

the stuff of dreams

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windows into the brain

For some years respectable psychologists eschewed the study of the content of dreams, partly due to the difficulty of studying it from an objective scientific viewpoint and partly for fear of being confused with psychoanalysts. However, now there is a 'respectable' study of the content of dreams as well as extensive knowledge of the externally observable and recordable aspects of both dreaming and sleep deprivation.

One of the key questions asked about dreams is what they are for. It is known that sleep is important for laying down memories and mental wellbeing. Clearly some form of processing is happening during sleep and so researchers wish to understand what way, if any, dreams form part of this processing. Of course it is quite possible that dreams themselves are an epiphenomenon, more like crosstalk or leakage from this sub-conscious processing into conscious mind.

Part of the debate of dreams relates to how like or unlike 'normal' thinking they are. Certainly quite strong empirical evidence points to relatively complex reasoning occurring during dreaming, albeit with limitations [\[**refs**\]](#). There is disagreement here, but again the focus seems to be principally on what this tells us about dreaming itself and its purposes.

In this essay I'll take a different viewpoint and ask more what dreaming tells us about normal thought. Imagination is intimately interwoven with our perception, planning and memory, but is constantly being calibrated against actual sensations and real unfolding events (at least for perception and planning, memories can take a life of their own). However, in dreams the internal models that drive our imagination can proceed without the continual 'corrections' of the real world.

That is dreams may offer a clearer view of waking thought than waking itself.

stories we tell ourselves

Understanding of perception, consciousness and memory consistently show that what we see and remember of the world is at least partially constructed or reconstructed.

Our perceptions and memories are partial and so we unconsciously fill in the gaps. This is adaptive in that we do not need to receive or recall

total information in order to live our lives; if this were not the case we would need massively more mental processing power and memory (and we have a lot already [*ref*]). Furthermore, it may be that partial memories where only the salient points are recorded are easier to match against new incidents and so guide future action. While we could also imagine way of thinking that kept track of the missing and partial information, our minds instead seem to work on definitive streams of narrative and so unconsciously fill in gaps.

This planning of for future action also involves some form of modeling and prediction if the world, imagining how it will be in the next few moments (or longer). In order to perform any purposeful action that is not purely reactive you need to at some level imagine the planned outcome. At a very low level this is evident in that the mental activity just before an action is nearly identical to the action itself, intention and execution are nearly the same. Of course there is a difference, the execution may not be as expected and when this happens we get some form of shock or are forced to reflect consciously on the action (breakdown in Heidegger's terms).

Some accounts of consciousness itself regard it as an autobiographic narrative about oneself, that the actual seat of action is distributed and reactive and that our sense of volition is largely a building of a consistent story about those actions. Certainly there is evidence for this, both at a low-level, including the action potential that precedes the *reported* moment of the intention to act, and also at a higher-level, for example when subjects whose limbs are stimulated artificially still report constructed reasons for 'their' involuntary movement.

So we have at least five different ways in which we are using some form of mental model of the world (order roughly in longer time frames):

- (a) in perception to disambiguate sensations and to fill in sensory gaps
- (b) in moment-to-moment papering over the gaps in our conscious experience of our own actions and the world
- (c) in immediate activity as we plan our own next actions and predict their consequences coupled with the predicted actions of others
- (d) in longer-term deliberative planning where again we require predictions of consequences and other people's actions
- (e) in memory to fill in the gaps of memory to create a complete and coherent account

Of these (a), (c) and (e) seem the more basic whereas (b) and (d) are more 'high level' connected with consciousness and reasoning.

Figure 1 shows a simplified view of how these interact. Note the central ellipse represents the person's current internal view of the state of the (relevant) state of the world. This is termed 'imagined' as it is the percept not the state of the world itself. Also note the term 'model' here is being used for the implicit and explicit rules about domains rather than for the imagined current state.



There are several questionable connections. For example, extreme epiphenomenalists would not include the arc from consciousness to planning, also the arc from planning to the imagined state of the world is effectively assuming the same structures are used for imagination during planning as for real percepts of the world. Note also one set of models have been drawn, but these may well be different for the different processes. However, the aim of the figure is just to give some view of the many ways models interact with high-level and low-level processes.

