**Lecture 4: Sleep, napping, dreaming and memory reconsolidation.**

Today's lecture is on sleep, napping, dreaming, and memory reconsolidation. I should tell you that this is not an area of specialization of my own. It's still an important part of the story. I've been surprised to see how much continuity there is between what we've talked about and what I’ll be talking about today. Sleep plays an essential role in memory and emotion interactions. I'll review evidence that sleep itself enhances memory. I will show that sleep preferentially enhances emotional memory relative to neutral emotional content. We will then talk about how REM sleep consolidates emotional memories, and the idea that REM sleep reconsolidates emotional memories, which is a kind of new research topic that people are investigating. We'll then go on to talk about how dreams mostly occur during REM, and we'll start to tie this back into clinically relevant material regarding dreams, as well as the research that we're going to be doing during this fellowship. I will also remind you about what Freud said on dreams, and then we'll look at some subsequent developments to Freud in terms of understanding where dreams come from and what their function might be. We will then discuss how dreams could potentially be used as an outcome variable in psychoanalysis. I will tell you the research that we're planning to do, and how that could be a preliminary study for a future grant application. Finally, we will touch on other ways of making clinical use of sleep related memory reconsolidation.

Sleep has several functions. Importantly, sleep is a time when you're not taking in new information. This is a time when the information that we've taken in during the day gets processed. There is a challenge here, because we don't want to remember everything, and we can't remember everything, therefore, we must have some selective processing. In addition, sleep is integral for development and learning. Young children sleep a lot and have a lot of REM sleep. Sleep is important for energy conservation but also a lot of basic maintenance functions of the brain, and neuronal metabolism take place. Sleep is very important for health. There was a study conducted in 1983, where rats were prevented from sleeping and as a result, they died. There was also a study with fruit flies that were kept from sleeping using a temperature manipulation, and as a result they also died. Very cleverly, as a follow-up study, they were able to figure out how to keep the fruit flies alive. It turned out that there was a reactive oxidative species of inflammatory molecule in the gut that went to very high levels, and when they introduced medication to counter it, it kept the fruit flies alive. An unexpected finding was that sleep plays a major role in regulating immune responses, and has a major impact on brain function, cognition, performance, vigilance, and psychological state. There are a lot of functions of sleep and what we're going to be talking about is just one aspect.

Tononi and colleagues put forward the so-called synaptic homeostasis hypothesis of sleep that is well supported and being actively investigated. Essentially, sleep selectively attenuates synaptic strength between neurons ridding the brain of unimportant information. This theory also re-establishes energy reserves which is housekeeping activity to attenuate sub cellular stress. Their conclusion is that the main functions of sleep are energy reserve restoration and re-sculpting the synaptic landscape. Figuring out what information is important to keep, and what information to discard when intake of new information is suspended due to sleep.

How do we know that sleep is important for memory? Well, there are a variety of studies in people. Napping is one type of research. Sleep deprivation, sleep physiology, and imaging studies are others, but also sophisticated mechanistic studies in laboratory animals, including direct current brain stimulation, cellular firing patterns in rodents, synaptic and intracellular measures of plasticity. That's what memory and learning involves, plasticity and synaptic changes.

I was really struck when I learned about this type of work during replay of memory during sleep. This was first reported in the 1990s. It involved hippocampal place cells in rats. They were able to show in the visual cortex and hippocampus, what the pattern of neural activity was as the rats were learning. The rats then slept and were able to show that these same patterns were reproduced in the visual cortex and the hippocampus. So multi-unit firing sequences during non-REM sleep demonstrate recapitulation of firing patterns observed during prior learning in both the cortex and the hippocampus.

Not surprisingly, it's a complex and interesting story. Replay during sleep is a mechanism by which memory traces are rehearsed and transferred to neocortical areas. You may remember when I presented multiple trace theory about the connections between the hippocampus and cortex. Since the 1990s, replay during sleep has been considered important in memory consolidation, and integration. It's now understood to be more complex because it happens not just when you're sleeping, but when you're awake and it plays out in reverse order as well. This seems to participate in decision making and planning. This remains a very active area of current research.

