but you would might want to suppress the recollection of a difficult memory if you didn't have time for it right now, you know, there'll be a better time later. And, you know, the brain uses sleep to do some of this reprocessing, which is a time that you've got time, you know, you're not busy. So it activates those circuits below, kind of in dream consciousness, rearranges things a little bit. So yeah, I think one should use discernment in deciding when to open up that box, you know. Paul?

Questioner

Quickly, and we don't need to dwell on this. But if you- I personally had COVID earlier this year, and I think I have seen a little decrease in memory. Nothing really to worry about was worrying if you had any ideas on how to improve it. I know, that's kind of a lame question as context, but I ask it anyways, thank you.

How to improve your memory, given COVID, for example, and so forth?

Rick Maddock

Yeah, well, if you're fully recovered, there are things that have a beneficial effect on the hippocampus. And one of them is aerobic exercise. And so I can recommend that, if there's no reason not to, for you, in regular, you know, I mean, this is just your standard prescription, but you know, 20 to 30 minutes, four or five times a week of exercise to get your heart rate up above 60-65% of your maximum, which is 220 minus your age- that has a well documented beneficial effect on a number of brain circuits, but in particular, the hippocampus. So that might have a restorative effect. Great. Yeah. And you know, sleep is also really important. And it's not just because of the information processing that occurs in sleep that does, it has an important role in memory, episodic memory, but because sleep is when the trash gets taken out of the cellular channels in between your neurons and your glia. It's the little channels dilate, like 300% or something, I forget exactly the proportions, and fluid washes through there. And that only happens during deep sleep. So you really want to get plenty of deep sleep if you've had a viral infection that that does affect the central nervous system and many do flu virus also does that. And apparently COVID does as well. So make sure you get plenty of deep sleep. One nice thing about exercising is it promotes deep sleep later when you go to bed.

Questioner

Fantastic. Thank you so much.

Rick Maddock

You're welcome, Mark.

Questioner

I'm a bit confused about unconscious intention. So until recently, I thought intention is a conscious thing. If I'm, say somebody is intent on harming or intent of doing good, especially in



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the context of the first step of the eight fold path. And so I can work with my conscious intention. But so is there an interaction between unconscious and conscious intention or how do you work with unconscious intention? How important is it and so on?

Rick Maddock

Thank you for that question. I think that's a really important- some points- a very important point you're raising. So the word "intention" gets used in different ways. And one of the ways, maybe the most common way it's used is the way you're describing it, that it would be conscious, means conscious intentions. But I think the Buddha used it in a broader sense. And I was trying to use it that broader sense. And I would like to say something about consciousness too, because that's a word that gets used in different ways. And I personally don't subscribe to the idea that it's either or conscious or unconscious, I think consciousness is a spectrum. And some things are easily apprehended with conscious awareness. And other things are a little trickier or slippery or harder to see clearly. And some things we'll never be able to be conscious of in ordinary mind states. So that's a spectrum; intention is a spectrum. And what I think is being pointed at here is that (and something I'll be talking about in the second half of this) is, it's a valuable practice to become more aware of more intentions. And often there's more than one intention arising in this complicated brain of ours. But only one of them usually wins the competition and governs our behavior at that moment. But one of the benefits of mindfulness is, and especially sort of a broad awareness, is becoming aware of different intentions that are bubbling up. Even though you don't act on all of them they incline the mind a little ways, even when they bubble up into thought. So part of the practice is having better skill at noticing what the actual intentions are. And I say this in a no blame format, you know, these intentions arise, it's not really personal. Nothing we do really is, I mean, if we're conscious of it, we're more responsible for it. But even if we're unconscious of it, if we had the skill to see those intentions arising, then we might not choose to act on them. Does that make sense?

Questioner

Yeah, I'm still struggling with it. But yes, and I think this is helpful, definitely will put me on the way especially what you're saying the, you know, consciousness and intention of being a question of degree or spectrum. And the awareness of what's bubbling up very helpful. Thank you.

Questioner

Stand. Yeah. Hi, thank you. I have a very good friend who is in her mid 70s. And she's been disturbed a lot in her life. And she has taken up the practice in the last four or five years is something called re-parenting as part of adult children of alcoholics to cover over the terrible upbringing that she had. And she does seem to get a great deal of comfort out of this. And so I looked at some of the workbooks that they went through and, and saw her actually practice this. And it seemed to give her a great deal of comfort. But it's very curious to me, because she still seems to remember and go back to some of the bad things that happened to her in her youth. So what do you think of the process of something like that, where you try and reinvent, imaginatively a loving parent as opposed to a hateful one?

Rick Maddock



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Yeah, interesting. I am not aware of this, this method, this technique, this therapeutic technique, so I don't have much insight to offer into that particular technique. But I guess one question I have is, is this entirely a self help thing? Or does she work with a skilled clinical provider?

Questioner

No, it's, it's part of the extension of Alcoholics Anonymous, to the adult children of alcoholics. I see. And this is a branch out of that. So there are people who kind of run these programs, and they have some kind of training, but you know, it's not official like what you guys have.

Rick Maddock

Right? Yeah. Well, there's a lot of diversity in what we have too, and so well, that's encouraging. So there might be some people who develop some discernment and experience with this process that are helping her I think we have a good guide I mean, the principles sound reasonable and should be helpful, but it would depend upon what kind of guidance you're getting from, from the person you're working with. Okay, thank you. Yeah. Let's see, Deborah.

Questioner

Great. Good afternoon. Thank you so much for your talk. I want to say two things specifically, before question, thank you for kind of your synthesis, your kind of putting things side by side, and just sharing that with us was super helpful. And I really liked the implications for practice. And the positive note about, you know, this is when there's an opportunity, so I just love that. Okay, I'm looking at my screenshot of one of your slides. And it's, you know, the, you know, step by step and the looping. And my question is, I guess, best way to say it is kind of: how much at any one point in time, how many of these at any one point in time, my hunch is a lot, not just one at a time, not just yesterday's upsetting event, but at any point in time, just a lot, and a lot of it we're not aware of. So that I guess it's a question. And then related or subsequent question is, and so what is the implication there for practice? And I guess I'm thinking about the experience of- there might not be anything going on, you're sitting, there's a lot, nothing is particularly whatever upsetting, but during those times, as you're saying, with compassion, you're sitting there awareness and compassion, it's like you're doing the house cleaning, because there's a lot going on, but you just, you're not aware and that's okay too, let the cleaning happen. So those are my questions. Yeah.

Rick Maddock

Those are great questions. So when I think about this material, or these insights, my mind often goes to the more traumatic situations. Because that's, that's really important in people's lives. But but that's not the only thing. You know, and I think as you're saying, you know, regular practice, minor things come up, that where, you know, they could be transformed by reflection, just in little ways, you know, as they say, we often have a mixture of intentions arising. And, in reflection, especially if things do pop up during practice, that there's some pressure for them, they're like, they don't fit with the rest of you. You know, and so they're being nominated for retrieval. And, and then you reflect on them and you say, you know, if I had looked at that situation this way, I could have been kinder, you know, it's not a huge deal, but it's part of the process, you know, of practice and purification and, and freedom really- freedom from those tendencies. So, when you ask the question, how much I'm not sure I got that completely. What,



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like, how many you're looking at this is like, this memory, or this karmic seed coming to fruition? It feels like any point in time, there's probably 15 of those bubbling around.

Yeah. Right. Yeah. So how does one prioritize them? Yeah. And again, you know, the setting-the time and place is important. If you are working person, for example, you're not just going to be doing this at work. So what are the time and I think they set priorities on their own? You know, it might depends on the conditions around you, what's coming up for you this week, you know, certain scenes will be at advanced in anticipation of what you're doing in the coming week, you know, because they'll sit there, they involve similar situations. So, yeah, I think it's not a something that happens all at once. I see it as a gradual process. And the really nice thing about having a regular practice is that you have the time or you have many opportunities,

Questioner

Everyday the opportunity. Thank you so much. You're welcome.

Questioner

Hi again, I'm wondering a couple of years ago, a vipassanā teacher that I sometimes sit with recommended that people reach out to someone that they've hurt. Or they feel that they've hurt from the past. And I did that, for someone that I hadn't seen in 40 years. And you know, she was very appreciative. And I'm wondering, first of all, if that's any kind of practice, in Buddhism, maybe other people know. And also, maybe it's something just to think of people I've hurt and just think about it and, you know, practice loving kindness or something. Because I wouldn't want to just reach out to somebody I haven't talked to in 45 years and say something. Have you ever heard of that kind of practice? Or?

