NOW WHY DIDN'T I THINK OF THAT? THE COGNITIVE PROCESSES THAT CREATE THE OBVIOUS

by
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The Supreme Court opinion in the KSR v. Teleflex *case offers several claims about the cognitive processes involved in creativity. The "nonobviousness" inquiry in the decision builds upon a host of assumptions about how to invent new solutions to practical problems. Research in cognitive science provides some scientific evidence about the cognitive processes involved in creativity. In this Article, the author presents studies from laboratory research in cognitive science, including both classic studies on problem solving and creativity and several of her own studies. From this evidence, she concludes that reasoning about the nonobviousness of ideas requires a rich and varied theory of human cognitive processes, perhaps more extensive than the one suggested by the Supreme Court's decision in* KSR v. Teleflex.

I. INTRODUCTION

The Supreme Court opinion in the *KSR v. Teleflex* case offers several claims about the cognitive processes involved in creativity.[**] [1] These claims

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[**] This Article is part of a multi-disciplinary conference on *KSR v. Teleflex* held at Lewis & Clark Law School on October 5–6, 2007. In respect for the multi-disciplinary nature of this conference, the Articles written by non-lawyers are presented herein in a modified APA citation format, rather than the usual Bluebook citation format. We have added some pinpoint citations to aid the legal reader

[1] KSR Int'l Co. v. Teleflex Inc., 127 S. Ct. 1727 (2007).

are evident in the assessment of the likelihood of any person's ability to generate a creative design:

> A person of ordinary skill is also a person of ordinary creativity, not an automaton. (p. 1742).

But what is a person of "ordinary creativity"? The "nonobviousness" inquiry builds upon a host of assumptions about how people invent new solutions to practical problems. Research in cognitive science provides some scientific evidence about the cognitive processes involved in creativity. Ideally, the science of problem solving and creativity would be incorporated into the nonobviousness inquiry. How well do the assumptions about creative processes in the Supreme Court opinion match this scientific evidence? In this Article, I draw connections between the process proposed in the Court's opinion for determining "obviousness" and the body of cognitive research on how people generate novel ideas.

In *KSR v. Teleflex*, the Court notes that in determining obviousness, "a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." (p. 1741). From the research literature, it is apparent that these "inferences and creative steps" are themselves far from obvious. Research on the obviousness problem cuts across several substantive areas but falls mainly in the cognitive literature on problem solving: How do people identify design problems and create solutions?[2]

In this research, the experimental paradigm is based in a laboratory, and volunteers with no particular expertise participate in the study. The volunteers are typically college students, who are not "ordinary" but are perhaps somewhat better prepared with the "ordinary creativity" mentioned in the Supreme Court opinion. During a single experimental session, participants are given simple problems to solve, and they create solutions that are then analyzed for their relationship to experimental variables. Within the session, the focus is on the individual working with goals and resources provided. The types of problems in these studies involve everyday behavior and objects found in American, middle-class culture. In test problems, goals and solutions are intentionally chosen so as to avoid requiring any specific domain expertise. The expectation is that the simple materials used in laboratory studies will make the cognitive processes more evident.

The laboratory paradigm allows researchers to address the cognitive processes engaged in understanding problems and creating solutions

[2] Hayes-Roth, B., & Hayes-Roth, F. (1979). A cognitive model of planning. *Cognitive Science, 3*, 275–310. Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals and understanding: An inquiry into human knowledge structures.* Hillsdale, NJ: Lawrence Erlbaum Associates. Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist, 54*(7), 493–503.

under well-controlled conditions.[3] Real design engineers operate in a much more sophisticated process: Designers work in groups of many individuals and over long blocks of time. In addition, the designers in engineering who actually file for patents are far from ordinary. Based on the rich literature on expertise, an individual performs "focused practice" for over ten years to become a true expert.[4] This suggests a true expert in an engineering domain has created a mind very different from that of "a person having an ordinary skill in the art."

In this Article, I present studies from laboratory research in cognitive science, including both classic studies on problem solving and creativity, along with several of my own studies. From this evidence, I conclude that reasoning about the nonobviousness of ideas requires a rich and varied theory of human cognitive processes, perhaps more extensive than the one suggested by the Supreme Court's decision in *KSR v. Teleflex*.