Trying to understand the mechanisms of memory consolidation and hippocampus – neocortical interactions. I was really impressed with this paper by Stickgold and Walker, “Sleep - dependent memory triage: evolving generalization through selective processing.” Their model highlights the discriminatory incorporation and then initially potent memories based on salience. In other words, events happen, and they have a lot of different characteristics. That's the pluripotent aspect. There is discrimination regarding what is selected for further processing based on emotion, reward, and what's salient for a given person. Then there is this triage function where memories can follow different pathways. So, one is item learning and unlearning, one is item integration, and another is multi-item generalization. It's a perfect example of how the brain is trying to create models that generalize and take advantage of individual specific circumstances by building and contributing to generalized patterns. The end goal is building and updating generalized knowledge and beliefs about the world in which a given person lives.

This is a schematic illustration of what I’m talking about. One possibility would be all the information that you have and the pre sleep state is uniformly encoded and processed. That's one possibility. That is not what happens. Certain aspects of memory are selectively tagged, and others aren't. It is the tagged ones that go on to be processed more during sleep. We can see that the tagged get special treatment during sleep compared to the non-tagged. We also have selective item consolidation, this is basically what I said before. The ones that are tagged get consolidated, the ones that aren't, don't. Item integration, which is that you have previous examples of the same thing, and it gets added in, it's another example. There's also multi-item generalization. You start off with this collection. But then a gist schema is generated. Ways of classifying what's true and what's false are generated, and rules for what belongs and what doesn't are generated. This happens spontaneously, and in this review paper, they review all sorts of evidence from different sources including grammar learning, where these kinds of processes take place.

What really strikes me is, the brain is doing all these things in general. That sounds a lot like what we were talking about in psychotherapy, and how change happens in psychotherapy. Memory systems are reorganized during sleep into consistent patterns or schemas. This reorganization involves integrating the new with the old reminiscent of reconciliation. This suggests, but doesn't prove, that old memories are updated. Sleep preferentially selects what's relevant to a person. I would submit that’s what an emotion is, a system for determining personal relevance and responding as needed. Therefore, a conclusion is that the way the brain sorts and saves information during sleep, roughly approximates the proposed mechanism for enduring change in psychotherapy.

We're getting more specific now from sleep in general to emotion and it's preferential processing during sleep. The next slides are taken from the Jessica Pain chapter that was assigned for this week. So here you have a photo with the background and an object that's neutral. Here you have a photo, the same background, with an object that is emotionally salient, a car that's been in a crash. About the neutral content, there's no difference between the object and the background. When it comes to the emotional content, the object itself is remembered better, and the background is remembered worse. That’s the so-called trade off that applies to eyewitness testimony. For example, when people can remember the gun, but they can't remember the background details, like the person's face, like who was attacking them. When comparing the effect of being awake for 12 hours, or being asleep for 12 hours, that has no effect on neutral material. Regarding emotional scenes, you have a decrement in memory for emotional scenes after 12 hours have passed. However, after 12 hours of sleeping you remember the object better. Sleep is preferentially enhancing memory for emotional content, and that's reminiscent of the Cahill study where emotional material is remembered better than neutral material, and that gets blocked by propanol at the time of encoding.

So, Jessica Payne really spends a lot of the chapter making the case for this two-step process. That there's a tagging procedure that happens at the time of encoding. For example, during the day something happens that’s emotionally salient, and there's release of cortisol and norepinephrine, and that somehow tags the memory traces for later processing, for consolidation during sleep. The stress response, which I view as a proxy for emotion in general, sets the tag, you sleep, and then those tag responses are preferentially consolidated in a network that includes the hippocampus, amygdala, and ventromedial prefrontal cortex. This is where emotional memories are instantiated. The neurotransmitter, norepinephrine, plays a special role in this and in the consolidation of emotional memories. Neuronal metabolism, transcription, and translation processes are activated by norepinephrine, thus providing the tag of synapses with the proteins required to reinforce and prolong a change in synaptic efficiency. These arousal-related neural modulators enhance connectivity within critical emotional memory circuits (i.e., the amygdala, hippocampus, and prefrontal cortex). As such, they provide a cellular mechanism for network level changes.