Rick Maddock

Yeah, well, it's part of the 12 step programs. And I've never recommended it to my patients, I haven't worked in the area of addiction. But I gather that it's very powerful. And I can see why it would be. And sometimes people don't mind. But I guess one thing I would like to clarify, and you made it clear that you understood this as well, but it isn't to be forgiven, you know, it isn't that how they respond to you reaching out to them is crucial, I think the reason that it's powerful to reach out to a person is that it really focuses your mind. Because there's a real person there that you hurt. But if you could focus your mind without having them in front of you, that would work just as well, you know, in my view, because the karma is internal. And when you fully retrieve it, what you did, and reflect on it, and you reflect, just like the Buddha advised Rahula on how it was really harmful to another person, and ultimately to yourself, you remember it as a mistake that you don't want to do again. And that changes something I think- it's a more complete accountability.

Questioner

Well, one thing that's occurred in the last couple of years since doing that, I've gotten in touch with some people that I was like, very good friends with from through high school, and but I've



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just not been in touch with them at all. And it recently in talking to them, it makes me realize, you know, their take on reality and their historical memory is just completely different than mine, and just the constructs in my mind are crazy, are just different.

Rick Maddock

Yeah. Yeah, I mean, I'll just say one other thing about that: when I first became a psychiatrist, and people would talk to me about things that happened, I would sometimes think that- well, that doesn't sound right. You know, something about current events that happened 10 years ago. I think that's not what happened. But I realized it's not important. What's important is how they're remembering it. You know, that's what's affecting them. There was no real point in trying to get people's memories to be accurate. It's get them to be meaningful in a way that's not harmful to them. Anyway, yeah, Doug.

Questioner

Thanks. It's good to see you, Rick. I have two things I wanted to mention. One is sort of a comment I'd be interested in having your thoughts on and another is a more personal thing. Somebody was talking just a short while ago about visiting the past and stuff. And I don't know if you've ever run across this- Jean Houston has a book out called "A possible human" and one exercise in it is befriending a child. And the idea is, is that you pick some time in your past when you were a child and relatively receptive shape, and imagine yourself as an adult, going back and befriending yourself as a child. Because you would know more about what's going on with that child than anybody in the world and then just do this repeatedly. And imagine, you know, going on walks and all kinds of things as the way she would describe it is it doesn't change your past memories, but it sets down another track. That if there were just one person in your life who really got who you were while you're going through this trauma with a difference that would make and kind of give us an alternate path through which I found helpful with a lot of my old stuff. So I wondered if you have any comments on that, but I had another situation I just wanted to.

Rick Maddock

Yeah, no, that sounds like a very constructive process. Yeah, that sounds great.

Questioner

Oh, about 15 or 20 years ago, I was in a bicycle accident. And you're talking about the hippocampus sort of brought this all back to me. And I was not able to form any memories for longer than about two minutes, for about eight or nine hours. And my wife and my oldest son were there. And I kept asking them- "What happened?" and they, you know, I think they were thinking, they were worried that they were gonna have to stake me up the backyard and throw food out or something, because I just couldn't hold anything. But it gradually came back. And so here I am, all these years later in my mid 70s. And I can feel my memory, sort of fading around the edges here and there, it's, you know, it's hard to hold stuff. And I'm just curious and interested, you know, as I deal with all this stuff, that whether, you know, this is some residual stuff from that bike accident that's showing up are how much of it's just kind of normal aging? And what, if anything, to do with it, and you kind of answered some of that earlier about with the,



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you know, aerobics and things like that. But I wanted to throw the specifics at you, see if you had any thoughts about it? Yeah.

Rick Maddock

You know, certainly, it's characteristic of aging, to have that decline in episodic memory. And in terms of the head trauma, you know, that acts a little bit outside of my expertise to know the natural history of that, that I haven't managed those kinds of problems in my own patients, it's always been neurologists who do that. So I don't have that direct experience from, you know, talking to 30 people over the last 40 years about the same problem and knowing what happened to them. So I just don't know. You know, it just seems logical to me that, especially because the hippocampus is, it's kind of the canary in the mine, or in the mind, really, but it's very, it's so active all the time that if something compromises brain function, it's the part that often goes offline first, because it's operating near the limit of its capacity most of the time. So it's a vulnerable area. So it's not too surprising that it's often harmed, head injuries and that sort of thing. But you know, it usually comes back and you have a period where it didn't make the code for memories, and so that that period is gone. But once it's working again, it does its job. You know, I'm not sure what else I can offer, in terms of caring for that part of the brain.

Questioner

Oh, well, thank you. But my assumption has always been that the brain doesn't actually repair whole circuits as much as it does compensate and rebuild around it. Is that true? Or does that actually rebuild them?

Rick Maddock

Well, both are true. I mean most of neuroplasticity is remodeling the brain. It's guided by what the organism needs. So yes, there's a lot of rerouting and rebuilding. But there are stem cells, neural stem cells in the brain. And they're in two locations. One of them is the hippocampus. Because it's a region that has kind of the most demand on its information processing capacity of any part of the brain, it needs fresh cells. So even the oldest humans that have ever donated their body to science, well into their 90s, they have neural stem cells in their hippocampus that are in the process of turning into new neurons. So it never stops. You always get new baby neurons in your hippocampus. So that's good news. And that's one of the things that exercise does is it accelerates that process and more of those baby neurons survive to maturity, when people are not sedentary in their life. Thank you. I think I can just take two more and then we'll have to let's take a break and move on. Nancy?

Questioner

Thank you. I wanted to ask a question, you talked a little bit about neuroplasticity and sort of rerouting things that had to do with karmic memory. And I have a chronic neurological condition that I've been doing a neuroplasticity retraining for a number of years now. And I'm wondering if you can talk a little bit more about how neuroplasticity retraining or exposure therapy would come up during meditation, how you would work with it during meditation.

Rick Maddock



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Okay, well, I'm not sure I know what this particular method is that you've been using. I mean, neuroplasticity is a very general term. So all the things that I spoke about were forms of neuroplasticity and reflection and reframing and changing the meaning of memories that do arise is neuroplasticity. But it sounds like you're talking about something a little more specific. And so I don't know, which type of memory you know, sounds like it's maybe not these episodic memories that we've been focusing on. But maybe more...

Questioner

I guess my question, my neurological condition really is vestibular. And so my neuroplasticity retraining is sort of exposure therapy and retraining my brain to find balance in a different way. In terms of meditation and dealing with dukkha and becoming more aware of what you're doing in meditation, I'm wondering if you can talk a little bit more about how neuroplasticity relates to that experience?

Rick Maddock

Yeah, well. Yeah. I mean, every, every moment of experience is a moment of neuroplastic change, your brain is always adjusting itself in the face of what it's encountering in experience. And when that's done in the context of mindfulness, it's always a step in the right direction in terms of those neuroplastic changes. It's like a universally beneficial factor, do you have mindfulness established? So that's very general answer. But it does apply. In terms of vestibular neuroplasticity, that is a problem I'm familiar with, and that vestibular apparatus is subject to injury or a slight change in how its functioning, and people have to relearn where balance is. And that's a neuroplastic challenge. And it's important that the cause of the change in vestibular function is stable. If it's a stable change, your brain will accommodate to it eventually. But it needs to have exposure. And exposure with a calm mind is ideal. And a confident mind is ideal. But one thing that accelerates neuroplastic change of that type is arousal, caring about what you're doing. So I don't know what sort of things you do for exposure. But if you could do things that really matter to you, that also challenge the vestibular system, it will have a synergistic effect on the neuroplastic change. There are many circuits actually, we will be talking about them in the next section that tell your brain what's important. And if your brain gets the message that we're doing now is really important. It will be more neuroplastic. During the time you do that.

Questioner

Meditation practice has been immeasurably helpful.

Rick Maddock

Thank you. You're welcome. Oh, last question, Paul. Yes,

Questioner

I just go quickly. Two things. One, I just again, want to reiterate, just thank you so much. This is just awesome. How is memory literally stored? Like, is it? Is it like a protein that's stored on a cell? Help me understand a little bit better if you could, please?



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Rick Maddock

Yeah, right. A good question. I forgot to say anything about that. Mostly, it's stored in terms of an anatomical change, a change in the connections between nerve cells, brain cells more generally, but mostly nerve cells, and they can be very small changes. Like the number of neurotransmitter vesicles, which are these tiny little bubbles at the tips of neurons. And you might have 500 of them before you learn something in this one location, and after you learn it, you've got 1000 of them. So that connection will be a little stronger, it has more potency for making a connection with the next neuron. And there are these little micro structural changes. And the number of micro structural changes that embody neuroplasticity is very great. There, there are many ways that the brain changes its structure in order to store what it's learned from experience, but mostly they have to do with the strength of connections in circuits of nerve cells.