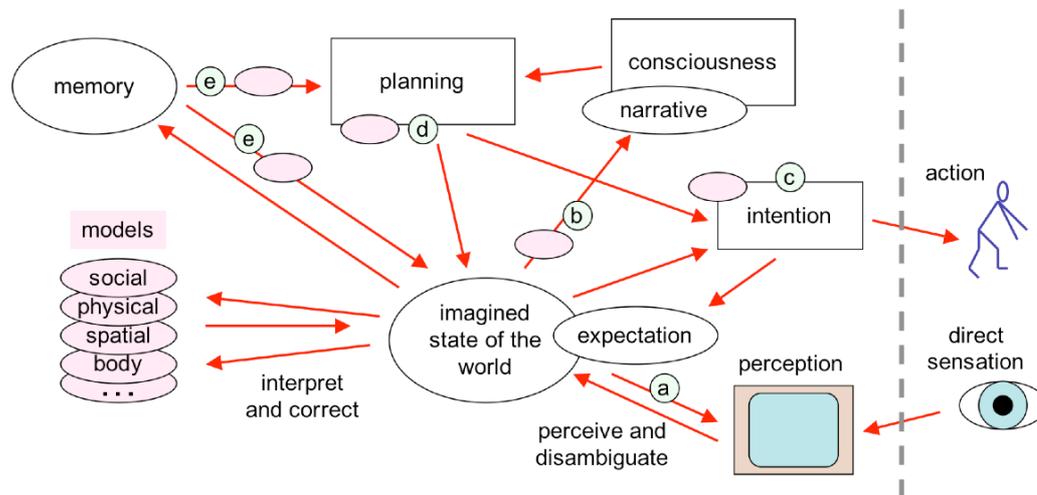


Figure 1. Simplified model of role of models in mental activity (small ellipses represent effects of models)

running free

Note the many feedback loops in figure 1. During dreaming the body shuts off most motor systems (why we do not flay violently in dreams) and we have only limited direct sensation (especially visual), that is largely the connections to the world, denoted by the grey dashed line, are effectively temporarily severed. We now have a feedback loop that is largely free running. This loop is fed either by random associations or by whatever process of internal processing is assumed to take place during sleeping. However, once fed with some form of input, the mechanisms are there to create images and stories as realistic and detailed as our own internal modeling processes.

Some of these processes and loops may be turned off during dreaming, like our motor responses, so not all the parts of this picture may be active. However, for the rest of this essay we will work on the assumption that it is precisely some of these internal prediction and modeling activities that are responsible for the images we see (and hear) during dreaming.

recollections of dreams

One problem about trying to understand the way in which our world models play out in dreams are the same as those that act as we

remember the dreams. This is we may ascribe things to what happens in dreams that are in fact part of our remembering of them. This is precisely the sort of problem that often makes scientists shy from such topics. However, while this is a problem, it is similar to that in any recall-based analysis, for example, when user testing software and interviewing users afterwards, or asking people how they enjoyed a play or novel.

Indeed studying any subjective experience will inevitable require either recall or that subjects in some way commentate or reflect during the experience. While the former will suffer from mis-rememberings (or rather constructed memories), the latter will also interfere with the process itself. It is interesting that while it appears that only memories of dreams can be used, in fact there has been some experiments where lucid dreamers do communicate whilst dreaming using eye movements [\[**ref**\]](#).

papering the cracks

The three interwoven processes (a), (b) and (c), informed by memory (e), are happening continually in normal perception and consciousness. You are shopping with a friend. Out of the corner of your right eye there is a movement, the raw sensation is indistinct, but based on the situation, memories and past experience, the vague shape becomes your friend's hand reaching out to touch something on the shop counter (a). Almost immediately as your eye glances at the hand, it seems less familiar and, still without consciously thinking about it, the hand becomes that of another shopper who has squeezed to the counter between you and your friend (b). You move over slightly to the left to allow the shopper to reach forward (c), but as you step you feel a bump, instantly your mental model that had a space to your left is now populated, even though you cannot see the person (b). It is only when these minor discrepancies become serious or we consciously reflect on them that we even notice they have happened and we feel momentary confusion.

Normally the process of papering over the cracks in our perception and memory happens without our being aware of it. However, our internal models in some way have an easier job in real life because the fragments of perception and memory corresponded originally to an actual experience and hence are guaranteed to (at least initially) be consistent. A local filling in of details is therefore unlikely to produce serious contradictions so long as the actual information available is sufficiently rich. We do sometimes notice these contradictions in memories, which are more incomplete than momentary perception, and furthermore memory gets gradually polluted as we remember our constructed recollections.