Now we're going to switch and talk about REM sleep. REM sleep is when emotional memories are processed, consolidated, and perhaps reconsolidated. There were seminal studies in the 1990s, by Macquet and colleagues, where they had people in the PET scanner, functional neuro imaging, and they're able to see what areas of the brain were activated and deactivated in different stages of sleep. This is what the brain looks like during REM sleep. A close-up of a brain

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What's in red is activated, and what's in light blue is deactivated. The emotional areas, including the amygdala, hypothalamus, thalamus, and the anterior cingulate cortex. As well as the visual areas, including the visual cortex, and the whole visual processing stream. And memory including the hippocampus, peri hippocampal areas and the medial temporal lobe. Okay, what's deactivated? The prefrontal cortex, and the parietal lobe involved in spatial processing. If you're not actually navigating external space, maybe that's why it's turned off. It's very interesting. So, we have emotional arousal, and we also have memory and not a lot of inhibition going on.

Here's a study that really shows preferential consolidation of emotional memories during REM. This is a small study, two groups of 15 or 16, and they had the subjects learn two sets of pictures with 120 pictures, 4 hours before the test. One group doesn't nap at all, and the other group does. Then 15 minutes before the test, they learn another set of pictures. What do they find? Well, we have emotional material here again. Each set had an emotion and neutral, and then the neutral over here. So, we see a difference in the group with a nap, and no difference in the group without a nap. This reinforces memory recognition. You can see that there's an advantage for the group that slept after learning the first set, relative to learning the second set without a nap. That difference between the two is captured by this bar here. For neutral material, there's no difference between the two data sets, for either the nap condition or the no nap condition. It really has to do with the emotional material and showing the effect of the nap relative to no nap. Then they took this quantity here - the advantage of a nap, and they show that that difference correlated positively with the amount of REM sleep that they had during the nap and correlated negatively to REM latency. The quicker people got into REM during the nap the better their recollection. This is a little complex, but hopefully you understood it.

This is a great article by Matt Walker and colleagues’ article, “Overnight therapy, sleep to forget and sleep to remember, why you usually feel better in the morning.” We have wake, REM, and wake. While you are awake you have coordinated encoding of hippocampal bound information within cortical modules that's facilitated by the amygdala. The amygdala is influencing how the hippocampus and cortex interact. The neurochemical environment is important here, because you have high aminergic milieu (i.e., serotonin and norepinephrine), and Lower cholinergic activity while awake. During REM, the same structures are reactivated by synchronous theta oscillations (3-7hz), supporting the ability to reprocess previously learned emotional responses. Importantly, the norepinephrine and serotonin are way down, and cholinergic activity is up. During REM the neurochemical milieu has changed, resulting in depotentiation of affective tone and progressive neocortical consolidation of the information. In this panel we see stronger cortico-cortical connections supporting integration into previously acquired autobiographical experience, aiding assimilation of the affective content with past knowledge, which may contribute to the experience of dreams. In other words, the low level of norepinephrine reduces the affective tone. The emotion has already had its effect in terms of labeling and tagging what's important to remember. That gets consolidated and the emotional component gets reduced, and the information gets complexly encoded in the cortico-cortical interactions. The key point here is that during REM, because of the difference in the neurochemical environment, it's down-regulating the emotional component and facilitating the transfer of information to the cortex. And so that's why you might feel better in the morning because the emotional component is dampened down. The emotion has played an important role in identifying what's important. However, it then gets modulated, and the information gets stored.

This just happens to dovetail nicely with a general theory of insomnia put forward by Van Someron and colleagues in Amsterdam. Their theory is that insomnia of all types is due to persistent limbic hyper activation at night, That is, emotional arousal that doesn't quiet down. The physiological review article is massive, 50 pages long. He reviews genetic, developmental, imaging physiological, and subjective findings. His summary conclusion is that insomnia is due to persistent limbic activation at night, associated with elevated norepinephrine. It should ring a bell now because we heard about overnight therapy and the importance under normal circumstances of norepinephrine being low. Sound sleep involves consolidated locus coeruleus silencing. In other words, the source of norepinephrine, and the brainstem is silenced during REM which provides a unique neuromodulatory context for synaptic plasticity in limbic circuits. Insomnia, however, involves elevated norepinephrine, which prevents down regulation of hyper arousal, and constitutes risk for common mental disorders. He describes hyper aroused sleep that people have with insomnia as sleeping with one eye open, and paradoxically, people are hyper aroused during the day.A diagram of a brain