Questioner

Got it, perfect. And what are those bubbles called again?

Rick Maddock

Vesicles- neurotransmitter vesicles. Okay, little storage vesicles waiting to see if that neuron needs to communicate to the next neuron. And if it does, they float up to the surface, and pop and release the neurotransmitter that floods across the tiny cleft and tickles receptors on the next neuron. This all takes place in like three milliseconds or less, it's very fast.

Questioner

That goes all the way back to what you talked about in the very beginning of this in terms of intentions and sort of repetition.

Rick Maddock

Yeah, that's right. Thank you. Okay. Let's take a break. Let's make it a 10 minute break. And oh, my goodness, it's 10 to three already? Could we just make it a five minute break? And then I'll get back to some more material for you. So I've got 251. So 256, we'll come back. Is that alright? Good. I'll see you then.

Yeah, okay. So I want to talk about perception. And frame it in both terms of neuroscience and in terms of the early Buddhist teachings. And, you know, one of the primary goals of the dharma practice is to recognize and abandon tendencies toward grasping and clinging that undermine our well being- this is the source of our discomfort, our suffering. Some of these tendencies that are unskillful are, are conditioned by cultural factors, and things that happen to us, of course, but some of them are just innate biological tendencies. And, in some sense, you know, the dhamma practice is like a workaround for the human predicament or just the way we're designed. The Buddha sometimes talked about going against the stream, "Patisothagami" going against the stream of sort of conventional responses, and in some ways, our biology. And, one of the things that, I mean, our biological tendencies are wonderful, they help us survive, and that's how they evolve, but they might not provide the best help for other aspirations, like toward an aspiration, to wisdom or to compassion or freedom. And so that's what the Buddha is teaching us is how to how to work with the situation we've been given. And some of the



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workarounds involve our perceptions. And the Buddha talked about perceptions in a number of ways. But one of the most fundamental ones, and I'm going to share my screen, again, is as one of the aggregates let me just put something up on the screen here.

Yeah, so there are many teachings in the early sutras about the five aggregates, skandas or khandas in Pāli. And for those of you who may not be familiar with them, I'll run through them: form, which is the English translation of "rupa" refers to the body and materiality in general and these aggregates together comprise pretty much everything we experience. Materiality and our body. "Vedana" is translated usually as "feeling tone", we experience feeling tones, which, in the simplest sense, are pleasant or unpleasant or in-between, we have an affective response to experience that's part of our lived life, of our mental life. And then recognition or perception is the translation of saññā. And that's what I'm going to be talking about here; and this is how we make sense of our experiences how we construct meaning from experience. "Sankara" is often translated as "intentions," the way I've been speaking about intentions earlier or "fabrications" or "volitional formations" or "choices", some people translate as choices. This refers to the intentions that give rise to a thought, speech, and actions. They motivate how we respond to the world. And finally, "viññāṇa" or "consciousness" or "awareness," you know, this is what allows us to have direct, conscious experience. So all of our moments of experience have some elements from each of these categories. And the Buddha taught us about noticing them, there was an aid to notice these different categories. And then the way he applied it, generally I'll talk about later. But before I talk about the sort of practical application of working with the skandas (the aggregates) I just want to say that when I learned about these, and I already knew a lot about neuroscience, I was really struck by how similar this is to like, this is like a table of contents of a modern textbook of neuroscience, you know, you've got under form in Rupa and materiality you've got our sensory physiology and our sense organs interact with the material world. And under vedana, feeling tone, there's chapters in the textbook about emotion and feelings and all the emotional and affective responses. It's a whole set of circuits that do that. And then saññā- recognition, big parts of the brain, that's it's main job is to construct perceptions. Intentions, that's the motor system and the planning system. And the areas that where different intentions compete with each other and one wins and then becomes the source of an action. And viññāṇa, then, there's always some chapters on consciousness in these textbooks, although those chapters are more speculative. Because, you know, in neuroscience now, although there's a lot of work in the area of how consciousness is embodied, there's not a lot of consensus, you know, this hasn't reached a level of understanding that people agree on unlike the case for the other three mental aggregates that is feeling tone, perception and intention, (which I sometimes call, when I'm speaking in the neuroscience language, I call this the sort of feeling tone evaluation.) It's this automatic processes that tell us us what to care about, and which way to care about it, do I want more of this, or I want less of this? Is this good for me or bad for me, pleasant or unpleasant, important or not important? These are non cognitive, they're sort of more basic fundamental evaluations that are engaged in our nervous system. So these three aggregates are the focus of much study in neuroscience and a lot of consensus and a lot of knowledge. So I'm going to talk a little bit about perception from a neuroscience perspective, but I want to just show you a few other things that illustrate how contemporary, the Buddha's Insight was in dividing up experience into these five categories. I mean, in neuroscience, we would say that the three middle ones that I've highlighted that we understand pretty well; these are what any animal needs- any animal with a brain. And in



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nature, if you see an animal, if you see a creature with a brain, it's a creature that moves around. You need a brain to have complex behavior. And in order to have complex behavior, you have to have sense organs and perceptual circuits or perceptual capacities, to make sense of what's happening. You have to have evaluative capacities to know what to care about what your goals are in your priorities. And then you have to have the ability to plan and generate action responses or to formulate- not necessarily plan in a conscious sense- but generate adaptive behavioral responses. And that accounts for the most elemental things that the brain does. And I just love the parallel with with the Buddha's formulation. And someday if we understand consciousness better, we'll put it on this graphic. But right now, I would just say perceiving, evaluating, and intending is what your brain is doing at the most basic level.

And this triad of functions is reflected in the architecture, the design of the brain, even at the largest scale. So here, this is a picture of the human brain looking at the cerebral cortex, and the front part of it the frontal lobe. It's specialized for planning and generating intentions and carrying them out: behaving. And the more posterior part behind it in white shading are our perceptual cortices, the occipital for vision, the temporal cortex for hearing and a lot of other additional higher level visual processing, and also memory, episodic memories and the temporal lobe, and then in the parietal lobe, where you have the body senses, touch and body awareness, and kinesthetic awareness, and also a lot of visual processing in the parietal lobe as well. But this a part of this half of the brain is specialized for perceiving the front half for acting, and intending and planning. It's not 100%, there are exceptions, there are parts of the frontal lobes that have more of a perceptual function. And likewise, in the posterior lobes, more of a motor function, but in terms of what the local expertise is, they're particularly good at these functions. The evaluative function, on the other hand, is in the more primitive parts of the brain, in a human being. And they're in the midline. If you were to slice the brain down the center, and you'd see all the way down to the, almost to the spinal cord, here, the brainstem, the hind brain, I should say, a lot of these evaluative nuclei are in the most primitive parts of the brain, but some are in the cortex, but they're in the midline of the cortex. And it's, this is actually the most primitive part of the cortex. If you look at it a rodent's brain, it's mostly these midline cortical structures are large. And the other, you know, the things that are particularly big in humans are not particularly big in a mouse. Anyway, at this macroscopic level, the Buddhist conception of the aggregates fits very well on to how we think about how the brains functions are segregated, and also at a microscopic level. And I'm not going to spend much time on this complicated picture. But this is a slice through a human cerebral cortex, it's a six layered structure, the layers are numbered over here. Underneath them is white matter. But each layer has a different function. And there are thousands and thousands of neurons in this picture. In layer four, that's where perceptual input comes in, from lower parts of the brain that are involved in delivering perceptual information. And layer five is where a motor response is generated as a separate layer. And the evaluative responses come up from those midline, those primitive regions that know how we care about what to prioritize, they come up and they tweak the activity of all six of these layers. There are other functions as well. But these are the functions that are probably best understood in the cerebral cortex. And they come down to these elementary functions identified in the aggregates. So I just- this always thrilled me when I discovered this teaching in Buddhism, because it was just like, a neuroanatomy lesson basically. But the way the Buddha taught about it wasn't, you know, to impress you with his insight into how the brain is designed, but to teach us, you know, what it is that we cling to. And these are the things that we tend to



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cling to. And he usually refers to them as the aggregates of clinging. And one of the things that conditions or makes us more likely to get attached to how we feel and what we see and what we do, what we think, is that we add qualities to them that aren't naturally present there. And the things we add to them like: that they're part of the self or that they will satisfy us without fail, or that they'll be enduring- these are distortions of perception. And one of the teachings about perception in the early suttas, it comes from the Vipallāsa Sutta, the distortions of perception. The Buddha describes these four distortions of perception of thought and of view: "Sensing no change in what is changing, sensing pleasure in what ultimately is suffering, assuming self where there's no self, sensing the unlovely, sensing the unlovely as if it's lovely, gone astray with wrong views beings misperceive with distorted minds." And then later in the sutta he describes, "When those with wisdom who have heard this (referring to the dharma) they recuperate their right mind they see change in what is changing. They see suffering where there is suffering, they see not-self in what is without self and they see the unlovely as such that by accepting right view, they overcome all suffering."

