Engineers Shouldn't Think Too Fast

By William M. Bulleit, Ph.D., P.E.

Engineers use intuition in design, but intuition can lead us astray. Daniel Kahneman (*Thinking, Fast and Slow*, Farrar, Strauss, and Giroux, 2011) describes how humans have two thinking modes: System 1, where we think fast (intuition); and System 2, where we think slowly (analysis). Since humans over history have lived in dangerous environments, System 1 tends to take precedence if we do not consciously apply System 2. When the bushes move, it is better to run than to stand and think about running. Those who ran often ran from nothing, but those who stopped to think about running eventually got eaten. Unless System 2 is consciously activated, System 1 will give an answer, and that answer will be accepted. Furthermore, since System 1 has worked so well for so long, we often are overconfident of our System 1 answers and do not activate System 2.

The following problem from Kahneman should allow you to see how System 1 works. Read the problem below and let System 1, intuition, determine the answer. Then consciously shift to System 2 and solve it again.

A bat and ball cost $1.10.
The bat costs one dollar more than the ball.
How much does the ball cost?

Most of you got a System 1 answer of 10 cents, but, of course, the actual answer is 5 cents, as System 2 determined.

When facing any decision, you cannot turn off System 1. It gives an answer whether you request it or not. One way it obtains its answers is using heuristics, techniques that help solve problems that would otherwise be intractable. I will use the term *engineering heuristics* to distinguish them from the heuristics that System 1 employs. Engineers know that engineering heuristics have limits, and care must be taken when using them. Similar care needs to be taken when System 1 uses its heuristics. An understanding of some of these heuristics may allow you to spot when System 1 is making a decision that should be reassessed by System 2.

Unfortunately, though, if System 2 is otherwise engaged, it will tend to believe what System 1 says. System 2 invests only as much effort as necessary; the easy thing to do is to allow System 1 to make the decision. The use of heuristics by System 1 causes biases in your thinking and the resulting decisions. The use of engineering heuristics is a more conscious operation than is the use of System 1 heuristics. When you use an engineering heuristic, you can examine it in light of the situation in which you plan to use it. That is not the case with System 1 heuristics.

Structural engineers get little feedback on their designs, in the sense that they experience few failures. Thus we can fall into the trap of thinking that everything we have done in the past was correct, and that our intuition is almost always right. This blinds us to errors that we might make by relying too much on System 1 and is referred to as *confirmation bias*. We all know that there may be errors in our designs, but that does not stop System 1 from telling you that the designs must be right, unless you take the time to use System 2. Another System 1 heuristic leads to the *availability bias*: you are inclined to believe that which is most available in your memory. The design decisions that are most familiar to you are the most recent ones. If they all have been successful, you will tend to believe that what you did was correct.

Engineering heuristics are not valid over the entire range of problems to which they seem to apply. It is not always obvious where the limits lie, but we know to be cautious when we attempt to use engineering heuristics to solve problems that are new to us or push the state of the art. The heuristics used by System 1 are also most questionable when we have not had a lot of experience in comparable situations. Intuition is most dependable when it is grounded in a long history of making similar decisions and receiving feedback, which requires a consistent environment. As Kahneman says, "Remember this rule: Intuition cannot be trusted in the absence of stable regularities in the environment."

System 1 will give you answers no matter what your experience. It may produce quick answers to difficult questions by *substitution*: the question answered is not the one intended, but the answer is reasonable enough to pass the limited review of System 2. Whether it is accurate or not depends on the situation. Common sense would tell you not to do this, but intuition is not always constrained by common sense. The worst part of such an intuitive judgment is that you will be confident in your System 1 answer. To quote Kahneman again: "This is why subjective confidence is not a good diagnostic of accuracy: judgments that answer the wrong question can also be made with high confidence."

Engineers are human and have innate abilities and limitations. One limitation relates to the two thinking modes that humans use: System 1, which thinks fast and is confident in its decisions; and System 2, which thinks slowly but is lazy and would rather let System 1 do the work. We as engineers use design processes that reduce the chance of errors, but the reduction of System 1 errors requires constant vigilance against its tendency to jump to conclusions and run from the moving bushes, rather than stopping to think.▪

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