Description automatically generated This is a figure taken from that paper, and on the top row we see normal sleep. You have a new emotional experience that's called limbic response and autonomic activation, because cingulate cortex plays a role in sympathetic arousal, in this case the dorsal ACC. This is what sleep stages look like. The successful normal sleep, and in red, you see REM sleep. There's a lot more REM sleep for the end of the night, and as we've seen from Matt Walker, there’s down regulation such that years later the recalled emotional experience is attenuated and not showing the limbic activation which, he says is associated with normal mental health and absence of mental disorder. In insomnia, these same areas are hyperactivated, and this is the sleep stage pattern that you see in insomnia with less REM. Its more fragmented and that persistent activation he proposes constitutes a risk for mental illness. There are different mental disorders: depression, anxiety, associated with sleep impairment. It's also the case that sleep impairment comes first followed by emotion dysregulation.

The psychopharmacology of REM, and the effects of antidepressants is very clear. REM is characterized by low serotonin, low norepinephrine, and high acetylcholine. We have previously heard that selective re-uptake inhibitors, SNRIs, and tricyclics all inhibit REM. Why? They promote serotonin and norepinephrine turn over. Moreover, tricyclics have a lot of anticholinergic activity, which is an additional reason why it would inhibit REM. It turns out that depression is often associated with excessive REM. For example, people with depression have short REM latency. Excessive REM may reinforce negative memories. Thus, the anti-REM effects of these medications may be part of their treatment effectiveness.

We've talked about how REM may be necessary for reconsolidation in a psychotherapy context, and we often provide psychotherapy plus medication. And here's a way of thinking about how the two might go together. We want to use the medications to treat symptoms of depression, for example, and then keep people in remission for 6 months, i.e. The symptoms are very low or gone. After 6 months, if you haven't had previous episodes at all, then you can stop the medication, and the depression is not likely going to recur. If you were to continue the medication when you're doing psychotherapy to prevent recurrence of depression, it could interfere with the effectiveness of the psychotherapy to the extent that the enduring change that you're after involves reconsolidation during REM. We need to give medications to treat depression and anxiety. There are alternatives, of course. CBT would be an example of a psychotherapy that's effective in treating certain kinds of depression. But if you're giving medication, it can counteract what we're trying to do, neurophysiologically, when we do psychotherapy through a hypothesized reconciliation mechanism. Therefore, not giving medications to interfere with that would be wise.

Consolidation and reconsolidation of emotional memories during REM. We can't remember everything, but we need to remember what's important. Stress and emotion mark what's most important through enhanced encoding. Norepinephrine and cortisol tag daytime memory for preferential sleep processing. Norepinephrine facilitates long term potentiation during non-REM, which is critical for memory consolidation. Emotional memories are preferentially consolidated during REM when most dreams occur. Low norepinephrine during REM down regulates and integrate emotional content. Consolidation involves integrating new information with the old reconsolidation of specific memories. Updating old memories during sleep is a new area of research currently being investigated. We can conclude that, because most dreams happen during REM, dreams could reflect the process of consolidation or reconsolidation of emotional memories, and thus provides a new perspective on the clinical importance of dreams.

Freud wrote a seminal book, “Interpretation of Dreams”, in 1900. Freud viewed dreams as the royal road to the unconscious. He believed the dreams represented the disguised fulfillment of repressed wishes. Because awareness of forbidden wishes would be too arousing and disrupt sleep, the true meaning of the dream, the latent dream, is disguised by the unconscious primary process. There's a difference between what the dream is about, the latent dream, and what people dream, which is the manifest dream. Patients experience and report a manifest dream to understand the latent dream and require free association during the session to elements of the dream, to understand what the elements of the manifest dream mean to the person, working your way back to the latent dream. A critical part of this is, what is the emotional experience in the dream, as part of the manifest dream, which is extremely relevant, and needs to be integrated with all the other information. That's how you make sense out of a dream.