So the Buddha teaches about these distortions of perception, that can make it more likely that we'll get attached to things and cling to things. And this undermines our well being. But perceptions are also important. And in the Nibbāna Sutta, where there's a dialogue between two of the Buddha's senior disciples, and Ananda and Sāriputta, and Ananda, asks Sariputta why some people become fully free in the present life? And, and Sariputta answers "It's because some sentient beings truly understand which perceptions make things worse, which keep things steady, which lead to distinction, and which lead to penetration." So, I think what he's saying here is that perceptions can be distorted, but they're malleable, you know, in the- conditioned by wisdom. And in this case, studying the dharma, you know, we can modify the way we see things and certain perceptions, kind of conventional or default perceptions in the human condition. You know, they tend to make things worse, they encourage attachment. But other perceptions can help us achieve a steadiness of mind. Other kinds of perceptions that we can cultivate, help us make discerning distinctions about phenomena of experience, and other types of perceptions that we can cultivate can lead to penetrating insight, and ultimately, liberation.

So the, I would say the neuroscience perspective, on perception is is like this, that the neuroscience perspective is that it's not like the conventional view. I mean, there's- not everyone believes this anymore, but it's not uncommon for people to think that we see things just the way they are in the world, like a video camera records events. But that's, that's not the Buddha's view. And it's certainly not the new neuroscientific view as well. From neurobiological perspective, perception evolved in each species, including ours to construct representations of the world that can guide adaptive behavior. Adaptive behavior is what allows us to survive and reproduce. And that perception constructs meaning from our interactions with the world much like memory. In fact, neuropsychologists consider memory a form of perception at the mind's sense gate. That's not the words they use, but it's how I translate into dharma talk. And the construction of meaning is in order to guide our behavior. And cognitive scientists are well aware that perceptions are useful, but not accurate. But the distortions in our perceptions have evolved to support our survival, we distort in a way that can meaningfully guide our behavior. So I'd like to show you some examples of this. So against a dark background, you can see two tiles, and you can see that they're identical in color and brightness. But if I change the context, if I change what you see around them, it changes their meaning and it changes how we perceive them.



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Now, those tiles, the tile on top looks a lot darker with this context than it did before. The tile on the bottom looks a lot brighter. If I go back, just do it again- like the colors just change in front of your eyes, they haven't changed- they're exact same colors, I found it hard to believe this when I first came across this illusion. So in my PowerPoint program, I put a little block a little mask around this lower tile to see if it really was the same. You know, it's the same tile. I'm making this myself, it just changes color when the meaning- the background meaning disappears. So the fact that the tile on top is under a bright light, if it's the color it actually is it has to be actually darker than that, you know, the mind makes it darker because that's how it should look in a bright light and the tile on the side. The way it looks to us now is how it should look in a shadow given the color it really is. And so it changes at given the presence of the shadow and the light. Here we see the color without any meaning imposed on it from within the brain by other circuits processing the background information and our prior experience with shadows and light and direct light. And (I'm sorry) and then you know when we have the direct light or the shadows, we change the color. And we do this automatically and it's useful.

There's another illusion that I also have hard time believing; is these two tables-are they different shapes? Or are they exactly the same shape rotated 90 degrees? Well, I wouldn't ask you this if they weren't identical just rotated 90 degrees, it just doesn't look like it. So I had to measure these because I didn't believe it. The red line is the length of the green table 2.3 inches on my computer screen. It's also the width of the red table. The green line is the width of the green table, 1.7 inches, and the length of the red table. These tables have the same dimensions, they're just rotated 90 degrees. So our brain is imposing a different appearance. And the reason that it does that is that the fellow who made this- a psychologist named Beau Lotto who has a lovely website, if you're interested in this sort of thing, it's where I got these pictures. When Dr. Lotto made these images, he changed the angles at the corners of the table to suggest depth and perspective. And we know that a greater distance make things makes things look smaller. So we changed the angle of the tabletop, these tabletop angles are not pure rectangles there, they have angles in them they don't have right angles. Seeing that makes us think it must be longer and we expand it in our mind, the green one looks longer than it is and the red one looks more squat than it is. So our mind does that for us automatically. It's useful. It's just not accurate. That's not what's actually there. Yeah, so what we see is, what a scene like this has usually meant in the past- and in this case, it means that one of these is different shape than the other. So how does the brain actually implement that manipulation. And I'm going to use some diagrams of nerve cells. On the left is a more elaborate sketch showing the cell body of the neuron with its nucleus and these things called dendrites that receive input from a different neuron. There's a synaptic connection here that gets input it's carried along a long axon- well, variable length, some of them are quite long. Sometimes it's insulated with myelin. And then it has an output end, and that's where it delivers the message to the next neuron. But I'm just going to represent that as this little oval with an arrow coming out of it. That's a neuron in these pictures. And I just want to show you how the visual system takes input from the external world, and blends it together with internal information in order to construct meaning. So a neuron brings some information up from the retina. And the first stop in the brain is called the thalamus- the visual part of the thalamus. And a neuron in the visual thalamus sends, conveys that information up to the visual cortex, which is where the first level of cortical processing occurs, primary visual cortex. And we also know that neurons in the visual cortex send information back to the thalamus, kind of telling it what to expect, conveying the benefits of prior



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knowledge, previous experiences, contextual information from other parts of the brain, what we're hearing, you know, what we know about the situation, we're looking at, what's happening on the other side of visual space, or adjacent to what this neuron is seeing- contextual information and prior knowledge. And some of this has been known for a long time that we blend the two to construct meaning. But what was a surprise, certainly, to me, and to many people, when this became clear from microanatomy studies, is that there are there at least 10 times as many neurons coming down from the cortex to the thalamus, telling it what to expect, imposing meaning, filtering out what actually comes in to these cortical regions. And even the primary visual cortex is not a region that is normally conscious. It's only the higher regions where the stuff is constructed and refined and put together into a meaningful visual scene that we have at conscious access to it. But at this level, and at many levels higher in visual processing, there are 10 times as many circuits carrying prior knowledge, contextual information, as there are circuits carrying the bare facts of what the sense organ has detected. So internal information predominates in the construction of meaning. And this is not just in vision, this is in all of our senses, at least the three major senses, hearing, body senses and vision. I don't know about taste and smell; they're quite different in how they're organized. So, what we perceive is not just what's in there, but more like, what should be there based on what we already know. And so we're getting this processed image, something that's been made meaningful and useful to us. Useful to us for survival, but maybe not necessarily in our dharma practice, because we tend to reify things because our brain sort of does that, it adds meaning, it makes it very useful for us. And we think it's just the way it is. There's a psychologist, I should say, a cognitive neuroscientist, a neuroscientist named Donald Hoffman, at the University of California at Irvine, who has written extensively about perception and also about consciousness. He is promoting and testing something called the interface theory of perception. And it's based on the same basic facts, but he takes it to its logical extreme. And it's actually very compelling. He says that our perceptions function like, like a graphical user interface, much like what's on our computer screens. We have the objects that we perceive in the world are like icons on the desktop, and the environment in which we perceive things, you know, our home, the streets, we live on the parks we're walking through, these are like the desktop itself, the objects of the icons, and the environment is the desktop. And their relationship with what's really there may be equally distant. Now, what's really there. In the case of this folder that contains my projects, I've got a lot of information in the Projects folder. What's really there isn't a small blue rectangle in the lower right quadrant of my computer. What's really there is a very complicated electrical engineering circuit board. And some somewhere in there is the contents of my projects directory. But that is not useful to me, I would really need to know machine language and probably need a PhD in electrical engineering, to usefully access that information. So software engineers have created these interfaces that allow us to interact with what's really there. Hoffman says that evolution has done a similar thing for our perceptual capacities, that it constructs a meaningful interface that actually helps us to survive. He makes the point that different species are going to have different interfaces. Every species has a specific one that has survived the test of time, and allowed those creatures to survive. So a crow will have a very different visual interface, an auditory interface, than a human being an octopus, even more different than a person or a crow, a praying mantis, very different perceptual world, different icons, different shaped desktop, you know, completely different. And those examples of animals I gave are among the more intelligent animals in those on those branches, of the tree of of animal life. So Hoffman makes the point that it's quite possible that what we know about what's