In contrast dreams have only the process of construction itself to hold them together. When waking our modeling processes have to predict just a little way ahead: what will happen if I pick up this cup, or speak to that person, actual lived action then takes over. During dreaming it is not surprising that these limited and local predictive processes starting with largely random inputs end up with potentially self-contradictory images. In fact, there is much documentary evidence that dreams are rarely truly bizarre which is due no doubt to the self-

correcting mechanisms ensuring that only sensible (and hence lifelike) predictions get through.

When recalling dreams, we often become aware of inconsistent and implausible parts. For example, McNamara et al. [[MA02]] citing [[SM96]] describe a subject's dream which involved a rocket launch where the politicians gathered to see the launch attempted to launch by hand. Locally this makes sense, it is reasonable to lift or throw something by hand, you often see people pushing cars to get them to start. With more reflective global reasoning we realize that rockets are large and heavy, so people could not lift them and even less launch one into orbit.

Interestingly, the attempt to launch the rocket was preceded by a (reported) conscious recognition of the potential for rocket to be launched by hand: "we fantasized whether the rocket might be propelled by the strength of a statesmen". This 'fantasized' potential then became 'really' acted out by other people in the dream. (Fantasizing in dreams is surely an interesting concept!)

In my own dreams I've noticed similar incidents, but where the inconsistency is recognized explicitly within the dream. In one I was in a ship's ballroom like the one in the Titanic, looking down the stairway. I then turned to the left, went through a door and found myself looking into another long room. I then became aware that as I had originally been in the already wide ballroom, then turned to my left I would have needed to go out the side of the ship. Almost instantly (in recall) I found myself on deck looking down the length of a long ship, and realised that the original ballroom must have been set sideways and by turning left I had moved to the next room along the length of the ship.

Note that here *consciously* noticing a discrepancy led (unconsciously) to a change in the dream. Now in fact the ship I saw was too narrow to have admitted the length of the ballroom I'd originally seen across its width, however that would have required me to remember back in my dream and instead it moved on, the *local* discrepancy had been fixed.

Lucid dreamers who have attempted to commit suicide in dreams have found that their attempts fail, a gun fails to go off or they jump off a cliff only to have a soft landing [[DN06]]. This may also be a form of papering either at the intention stage where the explicit intention to pull a trigger or jump off a cliff is countered by the instinct for self-preservation which looks for a way out, or possibly after the event where the fact that the person is 'still alive' in the dream needs to be 'explained away'.

memory in dreams

We clearly can recall some dreams when we wake however, during the dreaming process itself we are constructing an imagined world within which we have memories. So, what kinds of memory do we have in dreams?

There is clearly a situational memory of where I am what am I doing now. This is effectively the imagined state of the world and our bodies

that is constantly with us in day-to-day waking life. While short-lived and normally being constantly replenished and corrected by our senses, this is not the same as standard short-term memory, which is about things we can consciously recall. It may be that in dreams our normal situational awareness is augmented by visual and other sensory memories that would normally be used by actual perception.

We clearly also possess at least some short term episodic memory as in the ship's ballroom dream I was able to become aware that the world that had been experienced a short while before (looking into the ship's ballroom) was not consistent with the view when I looked into the room to the left.

Longer-term memories clearly affect the subject matter of our dreams and, while proportions differ from study to study (and person to person), the majority of settings and people in dreams are familiar to the dreamer, furthermore many dreams relate to recent events, mostly in the last few days [[NK04]]. What is less clear is the extent to which the dreamer is *explicitly* aware of these memories while dreaming. Certainly we do not appear to recall those memories which disagree with premises in the dream. Those acts of remembering in dreams that do agree with the dream 'reality' may well simply not be recalled afterwards because they were unremarkable.