Freud was a pioneer and said that dreams have a purpose. He was very specific in saying that the purpose was to maintain sleep because there were these forbidden impulses and wishes that would be too disturbing, and they had to be disguised. They maintain sleep by keeping arousal in check by disguising what the dream is all about. The latent dream comes first, then the manifest dream. This happened to fit his more general view of psychopathology that the clinical symptoms are like dreams. It’s a result of unconscious conflict that needs to be disguised and comes out in these weird ways.

Ernest Hartmann, is a prominent sleep researcher at Tufts University, was a psychoanalyst, ran a Sleep lab, and is a good sleep researcher. He was the son of two psychoanalysts, including Heinz Hartmann, who is a big figure in development of the Ego psychology. Ernest postulated that nightmares after trauma are a paradigm for all dreams. He examined dream sequences during the weeks and months after trauma in 40 separate people. He considered this a paradigm for how emotional concerns are handled by the processing systems in our brain, which are basically 75% to 95% of dreams contain emotional content. It is very difficult with little subtle, emotional perturbations, to really see what the sequence is. He thinks that if you start off with something traumatic, and then you see how it changes over time, that tells you something about the function of dreams. After a trauma, you often observe a concrete dream about the actual event. Often not always. Then the dreams contextualize the dominant emotions, such as dreaming of tidal wave. This corresponds to the overwhelming nature of trauma. He says that dreaming makes connections and mental networks more broadly than is possible during waking. He thinks the connections are not random but are guided by the person's emotional concerns. Essentially, these connections are functional by weaving in or integrating new material with older material.

How many people here dream about exams here? How often are those dreams positive, like you dream you're going to have wonderful success? Could it be that you dream that you're unprepared, or that you're late, or that you're forgetting your answers? Negative dreams are more likely the case. They did this study involving thousands of students. They followed people during a semester and asked them how frequently they dreamt about an exam coming up at the end of the semester. They looked at people who had a dream about an exam the night before the exam. Most of these dreams were unpleasant. However, lo and behold, having a bad dream the night before was associated with having a better grade. They also tracked, how frequently do you dream about an exam during the semester, and they found that the association between the frequency of dreams about the exam during the first term correlated with a better grade. An interesting result suggested that there might be some benefit to having dreams.

Another study, “Dream content after divorce predicted adjustment one year later,” recorded 49 subjects going through divorce who completed sleep studies at the time of the breakup and one year later. Thirty-one of these subjects were depressed. Roughly half of these subjects were women and half men. Depressed subjects who incorporated the ex-spouse in their dreams we're less depressed and better adjusted at follow up than the subjects who did not. These dreams are also rated as having stronger affect. It suggests that dreams with strong affect that include the stressor may facilitate recovery from depression. More generally, dreams appeared to prepare people for and improve their ability to deal with dangerous or threatening situations. So, remember, Freud, used these kinds of recurrent dreams as something that was inconsistent with the pleasure principle. This is a way of understanding what these dreams are about.

This paper came out in 1977 when I was finishing medical school, and I remember being really jazzed about it. I was very familiar with Freud's theory of dreams. It starts off as very coherent, and then it gets disguised. It comes out as a combination of things that do make sense and don’t make sense. Hobson said that based on the physiology of sleep, dreaming and REM sleep it may be the opposite. You end up with the same thing, but from a different route. What he said is that the mental content of dreams is initially random because it's generated by brainstem generators of eye movement, right? And we know a lot is going on in the brainstem with changes in neurochemistry, etc. The idea is that this neural activation happens and when the neurons are activated in this way it's associated with some mental content. Then, the cortex has an integrated function, and it tries to synthesize and make sense out of what's been randomly activated. You end up with the same thing. A combination of what makes sense and what doesn't make sense. However, the order of it is different, the origin of it is different, and perhaps the meaning of it is different.

Every two years we have an international conference on the Science of consciousness in Tucson, Arizona. One year there was a debate between Mark Solms and Allen Hobson. Mark Solms, the psychoanalyst, defending the Freudian view and Hobson defending his view. Then the audience voted on who won the debate. Mark Solms won the debate.