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really there is, you know, isn't much- of what we know is what's useful to us as humans to experience. We don't want to- in fact that evolution has protected us from having to deal with this level of complexity. Now, he does make the point and a point that the Buddha also makes, which says that our perceptions may not have substantial reality to them. They have this quality of emptiness, but we have to take them seriously. If I take a file that I really care about, and I drag it to the trash. I'm not going to be able to use that file. So this is serious. Now it's literally what's happening, but it's what I need, it's a useful proxy for what's happening. And so I don't drag to the trash to things that I don't want to lose. I won't say too much more about this but but this guy's works are very interesting. He has a book some some of you might have read or might find interesting called "The Case Against Reality- how evolution hid the truth from our eyes." And one of the things that he does is- he has an engineering background and mathematical background. And he's developed some expertise in these mathematical models of natural selection. And he creates virtual worlds with virtual organisms that have different perceptual attributes. And some some of the virtual organisms see everything in their environment, exactly as it is, and he creates a virtual environment. For that all the organisms have the same virtual environment, some see everything just at a ground truth level, including the things they need to see. Others see a 50/50, half of what they see is ground truth and half what they see is what they need to see. In other organisms, the only things they see or perceive are things that are relevant to their particular needs for survival. And then he allows these organism environment virtual settings to run for hours and days and weeks, and simulating evolution. And he's done this many times with different kinds of organisms. But what always happens is the only organism left- the organism that outcompetes and drives to extinction, all the other organisms are the ones that only see what they need to see. Seeing what's really there, if it's not relevant to your survival, slows you down, makes you less effective, in competing in the environment. So I mean, this isn't a proof that his theory is right, but it's actually fairly compelling. And his ideas conform with those of the number of physicists working really at the limits of what physics knows about the smallest particles in the world and in the nature of space time itself. And they, the conclusion of those physicists is much like Hoffman's conclusions, which is even at that level, space, time and matter. Those things are ways we think about the world. That's not the way the world really is- space time is a model that we've made. It's it's a fact about how we perceive- not a fact about how the universe is constructed. So that that gets a little to the limits. But I think it's a little kind of exhilarating.

I'd like to share with you a few clinical examples of how we perceive and what happens if our anatomy is altered. In some ways, our brains are altered, there's a famous patient, MM, who lost his sight at the age of three and a half. And he was able to get a surgery that could remove the opacities from both eyes when he was in his mid 40s. And right after the surgery, he was just like, confused. He couldn't make sense of what he was seeing, but gradually began to learn to see again. As a blind person, he had become an expert skier. He was in British Columbia, and there was a lot of good skiing there. And he would ski with a companion as blind skiers do, who would call out to him if there were obstacles that he couldn't know about, because he was blind. But mostly, you know, when you ski, you feel the snow, you feel the angles, you feel your speed. You feel the slope. And he was an excellent skier. And after his surgery, when he finally started skiing again, he'd get to the ski slope, and he would just close his eyes, because it was too confusing. He could do a lot of things with his eyes open but not ski. He had to close his eyes to ski because he couldn't make sense of what he was seeing. And that was in the beginning. And



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then, two years later, when they interviewed him again, he was now opening his eyes most of the time on ski slopes, except on the Black Diamond slopes, the most difficult slopes, he would still close his eyes, because he just felt more confident feeling than trying to construct meaning what he was what was flying by him so quickly. He said the difference between today and over two years ago, is I can better guess at what I'm seeing now. What's the same as that I'm still guessing. So what happened with him is different from what would have happened if he'd had this surgery while he was still under the age of about eight. Let's say a child loses the ability to get light into their eyes and then that's restored surgically. A few years later, but they're still young, when their vision is first restored. The retina is fine, it brings information up to the thalamus. But what's coming down from the cortex, it's not that there are actually fewer neurons, it's that the information value of what's coming from the cortex is much reduced, it's not able to impose meaning on the raw visual experience. But the child's brain is very, is more neuroplastic more capable of neuroplasticity. And before long, they've got the full load of information coming down from prior knowledge from prior experience, expectations, predictions, and they see normally. In the case of patient MM, he was older, even after years, he only had a partial supply of internal information, putting meaning on what he was seeing. So he was still guessing a lot of times what was there. There's another kind of syndrome. And I encountered this a single time in my practice. There was an elderly gentleman, 82 year old man who had been a music teacher, was still teaching actually, up until he finally lost his vision. He had macular degeneration. And he had recently reached the point of functional blindness. And then his doctor referred him to me, a psychiatrist, because he started having nearly constant, vivid and very upsetting hallucinations. And the one that I remembered was, he lived in downtown Sacramento in an apartment, and he would see a train crashing through the wall of his apartment and coming through his apartment, and he knew that couldn't be real, but it looked so real, it really upset him. And this was happening daily to him. And he needed help. When this person came into my clinic, I had never encountered this before. And I had to educate myself, what was going on. And I learned from him and from the medical literature that he had Charles Bonnet syndrome, which is visual hallucinations following visual impairment. And a lot of people get this after they become functionally blind or lose most of their vision, especially older people. And you know, neuroplasticity does decline somewhat as we get older, and people can't adjust. And I think what's happening and what what I understood to be happening, what was helpful for him, was to think of it this way. He wasn't getting much visual information about the external world, he was just getting a trickle, he could see patches of bright and dark. But he still had a fully formed prior knowledge system in his visual cortices bringing all that information down to the thalamus, he lived in downtown Sacramento, they have a light rail system there. And you can hear the squeals of these little rail vehicles, they're not big as trains, but they sound like trains. And, you know, he had this this, this auditory information that there was a train nearby and there was some patches of light and dark changing in front of his eyes. And he constructed a train out of that, and was afraid, was frightened by it. And so he did not have the kind of hallucinations that characterize psychotic disorders, there was no rationale for giving him an anti -psychotic medication, or any of those kinds of treatments. What would help and what did help somewhat for him was talking to his family, he lived alone, but he had family in the area. When people spend more time with him, talk to him about what was in the environment, give him more internal information that he could use, and to do something with the things that were being misperceived as trains and trucks in his apartment. And just even just teaching him about what was going on reassured him a great deal, he thought he was losing his mind. But in fact, his



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mind was functioning the way it's supposed to function. It just couldn't adjust quickly enough to the loss of vision. And the hallucinations didn't stop by the time he stopped seeing me, they were just less troublesome and less often. So the Buddha talks about this insubstantial nature of perception, the fact that it's constructed and the Foam Sutta is just an excellent source of his teachings on this. "Let's suppose that in the last month of the hot season of Mirage was shimmering, and a man with good eyesight were to see it, observe it and examine it appropriately. To him, it would appear empty and void and without substance, what substance would there be in a mirage? In the same way a monk sees, observes and appropriately examines any perception. To him it will appear void, empty without substance." This is a monk who has been trained in the dharma- what substance could there be in a perception? The same teaching is applied to all of the aggregates; form: it's like a lump of foam in the same sutta. Feeling is like a bubble; Perception: a mirage, choice is like a banana tree; and consciousness like a magic trick. However you contemplate them, examining them carefully, they are void and hollow, when you look at them closely. So this is not too dissimilar with what some of the far out things are being said by people like Donald Hoffman. It's an interface. It's not substantial, and yet, it's useful, and we're wise to take them seriously and to work with them. As Sāriputta told Ananda, some sentient beings truly understand which perceptions make things worse, which keep things steady, which lead to distinction or discernment, and which lead to penetration or penetrating insight. Let's see. I was going to stop there for questions. But I'm going to go on to the next section. And then I'll stop after that. And we'll have questions. There's another aspect of perception besides its insubstantiality and its constructed nature, in which neuroscience and dharma practice kind of have a parallel perspective. Many meditation teachers tell us that we can pay attention both in a narrowly focused way and with a broad open field of attention. Here's a quote from John Peacock and he talks about mindfulness and how we can do it in a fashion which is much more focused, or we can do it in a wider sense. And Andy Olendzki uses the term Sati-sampajanna, sati means mindfulness and sampajanna, which is often translated as clear comprehension or full awareness. He says the former term sati refers to detailed micro awareness when it's used together with sampajanna, while the latter indicates a broader, more global awareness of an object, as it's viewed in its wider context. So we have the capacity for both kinds of attention. And even they can be integrated together, and I know Andrea Fella has given some talks on on cultivating this broader awareness and integrating it with focal awareness and having both present in doing mindfulness practice. And I think neuroscience agrees with this formulation. And I just want to show you how it's thought about in those metaphors. This is a sketch of the visual system with the eyeballs and the retina, the optic nerve coming into the thalamus, the visual part of the thalamus- left and right. And then neurons going up to the primary visual cortex in the back part, the occipital cortex of the brain. This is the earliest part of visual processing. There are many more higher, more sophisticated visual processing modules that are not included here.

