# some loose notes for overview of core concepts in Don Norman's *The Design of Everyday Things*

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## Affordances

Discussion of affordances is not exclusive to Don Norman's work. In fact, affordances are a widely discussed topic within the field of design. Two interesting examples are Bill Gaver's 1991 work[1] and Rex Hartson's 2003 work[2]:

- Bill Gaver proposed a two-by-two classification of affordances based on their perceptibility and the actual presence. He argues that, when affordances are perceptible, they offer a direct link between perception and action, whereas hidden and false affordances lead to mistakes in product usage or interaction.
- Rex Hartson emphasizes the importance of establishing clear terminology within HCI (human-computer interaction). He points out that the terminology in interaction design is inadequate, a point with which Norman also agrees.

Affordances can be learned or discovered through interaction or instruction. Specificity of expertise helps with identifying and recognizing affordances.

Nudging makes selected affordances more perceivable, while decision making chooses between perceived affordances. Negative emotions and behavior-relevant attitudes (such as memory biases) simplify choice of affordances, especially at high arousal (Easterbrook's hypothesis).

## Signifiers

Deliberate signifiers are placed there by a designer, such as push and pull signs on doors or bathroom markings. Signifiers can be witty, funny, or even highly abstract, as long as they can be interpreted in a meaningful way.

Some signifiers are learned as they reflect rules and regulations, such as traffic signs or symbolic signs indicating that a mask must be work indoors.

With accidental signifiers, Norman's most commonly used example is observing how many people are on the train platform. If the platform is crowded, it signifies that the train has not arrived yet, whereas an empty platform can indicate (or: signify) that we just missed our train.

Another example of an accidental signifier are empty supermarket shelves where toilet paper is usually stocked. Nowadays (2020-2021), missing toilet paper often signals that a press conference regarding covid-19 restrictions has just taken place, or has just been announced, and people are stockpiling critical supplies. In Denmark, people tend to stockpile yeast in emergencies: so accidental signifiers are also culture-specific.

## Are affordances and signifiers binary?

Norman presents affordances and signifiers as a binary (you either notice them or you don't), but we can also think about them in terms of a probability distribution. What is the likelihood that someone will act on a specific affordance or signifier? How can this probability be increased or decreased?

So we can say that perceived affordances are binary: I either perceived it, or I didn't. But perceivability of affordances is continuous and probabilistic: how likely am I to perceive it?

[1] Gaver, W. (1991). Technology affordances.*Proceedings of the SIGCHI conference on Human factors in computing systems Reaching through technology - CHI* '91. pp. 79-84. https://doi.org/10.1145/108844.108856

[2] Hartson, R. (2003). Cognitive, physical, sensory, and functional affordances in interaction design. *Behaviour & Information Technology, 22*(5), 315-338. https://doi.org/10.1080/01449290310001592587

 

## Discoverability and understanding

Discoverability is a feature of our design that makes it possible for the user to figure out what actions are possible, and how they should be performed. The core requirement of discoverability is that relevant components must be visible – after all, how else is the user supposed to infer their presence and therefore the scope of possible action, if the user cannot see the components or functions?

And understanding is, well, simply that. Can the user gather a coherent understanding of all the components of a product in order to deduce how the product is supposed to be used, and how to maximize our knowledge of all functions and options?

Norman emphasizes that understanding is not always intuitive – and that is fine. More complex devices will require manuals or instructions or specific training. Nobody sits in the cockpit of a plane and knows how to fly it just by looking around. But, in principle, no manual should be necessary to understand the use of simpler objects. Such objects should be logical and support required action.

## Mapping

Simply put, mapping is the relationship between actions and consequences. Take a simple tv remote. Assume you want to increase the volume.

You find the appropriate button, and in order to increase the volume you need to quite literally add the volume, so you press the corresponding plus sign. Even better, the plus sign is above the minus sign, indicating that pressing the top part of that button will be increasing something in value. Here it is volume, but one button over the same action on the same kind of a button would change the channel upwards, by adding numbers to the current channel number. That relationship between pressing up and therefore adding or increasing is very easily understandable to us, because the mapping is simple. Up means more, down means less.

This is why mapping is particularly relevant to the layout of controls and displays. Mappings can be cultural, like the notion that up means more, or that right means more (whereas left means less). But they can be also perceptual, for example like in Tesla's electronic key. It is shaped like the car itself, and pressing on corresponding areas of the keychain results in action with regard to the actual car, such as opening the trunk or unlocking the door.

Natural mapping relies on an innate (meaning: shared by many. Innate DOES NOT mean something we are born with here) mental model of the relationship between affordance and feedback. Non-natural mapping depends on one cultural (shared by fewer people compared to natural) mental model.

Habits and recognition can be seen as one "memory mapping" between past and present situations: the better the match, the better the transfer.

## Feedback

When we interact with an interface, or any other object for that matter, we know that our interaction was successful, because we immediately receive feedback.