II. WHAT IS THE PROBLEM?

> Under the correct analysis, any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed. (*KSR Int'l Co. v. Teleflex*, 2007, p. 1742)
>
> The second error of the Court of Appeals lay in its assumption that a person of ordinary skill attempting to solve a problem will be led only to those elements of prior art designed to solve the same problem. (*Id.*, p. 1742)

The *KSR v. Teleflex* opinion suggests that elements of a design may be combined for a known reason, for any possible reason, and for no reason at all. Yet considering elements of a design makes no sense without an overarching reason to consider the elements in the first place. The relevance of information to a target goal is crucial in selecting and screening out the mass of information available. Even when a problem is presented, there is always work to be done on specifying what the problem really is, as opposed to what it might seem. Is the problem in *KSR v. Teleflex,* "How to put electronic sensors on adjustable pedals"? How does the designer arrive at this description of the problem? It seems quite easy to ask a similar, but less successful question. An example of the

[3] Kantowitz, B. H., Roediger, H. L., & Elmes, D. G. (2005). *Experimental psychology: Understanding psychological research* (8th ed.). Belmont, CA: Wadsworth Thomson Learning.

[4] Horn, J. & Masunaga, H. (2006). A merging theory of expertise and intelligence. In Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (Eds.), *The Cambridge handbook of expertise and expert performance.* (587–611) Cambridge: Cambridge University Press.

importance of problem specification comes from studies of insight in problem solving:[5]

> If you have a total of 36 black socks and brown socks in your drawer mixed in a ratio of 5 to 7, how many socks will you have to take out to make sure that you have a pair of the same color?

This is characterized as an "insight" problem because the majority of subjects are initially unable to arrive at a solution.[6] Most focus on the ratio information, and attempt to determine probabilities of various outcomes. Subjects who do solve it seem to experience confusion followed by an "AHA!" moment, where they suddenly see the solution path. In a series of studies, we presented subjects with insight problems that contained misleading information, and problems with this information removed. When the ratio information is removed from the presented problem, solvers quickly recognize it as an everyday reasoning example: How many socks do you have to pull out of a drawer when there are only two colors available? Once the answer (three!) is discovered or provided, it suddenly seems quite obvious. In studies using many such problems, we found the solution rate doubled (from 1/3 to 2/3) when the extra misleading constraints like the ratio information were omitted.[7] Those who reach solutions must manage to first define the problem correctly to avoid adding any unneeded or incorrect elements to the problem description.

Typically, insight problems suggest constraints that are not actually required in the solution. Consider this example:

> Using only three straight cuts with a knife, divide a round cake into eight equal pieces.

The problem as presented (a round cake) suggests that the cuts should occur through the top plane of the cake. However, this problem description is overly constrained: There is no constraint to cut only through the top of the cake. Once the problem is considered in three dimensions, a solution of first cutting the cake through at its midpoint in height is evident. This problem of overconstraint in representation occurs even with little given information. Incorrect specifications for the goal must be carefully considered before attempting to solve the problem. If not, efforts may lead toward a solution that is not relevant to the one that needs solving.

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[5] Sternberg, R. J., & Davidson, J. E. (1995). *The nature of insight.* Cambridge, MA: The MIT Press.

[6] Seifert, C. M., Meyer, D. E., Davidson, N., Patalano, A. L., & Yaniv, I. (1995). Demystification of cognitive insight: Opportunistic assimilation and the prepared-mind perspective. In R. J. Sternberg & J. E. Davidson (Eds.), *The nature of insight* (pp. 65–124). Cambridge, MA: The MIT Press.

[7] Seifert, C. M. (2007). Problem finding in insight problems. Unpublished manuscript. University of Michigan.

Some classic research on problem understanding was conducted in the 1970s.[8] This work distinguished between "presented problems," where you could begin solution attempts directly, and "discovered problems," where you need to work on a problem in order to identify its specific nature. Discovering the problem was termed "problem finding," defined as identifying more specifically what is to be done, how it is to be done, and when it is complete. These studies identified "discovery-oriented behavior" as the key to creating successful solutions.