But if you take the optic nerve and cut it in half and look at its cross section, it's got this appearance; there are two zones in it. There are two different kinds of neurons inside the optic nerve. And they're kept separate in the center are what are called parvocellular neurons. And on the rim, the annulus around it, these magnocellular neurons. And that's because the parvocellular (which means small cells- in I believe, Latin) come from very small cells in the retina. And the magnocellular neurons come from very large cells in the retina. And they are separate, they kept separately, they don't talk to each other in the retina, they don't talk to each



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other in the optic nerve. And when they get to the thalamus, they don't talk to each other either. They're processed in separate layers of the thalamus and then they are projected separately up to the primary visual cortex. And only when they arrived there, do they start pooling their information content. And the way these cells are laid out in the retina and wired in the retina makes the small cells very well suited to a narrow focus kind of attention and to discerning the nature of objects, the categorical membership of an object of visual perception, whereas the magnocellular neurons and their wiring in the retina is particularly good at making sense of situations integrating broad awareness into a kind of a global view of what's going on. And if you look in the retina, to see what information is coming in to the Parvo and Magno cellular systems for the Parvo system, each parvocellular neuron in the optic nerve is getting information from only one cone cell- and there are a lot of cone cells in the human retina. So there are a lot of these parvocellular neurons, many more than there are of the magnocellular neurons. One cone cell, there are typically two intermediate neurons that do a little bit of fine tuning of the information from that cone cell, and it delivers it to the parvocellular optic nerve cell. And that takes it up into the brain. So it's a very granular kind of information. Magnocellular system, those optic nerve cells, they're getting input from about 50 rods and cones- the rods are the black and white sensitive ones, the cones are the color sensitive ones. And these rods and cones are spread out various places in the retina to kind of get a big picture of what's going on. And they interact with many intermediate neurons, about 200 for every single magnocellular optic nerve cell. (Excuse me.) So there's a lot of processing going on before it even gets to the optic nerve of this broad information. And that process is intended to make a meaningful data reduction of kind of broad global situational information. And then a single there's a single channel of information, and one neuron can only send one message at a time. So this is being reduced from 250 earlier cells down to one cell, about big picture information.

So that's the contrast between what underlies these two kinds of cells. When they get to the cortex, as I mentioned, they for the first time, start sharing their information. And the granular information that the Parvo cells are really good at is preferentially shared with what's called the ventral visual pathway. And ventral means lower down. Dorsal means higher up in terms of the human brain. And these higher visual processing areas as you move forward in the brain from the back, have more and more sophisticated jobs. And the ones in the ventral area, their jobs involve fine grained analysis, object oriented perceptions, narrow things, identifying members of categories, knowing identical twins from each other, you know, if you if you're familiar with them, you learn to tell them apart, or one cat from another cat or any things like that. The dorsal visual stream tells you how to engage within in a situation. It's a big picture, and it enables you to act in situations. It's laid out, it's a little bit like the icons on the desktop in Donald Hoffman's analogy, these icons are processed down here in the desktop, the environment, the situation is processed up there. Now, the nice thing, of course, is that they're talking to each other the whole way. And it's really, after it gets to the cortex, it's no longer a dichotomy of two different streams, it's now a spectrum. And the in between areas of the brain have sort of in between perceptual talents. But the the most dorsal part is the most global, and the most ventral part is the most focal. And in between is a spectrum. I just want to illustrate some of the things that our mind does with these two talents it has, we can tell, with our ventral stream, we can tell if that's an edible or poisonous mushroom, if we have prior knowledge of the right sort. We can tell that there's a creature hiding in the grass. And we know what what kind of creature it is, and we know that it means we should back away quickly. With our dorsal stream, we find ourselves in



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this situation, we know what angle to take to go down that slope, or maybe perhaps we should turn around and go back that's a little beyond our skill set.

If you're a little boy getting a Frisbee from your dad, you see it, you map it with your dorsal stream, you know where to put your hands, where to put your feet, where to aim your eyes, it's situational information, dynamic information. Some other illustrations, the dorsal stream is good at knowing how close things are, how fast they're moving, what the arrangement is around you. really built for action planning- an intuitive kind of thinking and memory for processes. And it's what I would call subconscious. It's often not right in the center of conscious awareness. Not that we're not aware of it. It's just more implicit more on the edge of awareness. As, and this is- many mammals have this kind of processing system much like ours. In fact, a lot of animals are better at it than we are. But then the ventral system, which is sometimes called perception for cognition is really good at shades of difference in shape and color and recognizing categories. If you were fluent in Sumerian cuneiform writing, you would see the differences between the letters on this tablet. This system is well suited for language and abstract thinking, and representational memory, categorical semantic memories and its has easy access to conscious awareness. Often the focus of conscious awareness is what's being processed in our ventral stream. And the sophistication of the circuitry is unique to humans. And I think is part of why we have language that has developed as much as it has. The comparison is really with other primates- and other non primates, it's harder to make that comparison because their visual systems are different, but humans are really stand out in the ventral stream. And it's, it's informative to see where the streams culminate. The ventral stream culminates in the language areas of the temporal cortex where we have the ability to understand language in our semantic knowledge stores. And a lot of highly sophisticated modules like recognizing faces and recognizing the emotional expressions on faces, recognizing different species of animals, different types of foods. That's all in this temporal region. where the where the ventral stream culminates. The dorsal stream culminates in the frontal lobe, which is where actions are planned where intentions are generated, where our values are compared to the opportunities in this situation- what are our options. So I think it's useful to say that awareness in the dorsal stream is good for supporting our actions, it gives us a big picture view of what's going on, it gives us kind of a situational awareness. And it is framed by our actual intentions and our habits. The the intentions that are inclined to arise in this situation, are implicit in the dorsal stream processing.

And when meditation teachers encourage us to be aware, broadly- that's one way that we can have a clearer understanding of the actual intentions that are kind of latent or competing under the surface to be expressed, because they will frame how we see, how we're sizing up a situation- we can learn somehow a little more about those- some of the intentions that are a little harder to see directly. The ventral stream, on the other hand, supports abstractions and cognition, a narrow, specific focus identifying objects, and it's framed by what we already know and believe, and it can tell us about biases we have in our prior knowledge and beliefs. Because we're imposing that on how we're organizing information in the ventral stream. (I'm gonna skip through this...well, okay, I'll go through it quickly. But we're running out of time.) Like, if I ask you what are these objects, you immediately in your ventral stream go "This is a blue plastic and metal eggbeater. And that is a green plastic watering can." And that's automatically presented to your consciousness by your ventral stream. But if the question is, "What can you do with these objects?" You automatically know that you can pick it up here by this handle, you can spin it with