Feedback is the immediate environmental demonstration and manifestation of our action, and as such it must not be delayed. Think about pedestrian buttons, which you have to press in order to activate the green walk light. In this instance, you hit the button and wait. There's no indication that the button actually did something, other than maybe at some point the light will actually change. It's not uncommon to see people standing by the button and pressing it repeatedly until the light changes. That kind of action is pointless, because pressing the button more times does not affect how fast the light will change. But at the same time we know there has to be a delay between pressing the button and the light change, because rapid changes in street lights can catch drivers off guard and result in some dangerous sudden maneuvers and collisions. So how can we provide feedback here?

For example, by indicating on the button that the signal has been received, and is being processed.

In many instances immediate feedback is absolutely necessary, for example when we perform a sequence of actions where each subsequent action depends on the success of the previous action. Think about taking a turn while driving a car. Putting on the turn indicator successfully is only one of many small tasks we have to complete in order to turn left, and any delay in the indication that our turn signal is successfully on could have detrimental consequences on task performance. Good feedback is essential, but it has to be done correctly and appropriately.

On the other hand, poor feedback can be worse than no feedback at all because it is distracting, uninformative, and in many cases irritating. And here the one example that comes to my mind any time I think about terrible feedback is all those singing toys for kids where you want to encourage some kind of an action, so you reward it with a song. But those songs are sometimes terribly shrill and terrifying for kids, and you really should hear the list of swearwords my brother has screamed at a singing baby toilet seat he foolishly bought.

Feedback helps us build mental models, which is important in problem solving (especially when feedback is negative; negative feedback means the desired goal was not achieved). Other kinds of feedback, such as hedonic pleasure of using an object can in turn influence motivation.

## Conceptual models

According to Norman, successful action requires the user to possess a conceptual model of the system they are interacting with. A conceptual model is a highly simplified explanation of how something works, for example think about the save button that looks like a floppy disk, or folder icons on the computer that look similar to paper folders, and therefore indicate in a symbolic way the underlying mechanics of information storage. The purpose behind that is simple: if we have an idea how something works, even a vague one, then we can predict some affordances. And that conceptual model does not have to be complete or even accurate – but it has to be useful, in that it has to hint at affordances.

This brings us to another question: how do we produce a reliable conceptual model? How do we assess if the conceptual model is reliable? Which are essentially questions of how do we explain to users how things work, and how do we test whether they understood us correctly? Those ultimately are some of the core questions of applied cognitive psychology, wherein we investigate how people interact with objects in their environment.

Conceptual models are primarily stored in long-term memory and therefore must be learned; but learning is context-specific, so how big or small are our mental models really? The opposite of a mental model would be emotions, habits, heuristics that are "fast" and "action-ready" models (thinking fast vs. thinking slow).

Problem solving and decision making takes a mental model as a starting point, which is especially relevant for novices (with low expertise).

Norman contrasts conceptual models with mental models, but his distinction between the two is not very clear.

## Mental models

Mental models are internal representations of something in the mind; they are internal models of the world that people create in order to interact with the world that surrounds them. So the main takeaway here is that conceptual models are a kind of a mental model that represent a specific object or system that the user is interacting with. Mental models relate to everything around us.

Mental models, or mental representations, do not have to be detailed, or accurate, to be useful. In fact they tend to be biased and oversimplified, and there is an ongoing debate in the scientific community about how, why, and where mental models get simplified, corrupted, or revised.

Take the example the intersection of two streets, College Avenue and Boston Avenue in Medford, MA, USA. This is a google maps screen shot of the intersection that was right outside my department at Tufts, and it was an excellent example for studying how people oversimplify their mental models of the environments. As you see in the map, the two legs of Boston Avenue intersect with college avenue at somewhat odd angles. But when we asked people to draw a map of the streets from memory, they drew something like this, with both Boston Avenues at a perfect 90 degree angle to College Avenue. This is clearly not correct, but it was not relevant for people to remember the fact that the streets intersected at an odd angle. And intersection was oversimplified to 90 degrees in their mental model. In this research scenario, we were interested in how people reproduce maps of their immediate environment – so mental models of their neighborhoods. And to study that, we simply asked them to draw maps from memory on a piece of paper, and then we analyzed the discrepancies and oversimplification common among various participant groups.

## How do we study mental models?

Mental model is knowledge of the environment as we see it. So how do we study and identify mental models?

Like many important topics in cognitive science, this is also a topic of heated debate, with some researchers arguing for prevalence of subjective reports where people simply explain how they think about different things. Whereas others argue that self-reports are too subjective to be valid and generalizable, and therefore we must focus on developing more sophisticated, objective measures and experimental paradigms. Here you have couple citations if you are interested in the discussion about validity of self reports.

And finally, we put together all the things we talked about – affordances, signifiers, mappings, models, and we arrive at what Norman termed the system image.

## The system image

The system image is all the combined information on the system that is available to the user. The users have access to physical structures of the object, information available in documentation, instructions, signifiers, product reviews on the internet, help websites, information forums... anything related to the operation of the system.

So think about this: designers have a conceptual model that drives the design of the product, and that is revised throughout the design process to reflect the changes made to the original product idea as the product is being developed. The users' conceptual model comes from the system image. And ideally, the most optimal usage of the product occurs wen the designer's conceptual model is identical to the user's conceptual model – that is, the user knows everything there is to know about a product.