I came across this paper, “The overfitted brain: Dreams evolved to assist generalization” by Eric Hoel. Overfitting occurs when a statistical model fits a training data set exactly. But then you apply those same parameters to another data set, and it doesn't generalize because the parameters are so specific to that first data set. Well, it turns out that all deep neural networks face the issue of overfitting. This is a ubiquitous problem solved by experimenters injecting noise in the form of noisy or corrupted inputs. This paper argues that the brain faces a similar challenge of overfitting. We're trying to provide models of how the world works that will generalize and be adaptive. Nightly dreams evolved to combat the brains over-fitting during its daily learning. Dreams are a biological mechanism for increasing generalizability. Dream loss leads to an overfitted brain that can still memorize and learn but fails to generalize appropriately.

Earlier today I was having a conversation with someone who is extremely knowledgeable about computational neuroscience. He agreed and said, oh yes, this makes perfect sense, because what you're trying to do in creating models is to reduce complexity. You want to increase accuracy, reduce complexity, and rid any unnecessary parameters. By injecting noise into the system, it can figure out whether a given amount of data, which might be noise, is predictive of something or not, and you can sift out what you really need and what you don't. This to me is highly consistent with an activation synthesis idea. There's randomness, and purposefulness to it. Purposefulness to the randomness in dreams. At the same time, clinically, dreams are very useful because they're coming from the person's brain, and there is some integrative activity involved in generating the dream itself.

Can manifest dream content be used as a psychoanalytic treatment outcome variable? Reconsolidation of emotional memories likely happens during REM sleep and dreaming. If so, manifest dream content may be a real time read out of reconsolidation as it is happening. Psychoanalysts have a primary interest in altering unconscious processes that are clinically problematic and are a bit less interested in symptoms as an outcome. Dreams are a potentially interesting outcome variable for psychoanalysts. The hypothesis is that changes over time in manifest dream content may be an index of memory reconciliation processes related to treatment.

In the context of chronic depression and early life trauma, how might dreams change during psychoanalytic treatment? This is going to be studied in a group of patients with chronic depression and early life trauma, which involves being emotionally overwhelmed. Trauma also involves being alone, unprotected, and helpless. We're going to take dream reports, and we're going to try to assess 5 different dimensions. One is the quality of object relations. To what extent is the dreamer in the dream alone, or engaged with others? To what extent is the dreamer a bystander observing the action, or actively engaged in having a sense of agency which is not present during the trauma? Is the person helpless? We're going to try to develop a scale of problem solving in the manifest dream content. Traumatic emotion is highly arousing and undifferentiated. To what extent is there an expansion of emotional range in the dreams, and to what extent over time is there a decrease in nightmares, which would be a reduction in the high arousal state at night?

Relevant to patients who are chronically depressed, and had early childhood adversity, we thought we'd add some face validity to it, by having people tell us about early trauma memories at the beginning and end of treatment and see if those memories change. Afterwards, we're going to get outcome variables. We are going to look at symptoms, but also the kinds of functioning that we're interested in in terms of interpersonal functioning and occupational functioning, etc... The hypothesis is that both dreams and trauma reports will change in parallel with each other and with clinical improvement.

We are taking 30 patients with depression and early childhood adversity from a multi-center trial here in Europe that is principally designed to compare high frequency psychoanalysis (4-5x week) to low frequency (once a week). We are also going to have two other groups. One group of 15-30 patients who are currently being treated with emotion focused therapy. This is a gestalt method that is not psychoanalytic and does not pay attention to dreams. People are encouraged to report their dreams, etc. We will assess people at the beginning of treatment and 6 months later and see if their dreams change. We're also going to take 15 – 30 healthy volunteers, age and sex matched, not in treatment. We'll test them on two occasions and see if their dreams and early childhood memories change. In a healthy population roughly 50 % of people have had early childhood trauma. Childhood memories and dream reports will be obtained pre-treatment and 1 year later and correlated with clinical improvement. The prediction is that these early memories, dreams, and clinical status, will “improve” together. We think it will be useful to use those same 5 dimensions for the scoring of childhood memories, and how they change, as well as dreams. What we're doing while I'm here in Vienna is developing the coding systems along these 5 dimensions. Later this year, the data acquisition will be complete, and then we can see if these hypotheses are true.