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this crank, and you can maybe whip cream with it. Or if it's a watering, can you put the water in there, you pick it up here and you can carry it somewhere and water plants with it. These are conceptualized as affordances rather than objects, they're affordances. They're opportunities for interaction with something. That's the kind of thing the dorsal stream does. And as you can see, it's framed by the intentions you might have. Finally, I'll say that (I kind of said this before, but) the dorsal stream is process oriented, it's harder to put into words, it's often in the background of conscious awareness. And it takes a little bit of practice to cultivate awareness of it. The ventral stream, it's content oriented, often in the foreground, easy to talk about, and easy to be conscious of. They are susceptible to different kinds of illusions, these two streams, if I were to ask you which circle is larger, you'd say they're the same. But now if I asked you the same question, your ventral stream will tell me that the one on the right is larger, because it just looks like a larger object surrounded by smaller objects. When you put the background on it, it fools the ventral stream. It changes the characteristics that we attribute to the object includes large for the one on the right. But the dorsal stream is, is not fooled nearly as much. And the affordance of that orange circle, if you were to make it three dimensional, which some scientists have done, and asked people to reach out and grab it, and measure the distance between their thumb and their index finger, they use the same grabbing distance to reach to the orange circle on the left and the orange circle on the right, because their action is being guided by the dorsal stream, it's proceeding an affordance, not an object, and it's size relative to your hand is computed the same way. So this is true for hearing and in some body senses, and it's hard wired. Unlike some other differences in the brain, the left and right hemispheres are kind of different, you know, we have language, most people have language in the left hemisphere, not in the right. And the left hemisphere, especially in the language areas, it's a little slightly different shape and volume. But if a child has to lose their language hemisphere for a surgical procedure that's necessary to save their life, and they grew up with only right hemisphere language regions, they will develop perfectly normal language of the right hemisphere. The architecture, the underlying wiring is similar enough in the left and right hemispheres that any function on one side can be replaced by the other side, but not so for the dorsal and ventral streams. If someone is born blind, and they never have vision, those parts of their cortex that were normally devoted to vision will be taken over and colonized by hearing and touch and blind people become very sensitive and intelligent in those kinds of perceptions. They're using what used to be visual cortex areas, but the auditory colonization of visual structures will always respect the dorsal ventral difference, the wiring is just not adequate for object perception with hearing or touch in a situation perceiving region of the brain. This is a fundamental difference. It's a basic spectrum of our awareness. It comes up in psychotherapy sometimes, because it's not just simple perceptions, it's all the way up to the level of views and high level models of the world vary along the spectrum. And the more abstract models, which are more like the ventral stream, are often reified. They're, they're imbued, so it's so easy to imbue substantive reality to them. And this is the source of a lot of suffering in people who have anxiety and depression, it's so easy to be aware of these kinds of perceptions and views and thoughts. And they often are distorted in an unhealthy way, an unskillful way and it causes them to suffer. So one of the sort of sidelights of psychotherapy intervention, in addition to working more directly on the problems is to encourage people to cultivate their affordance perceptions. Because people who might be very unhappy, very anxious, they can still do lots of things with mastery, they just don't notice it. They don't know they're not, it's not the center of their attention. So you encourage people to use the parts of their awareness that are not being quite as distorted by some false beliefs about themselves.



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So just to wrap this up, I'll mention how this relates to the concept of Sampajañña, which is described in some of our instructions on mindfulness practice in the Satipaṭṭhāna Sutta. It's described as "Abiding contemplating the body as a body: ardent, fully aware," is this translation by Bhikkhu Bodhi of Sampajañña- "Mindful, having put away covetousness and grief for the world." And if you unpack this word Sampajañña, The noun form of it is, it means very full knowing. It's this non object focus aspect of awareness. And, and I think it's pointing in part, to this capacity we have for situational awareness that's embodied in the dorsal streams of our sensory apparatus and our perceptual apparatus. Other translations of this, I mentioned Bhikkhu Bodhi, also Ñāṇamoli also calls it "Full Awareness." But some of these really point directly, I think, to the dorsal stream. Thanissaro Bhikkhu calls it "Clear Comprehension", and comprehension implies engagement. Prehension is a word that means "to grasp" and its etymological roots, like a prehensile tail can grab onto a branch. Clear engagement and understanding via engagement. Sujatto calls it frankly, "Situational Awareness" which is a synonym for the dorsal stream. Buddhadasa, in his writings called it "Wisdom in action," which I think is a great way of defining Sampajañña. And again, this is what the dorsal stream circuits are particularly good at. Analayo, in his first book on the Satipaṭṭhāna Sutta, talks about four aspects of Sampajañña, from the perspective of the commentaries, and some of these point also to the dorsal stream, the four aspects are seeing the intention of any action. And that's an awareness of intentions and that is more accessible to us through that kind of situational awareness how we're sizing up the situation tells us something about the intentions that are arising in our mind. The suitability of an action, that is what action is suitable in this situation, again, dorsal stream. Maintaining sensory restraint in support of mindfulness, I'm not sure that points to the dorsal stream, but maybe I just haven't seen it. And finally seeing the three characteristics in any phenomenon. And those are inconstancy, unreliability, and not-self. For me, that's like a big picture awareness. That's kind of the biggest picture awareness. And that's the kind of thing that that we have the capacity for that really global view of the situations we find ourselves in.

Yeah, I am just going to wrap this up, I already talked about Olendzki's quote, but I'm going to talk about Joseph Goldstein, who says, how important it is to cultivate this Sampajañña, clear comprehension in terms of knowing what we're doing and why- a profound and transforming practice. It's understanding that mindfulness is more than simply being present with clear comprehension- Sampajañña, we understand the motivations behind our actions. Let's stop there. And I'm sorry, this has taken so long, but I'm happy to stick around for questions. If you have them. Yeah, Paul

Questioner

yeah, I second staying around for questions. Just wanted to throw that out there. I think it's great if we can talk a little bit longer. But on that note, you talked about so basically, at the end there, are you basically suggesting that dorsal you know, help enhancing dorsal activity is maybe a way to help reduce suffering. And how do you do that? And? And why and is that what an affordance circuit is? Thank you.

Rick Maddock



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Yeah, that's an affordance circuit. And for me, just knowing that that's like a big part of our anatomy that we don't, it's not the center of awareness, often, it's the periphery- just knowing about it and learning to direct your attention to it, it's there. You don't have to construct it. It's just learning to pay attention to it. And that's, I think, a trial and error process. I don't know if any of you read the Don Juan Carlos Castaneda books back in the day. But there was a part in that book in one of his first books where he talked about how to run in the desert on a moonless night. And, to me, that was like a teaching about the dorsal stream, because what you do is you don't look right at things because the ventral stream is concentrated in the center of vision, and the dorsal stream is spread out over the whole retina. And Carlos Castaneda was told by Don Juan, if you need to run fast in the desert at night, and there's no light look to the side, and then you'll see what's in front of you. And that's accessing the magnocellular system, which sees situations and enables action. So look a little bit to the side of what's in the focus of your awareness. And, you know, and trial and error, just knowing that that's one of the things that is happening in your awareness, learn to make it a little more prominent. Mark?

Questioner

Well, that was a fascinating set of observations that I definitely have to integrate and reflect on but I've been interested in predictive coding, what was the first part of your- of the second part of your presentation. And so I was recently was looking at a presentation by Anil Seth who is you know, a big proponent of that as well. And so it was a very recent talks, it's up to date. And the evidence that he...so lots of the suggestion, this is a theory. And so it's computational right. And so there is a little bit of experimentation that actually I was in this respect, stunned by the example of the skier who was blind. And then..so that was really very convincing. But, but such an experimental evidence, the best experimental evidence that Anil Seth was bringing forth was actually, I'm not going to go into whole experiment, but the effect size of this was less than 10%. So when there was a, it was a visual exercise. And when there's a suggestion when people say, Well, you know, you're looking for a face rather than some geometric object. The difference was, was really minuscule. And, and so I'm saying, well, that's not a way to convince, you know, people, but so so I'm wondering, in your reading, and studies, so how good is the experimental evidence for this? I mean, whether it makes a difference, did this predictive coding paradigm? Yeah.

Rick Maddock

Right. Effect sizes are so dependent upon the details of the experiment. So whether it makes a difference, so do you mean? Does it make a difference that what we're seeing is not exactly what's there? Is that what is that the difference? You're asking about? Yes. Yeah. Yeah. So for conventional activities, no, I would say not. Where it makes a difference is where- and I'm basically, at the moment, have confidence that that's true. I mean, the Buddha has taught it from one way of acquiring knowledge through mastering his own mind and observing it. And neuroscience is showing the same thing. So they come together, as I'm sort of convinced that this is true. And if it's true, then you wouldn't discard it, it's still useful, it doesn't make any difference unless you're pushing your system beyond what it's evolved to do. And what the Buddha did was push the human system beyond what the evolution shaped, which is an animal that could survive in the wild. And it if this is an animal that wants to free itself, from its predicament, and that's different. So when, when you tried to do something we weren't evolved



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to do you have to learn to see through the errors in what you project onto reality. Or if you're a physicist trying to explain what happened in the beginning of the Big Bang, or what happens in the Large Hadron Collider, because that was one of the sources of some insights into that the world is actually not made of spacetime, because it's much simpler to explain the patterns they saw in the Large Hadron Collider, if you abandoned spacetime, and other assumptions about the true nature of the physical universe. So when you push things, then it makes a difference. Thank you. Anne? Oh, can't hear you. You must be muted.