From personal experience it is certainly the case that one can effectively *manufacture* long-term memories during dreams. I recall dreams where I have 'remembered' in the dream things about places or people that are entirely fictitious. This would be consonant with the normal process whereby we are manufacturing our recollections around the fragments of our memories. Note though the manufacturing process here clearly involves not just the more generic models of what is sensible, but also take into account the current (internally imagined) world state. Assuming this process in dreams is similar to that during waking, it suggests that our normal processing memory manufacture will create memories that depend on our current momentary world state.

memory of dreams

It is clear that we remember some of our dreams and even those who appear to rarely or never dream, do recall dreams if woken during REM sleep (with the exception of those with specific brain lesions or taking certain drugs). However, if not explicitly recorded and rehearsed even those dreams we wake from are soon forgotten. Given odd circumstances are usually most salient and hence most likely to be remembered, and also that we often wake in nightmares or other extreme dreams, perhaps the question is: why don't we remember more of our dreams?

subconscious work of dreams – I guess the traditional psychoanalytic answer might be something like we do remember them but we don't remember that we have ... At this point Popper is in order, but of course the argument is that there are subconscious effects at work. Certainly it is argued that depressed people have depressing dreams and that drugs that inhibit dreaming may well be effective partly because of that [[**ref**]].

dreams are too strange – Memories are encoded through association. Whilst dreams may be prompted by life experiences, they are unlike life and so have few connections with other things. So dreams (even those we sleep through!) may well be stored in our memories, but inaccessible through lack of connectivity.

dreams are too normal – We notice and recall things that are salient. Salience is in part related to absolute elements of sensory experiences loud noises, bright colours, but also adaptively is about things that are unusual or unexpected. That is as out world models predict what will be, the salient things are those points where the predictions fail. If therefore dreams are driven by exactly these predictive mechanisms, then, however strange they may seem after the event, while dreaming the events are by construction as unremarkable and hence by definition unmemorable.

the memory knob is turned off – Just as our brains 'turn off' motor activity during dreaming (to stop us kicking people in our sleep), it also turns off (some) normal memory mechanisms. The fact that we can remember dreams at all seems to contradict this interpretation, especially when woken up by external events (dreams we wake form because of the dream could easily be exceptions when such a mechanism failed or was weak). However, it is quite reasonable that we may retain a level of recent episodic memory during dreams (which is why we can remember them afterwards), but that the mechanisms for turning this into longer lived memories is 'turned off'.

the emotion knob is turned off – It is known that the emotional centres of our brains are partially deactivated ^{[[**ref**]]}. Extreme emotions, especially negative ones, can break through, but more commonly events in dreams which would be expected to have major emotional impact are often reported as eliciting little felt emotion at the time. Given that emotional intensity affects memorability it may be that dreams are too boring to remember.

Disentangling the above and understanding their implications would seem to offer much to tell us about memory as about dreams. If certain kinds of memory are 'on' during dreams and other kinds are 'off', then this has implications for understanding our memory architecture in general.

sensory perception

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modeling dreams

In one episode of *Star Trek Deep Space Nine*, Nog asks Vic Fontaine, a character in a holographic program, "do you dream?" and Phillip K. Dick's novel that inspired *Blade Runner* is famously called "Do Androids Dream of Electric Sheep?"

In fact, the model of dreaming as playing out of world models does seem amenable to programming into a computational agent. The key features would be an agent that:

- (i) inhabits some real or virtual domain (it may be virtual and still be the agent's 'reality')
- (ii) has limited perception of that world (e.g. limited field of view)
- (iii) uses the partial perceptions to update an evolving internal state of the world
- (iv) continually corrects the model based on an internal model of 'sensible' and likely phenomena and incidents
- (v) uses feedback from the internal state to disambiguate and fill in missing details in perceptions (even in the extreme case of NO perceptions)
- (vi) employs short-term predictions of this internal modeled state of the world to plan actions
- (vii) can have perceptions and actions temporarily 'shut off' (sleep)
- (viii) has some element of random stimulation of images

Given such an agent that can act reasonably well in the real (or virtual real) environment, we could send it to 'sleep' and watch the images forming.

Note that this is not modeling sleep itself, except insofar as we explicitly make it sleep, but dreaming the stream of images of which we are conscious.

Note too that while a defining feature of a dream is that we are conscious of it, for this model it is sufficient that we create the stream of images not the consciousness itself! One writer on dreams talks about a "Consciousness Pointer" [[T03]] that follows the dream thread. The aim here would be to create the thread and perhaps an attentional pointer.

It is good to end up on consciousness, a bigger and far more complex topic than dreaming itself, but perhaps closely linked. Dreaming is often contrasted with consciousness and some writers use the difference between dreaming and waking as a touchstone to understand consciousness. In contrast, I would propose that in some ways dreaming could be seen as pure consciousness unobstructed by physical reality.

Notes

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