Norman shows this relationship in the form of a slightly odd triangle, and an important thing to notice here is that there is no arrow between the designers conceptual model and the users conceptual model. The designers communicate their models through the system image, and the users infer their models only through the system image. And so Norman concludes that there are no bad users, but only bad designers who were unable to communicate their product's functionality to the user.

So how do you optimize the system image? Norman says: through communication and excellent design.

## Gulfs of execution and evaluation

First, we have an object. Here, we are using my favorite clothes drying rack with some secondary exercise functionality. The object has signifiers and constraints on usage. We then have a user, and the user comes with their own mental models of an object, which is based on prior knowledge or mapping or knowledge of the system image.

The system image consists of all the information available to the user, including manuals, access to google, watching other people exercise, and so on. And in this system we also have a designer, who has a specific conceptual model of the system itself as well.

The user examines the affordances of the system, and that judgment is weighted by mental models; which means that the user applies existing knowledge to figuring out the system affordances. In return, the user receives feedback both from the system image and from the object about the appropriateness of the affordances and actions executed toward the object.

So the gulf of execution occurs here. What does Norman mean by the term gulf of execution? It's the process by which people try to figure out how things operate. We ask – how do I work this? What can I do with this?

Gulf of evaluation is the process by which people try to figure out what happened, and whether that was the desired outcome.

So essentially, as users, we go through the seven stages of action cycle when we interact with systems. At least according to Norman.

## Norman's stages of action and processing

There are seven steps to completing an action: first, we form the goal for action. Then, we execute the action: we plan it, we specify the sequence of behaviors needed to deliver the action sequence, and then we perform the sequence. After that, we move onto evaluation of action: we receive feedback from the world through perception, which we then interpret, and compare it to the original goal. Successful action is an action where the outcome matches the intended goal perfectly, or closely enough for our needs.

And action sequence is distributed over three different levels of processing: visceral, behavioral, and reflective. Visceral level (steps 4 and 5) encompasses fast, subconscious responses over which we no conscious control. This is physiology, or immediate perception. Behavioral level (steps 3 and 6) encompasses learned skills, which are triggered by situations that match appropriate patterns. Our behavior here is still largely subconscious, because even though we are aware of the actions themselves, we are often unaware of the details of the action. And at the top, reflective level (steps 2 and 7) is home to conscious cognition. This is where deep understanding develops, this is where reasoning and decision making takes place according to Norman.

Norman's take home message here is that good design takes into account all three levels, as all three play a crucial role in action.

## Norman's error classification

Capture slip example: when I cook pasta, I put a strainer in the sink. When the pasta is ready, I dump the pot's contents into the strainer. When I make chicken soup, I also put a strainer in the sink so that I can use tongs and remove whole vegetables and meat from the pot and place them in the strainer. A capture slip is when I take a whole pot of chicken soup and dump it into the sink.

Description-similarity slip: in Polish, when you say "go potty" to a little kid, you use the phrase "go make a pile." My sister-in-law once asked my toddler nephew to help her sort laundry by putting the clean socks "on the pile" (of other clean laundry). She then had a lot of fun fishing clean socks out of the toilet. To prevent description similarity slips, use knowledge of human perception to ensure that users can easily and automatically identify differences between controls and displays.

Mode errors: I bought new Bluetooth headphones and any time I tried using them for online meetings, they would turn off the moment I started speaking. Why? Because there was a default mode setting in the control app that indicated headphones should turn off when a conversation is detected. Preventing mode errors: just don't do them; a mode error occurs because the user mis-maps controls onto tasks.

Correcting rule-based mistakes: provide plenty of information; provide guidance; provide *simple* guidance, preferably visual through affordances and signifiers and other kinds of signs. Also account for what interferes with situational diagnoses: stress, arousal, sleep deprivation, etc.

Preventing knowledge based mistakes: ample training; transfer of skill; but also formulating instructions and tools to match the user's appropriate conceptual model.

## Social and institutional pressure

Note on the Asch study: it is an illustrative example of social pressure, but findings must be interpreted in the proper context: biased sample, artificial task, lack of allies in the group (everyone versus one participant), and overall cultural context of 1950s USA.

How can we counteract social pressure? Norman's example of the scuba instructor encouraging caution by dumping expensive weighs into the ocean.

- Social support networks and allowing for failure: paid sick leave, paid vacation time, unemployment insurance, public health insurance, permanent residence: my life won't be ruined if I get fired.
- Work environment, leadership qualities, intrinsic versus extrinsic motivation.
- Matching task difficulty with skill level. Providing low stakes environment to just try things out.

Educational context: is there a point to giving really difficult exams? Or should your grades from university be included on your cv?

But also self-imposed pressure: I am useless if I can't get this to work; my family will be disappointed; I paid so much money for this, so this shouldn't be this hard.

Ego-preservation, protecting my self-identity: I am good with computers so I should be able to figure it out; I am a healthy person so I should be able to do this kind of sport.

 