How could we take these results to the next level? It would require doing something that psychoanalysts don't typically like to do, which is to have their sessions recorded and to do all sorts of assessments. That's traditionally thought to interfere with the whole process. I think hopefully it can be done under certain circumstances with certain people. It's essential to record the sessions to make various kinds of ratings. One of the things that is useful is called the narrative emotion process coding system that can be used as often as every minute in a session. It broadly assesses narrative, what people are saying, into 3 categories. One category is a problem category. The same old story, the same thing repeated. Transition markers are where you might have different plot lines, things are being shaken up, things are different. Finally, change markers, such as discovery and success stories, where things have changed, and people feel differently. I think what we'd be looking for is times when old memories and old painful feelings are activated in a session, As well as times when there is a corrective emotional experience or new emotional experiences that are counter to expectations that constitute a prediction error, That can potentially be reconsolidated. After the session but before sleeping you would assess changes in emotional state and changes in recurrent and repetitive maladaptive patterns after the session. Then you would have the patient hooked up to some kind of psychophysiology with actigraphy, maybe some other physiology, that you could tell when they're in a REM period, and you would wake them up by giving them a call, and you would obtain a dream report. Then the next day you'd monitor for changes in emotional state and repetitive pattern. You would be observing for changes in the current pattern over time because we’d like to see whether they're practicing new ways of construing and responding. You would observe the long-term outcome. In other words, we're really trying to connect the process of what's going on in the therapy to outcome with specific mechanisms in mind that we'd be testing. This is the narrative of emotion process coding system.

There are other ways of working with memory reconsolidation during sleep. Napping really does seem to work, rehearsal before you go to sleep helps with memory reconsolidation, rescripting (something happened, and you come up with an imaginary outcome that can influence what gets consolidated). And then targeted memory reactivation. That's an experimental method where you're pairing certain information with sounds or smells. While the person is sleeping, you present the sound or smell to see if that influences memory consolidation. That's an active area of investigation.

I thought this study was interesting because I had taken you through that study of memory reconsolidation previously, where people learn a list on day one, and then they come back, and one group is reminded of the previous session that puts it into a labile state. Then you learn a second list, and that second list intrudes into the memory of the first if it's been reactivated. If the day one list hasn’t been reactivated, then it doesn't intrude as much right. In this study, what they did was they introduced a nap. On day one you learned a list of nonsense syllables that went together. On day two, participants were given a reminder of the day one list learning. Then they had these different conditions. In one condition they stayed awake, you got a reminder after 90 minutes about the first learning event, and then you learn the second list. In this next group you had a reminder, and then you waited 10 hours, and then you learn the second list. That is outside the reconsolidation window. Theoretically, it shouldn’t interfere as much. The third group they got a reminder and then they slept for 90 minutes, and then they learned the second list. They had the opportunity to consolidate and reconsolidate the first list. Basically, what they found was that there was an advantage to sleeping after the learning. You learn it, you sleep, you consolidate it, and then you get the reminder which should interfere, but it doesn't interfere as much compared to the group that didn't sleep, or compared to the group that got the reminder but didn't interfere because it was 10 hours later. All by way of saying that napping really does seem to make a difference in consolidating information. It’s not unreasonable to think that it might help after a psychotherapy session because you are consolidating what you learned, and you don't have all that additional time and other things could interfere.

The story of how emotion and memory interact to create change is incomplete without understanding how sleep and dreams participate. Sleep plays a major role in integrating new information with past knowledge. Evidence supports the role of naps in promoting consolidation. Emotional events during the day are preferentially tagged for encoding and later processing and are preferentially processed during sleep relative to neutral content. Emotional events are preferentially processed during REM and integrated with previous knowledge. The low norepinephrine milieu helps ensure that the emotional content of the memories is modulated while dreaming. Freud, correctly associated dreaming and modulated emotional arousal, but he didn't know about REM (discovered in 1953). He didn't know about REM neurochemistry and the role of norepinephrine, and he didn't know about the need for randomness and deep neural networks to promote generalizability in newly acquired information. The observation was there: you dream, and you sleep; you don’t sleep and you don’t dream. However, the explanation for may be different. Dreams do have meaning and are clinically useful just as Freud said. Dreams could be a marker of memory reconsolidation as it's happening. Finally, changes over time in dreams and childhood memories of trauma could be useful markers of outcome in psychoanalysis and psychodynamic psychotherapy.