Questioner

Yes, I'm muted. Sorry, this has been so wonderful. I have been trying to do this reading on my own of all these neuro- blah, blah, blah. And just this talk, like was so useful to me. I have personally, somebody was talking earlier about all the memories that come up. And I've personally found that somatic awareness, somatic therapy and somatic awareness really aligns with what you've been describing, or my understanding of what you've been describing. And I find by bringing my nervous system online and kind of seeing that oops, these memories are habituated, sometimes or my perception of them has been habituated, almost really clearly has over a couple of years now obliterated my tendency towards anxiety, I'm quite high functioning, but anxiety, I thought it could fix everything by thinking but and creating stories from the memories as what would happen. But that thing about with somatic awareness, I find that that really opens up like what you were saying about the blind person. Like I could be overwhelmed by the thoughts. But now, what else is here is my regular question. So when my brains overworking I say what else is here and then suddenly I'm sensate aware. And then brings me into some kind of Vedana that just releases the triggers just somatically. I can't explain it-it just happens. But you have explained what's happening in my brain. So thank you so much, because it's just encouraging that the practice I'm doing, I always say to people, the Buddha was a neuroscientist before there were neuroscientists, and that- what you explained today has been so helpful to me. So thank you so much. I know I'm babbling, but it's just from excitement and passion. Thank you.

Questioner

Hi, hello, thank you so much for your time and your talk. I really enjoyed it. I have three questions that I'll make them really quick, if that's okay with you. I was wondering if you could touch on the differences between male and female brains like the neuroplasticity and development? And then... maybe I'll just ask that one first.

Rick Maddock

Yeah, well, there will be people who know more about this than I do. I haven't made a point of mastering that growing literature. But there's one thing that I have learned that I think is true, of course, I'm generalizing maybe from my wife, but that language is bilaterally, it's lateralized, you know, and most, virtually all right handed people have language in the left, and the little bit of language in the right. And it's it's switched and half of left handed people. But the amount of language in the right hemisphere varies. And in part by gender, that women have more bilateral language ability than men do. In general. Now, you can't really talk about an individuals this way. And that correspondingly, spatial awareness is slightly somewhat lateralized to the non-dominant the non language hemisphere, knowing how to- it's kind of like a dorsal stream



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function, this spatial awareness- and language: it's kind of like a ventral stream function. So the right hemisphere in most right handed people is spatially oriented. And it makes better distinctions about spatial relationships, it's more spatially fluent. And that is a little more bilateral in men, and a little more unilateral in women. So that's one difference between men and women, and I personally, I think I'm very left lateralized for language, if there are people talking, I can't write, you know, I just have one language channel, whereas I know people who can write and hear speech, and I can't do that. Neuroplasticity-wise, I'm not aware of any differences.

Questioner

I think one thing that kind of interests me is like, maybe why you see more males like boys, development wise, maybe be more susceptible to environmental influences or such as like not graduating, higher rates of incarceration, whatnot, or maturity levels. And...

Rick Maddock

Actually, there is an important difference there I forgot about that I do know about, which is that... so the brain develops quickly, in utero, and in the first few months of life, and then it sort of starts developing more slowly after that, but it doesn't stop its developmental build out until late 20s. Even though the body is fairly, you know, it's completely grown. The brain especially the frontal lobes, action planning, intentionality, values. And the myelination of the white matter tracks- that is, the cables that allow neurons to communicate with each other, they become faster when they get myelinated. And the myelination of the frontal lobes doesn't end until the late 20s. And that's what I'm saying is true for men. And for women, it's like five years sooner. Okay. And I think this is one reason that more young men get into trouble than young women because they don't have this kind of executive control over more primitive default response tendencies. Frontal lobes is where the executive control is. It benefits more from conscious deliberation, influencing action choices. Primitive parts of the brain don't have that extra tool of conscious deliberation or lasting as long you know, they can't pause as long before they act.

Questioner

Okay. Yeah, I had worked with a lot of at-risk youth and I just sort of my own general experience seemed like the females were able to deal with trauma a lot more successfully and navigate sort of the hurdles of life. And then the ups and downs that we all sort of experience. My other question, sorry to hop the screen, is how- you talk about perception and distortions- How does one foster and more flexible and altruistic, sort of outcomes?

Rick Maddock

Right. That's a great question. Well, I do think that that meditation practice provides some perspective on perception in general, and gives us some insight into its lack of substantialness, you know, that it's malleable, and that it changes with what we're doing. And that allows us to, perhaps, to have a little more flexibility in how we respond a little more freedom and how we respond if we don't reify things, you know, this reification is like one of the worst habits human beings have. And I think we might be particularly designed to do it because of our ventral streams being so highly developed. So to move beyond that, is one thing. Also, perspective taking, which is a dorsal stream talent, is to try to cultivate the ability to see how things would



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look to someone else, that sort of a situational awareness, like looking at a situation from a different point of view. And recognizing that the way you're sizing it up, is your point of view. And so that that encourages a little more of an altruistic perspective.

Questioner

Okay. And then my last question, thank you so much. You had talked about time, and I'm not sure if I'm getting the verbiage, right about time sort of being like a man made concept or sort of some theoretical principle. I was interested in how that sort of relates to trauma. And I think of like the PTSD soldier who is sort of physiologically stuck in that sort of heightened awareness, many years later, or gets triggered, how does trauma sort of relate to time or the physiological sort of experience?

Rick Maddock

Yeah. Well, the way I was talking about time, doesn't really pertain to the question about a traumatized person. It's more like a physics issue. But your question is a good one, because people who have been traumatized and have post traumatic stress disorder, in a way can't come into the present, you know, I mean, they're the past is being imposed upon the present. So it's a good question. And well, you know, I mean, what really helps, I guess one way to think about is kind of a metaphor. But the process I described of present moment experience moving through labile memory forms, various iterations of labile memories, and then into a stable memory. That hasn't been completed in someone who's suffering from post traumatic stress disorder. Things are stable, and they're a little resistant to change, but they keep cropping up, they're being retrieved when they're not called on, you know, it's intrusive, re experiencing is happening, taking the person back to the into the past a different place in time. And it's, the brain is doing what needs to be done to solve the problem to retrieve reframe, reconsolidate in a less toxic way. It's just not happening. And that's when professional help is really valuable. And data is clear when we have some medicines that help a little bit with PTSD. But the Psychotherapy is way more effective. And it's involves assimilating that past episode, and really getting it into a normal stable store. So it's not intruding into the present moment. Slipping the person back on their timeline.

Questioner

Thank you. Thanks so much. enjoyed the talk. You're welcome. Yeah,

Rick Maddock

Paul, another question from Paul.

Questioner

Yeah. Hi. Thanks for the patience. I just want to make sure if anyone else has questions, please. Okay. So I think this is a pretty interesting question. So I listened and it seems to me there's a tension or inconsistency between the Hoffman approach versus the dorsal approach you described. Hoffman suggests reducing information input for easy interface is more effective, consistent with a predictive model and speed of the advantages of speed of doing that. But the



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dorsal approach seems to be suggesting more information looking to the side while running the dark desert may be more effective, though, so those seem to be in conflict, which is better the Hoffman approach or the dorsal approach? was Buddha advocating for the dorsal approach to advance humanity, do you understand the question and I'll stop.

Rick Maddock

But is one assumption you're making that I would disagree with. And that is there isn't more or less information in the dorsal or ventral approach is just formatted differently. It's like the difference between the software that realizes the desktop of a computer that's just x amount of information, but it's laid out so that you can interact with it. And the software that realizes an icon that might not have less or more information, it's smaller. But that doesn't mean it has less information. It's just being realized in a way that you can recognize it. So it's the difference between sort of object recognition versus situational engagement. And it's not a matter of more or less, it's that apparently, these two ways of sizing up the world have evolved because organisms need to have both those abilities to evolve. So it still boils down to just what's needed in the organism. From a Hofmann perspective, if that makes sense. It's just there's no excess information there, it just that one is formatted broadly. And one is formatted concisely. And the broad is dorsal. Yeah. Okay. And I don't think the Buddha was advocating for the dorsal stream, I just think he noticed that his mind did that and that there was some value in paying attention to that, especially because it's easy to ignore. But if you cultivate his level of self discipline and awareness was pretty amazing. And so he could see that that was a way to know what your intentions were in one way. It's a way of seeing what intentions were shaping how you sized up a situation.

Questioner

Ah, I think I helped Thank you.

Rick Maddock

Well, I really appreciate everyone's attention.