In these studies, art students at the Art Institute of Chicago were asked to draw a still life arrangement of objects from life onto canvas. The objects included flowers, a bowl of fruit, vases, and other similar objects placed on a table (see Figure 1). The experimenters recorded the behavior of the artists in the session as they completed the task. Then, the drawings were judged by professionals (instructors and collectors) for their artistic quality.

Figure 1. An arrangement of still life objects and an artistic rendering.

When the researchers looked back at the sessions where better quality drawings occurred, they found several distinctive qualities. Those artists judged "more creative" spent more time in their session exploring alternative approaches before settling on one they would pursue. So they spent more time arranging the objects and perspectives in the collection. They also showed evidence of being ready to change their course if a new approach was suggested. Rather than viewing their arrangement as fixed, they often altered it to fit the composition developing in their drawings. The "what" of the drawing continued to be refined throughout the artistic process.

So, there was a relationship between the extent of problem finding involved in making a drawing and the originality or artistry of the drawing. But does this problem-finding process predict the artists' success as professional artists years after graduation from art school? The authors returned to these subjects after nearly twenty years to determine if problem finding was related to artistic achievement at mid-life, as

[8] Csikszentmihalyi, M., & Getzels, J. W. (1971). Discovery-oriented behavior and the originality of creative products: A study with artists. *Journal of Personality and Social Psychology, 19*(1), 47–52.

measured by recognition and income.[9] Indeed, they found that the problem-finding skills in their drawing test correlated with the quality of their work judged twenty years later. This is the best evidence available that discovery-oriented behavior in finding the problem plays an important role in creativity. In practical design problems, the goal may require significant effort towards refinement, and require an openness to reconsider the goal at important times along the way.

III. PROBLEM SOLVING AS SEARCH THROUGH ALTERNATIVES

The Supreme Court decision in *KSR v. Teleflex* advances a theory of how designers work with evident patents to develop new designs. The case is suggested to be a simple combination of only a few needed elements that lead directly to the patent at issue:

> The combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. (p. 1739).

The *KSR v. Teleflex* case is described by the Court as a simple combination of all known patents to create a superior design. This view of the design process fits with a cognitive theory known as "search for a problem space."[10] The "problem space" approach identifies a starting point, an end goal, and the operators (specific actions) that can be attempted to convert the current state into the goal state. As an example, consider a simple combination lock with a five digit solution. In order to find the correct combination to open the lock, you identify the goal (five digits that open the lock), the current state (that the solution has five unknown digits), and the operators involved in solution (entering 1, entering 2, entering 3, etc.). The problem space is defined as all of the possible paths you might try as you attempt to solve this problem (see Figure 2).

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[9] Csikszentmihalyi, M., & Getzels, J. W. (1988). Creativity and problem finding in art. In Farley, F. H., & Neperud, R. W. (Eds.), *The foundations of aesthetics, art, & art education* (pp. 91–116). New York, NY: Praeger Publishers.

[10] Newell, A., & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, N.J.: Prentice Hall.

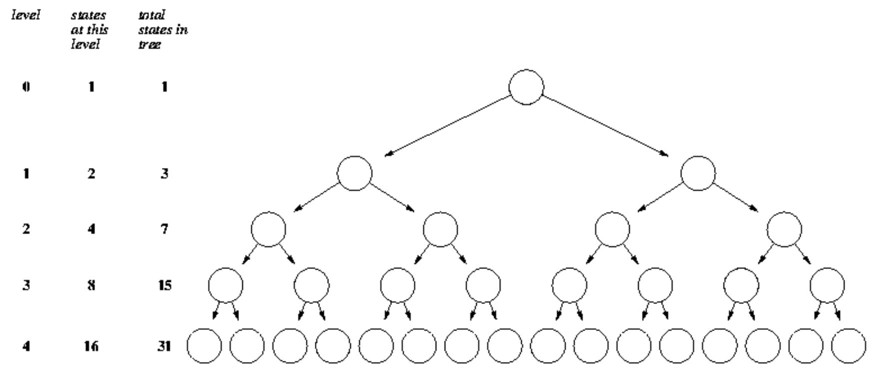

Figure 2. Partial diagram of a problem space.

So, following the leftmost path between the circles, we find a path for 11111 as a first solution attempt, then 11112, 11113, through 11119, all on level 4 in a diagram such as the one above. Then, backing up a level, attempts begin with 11121, 11122, and so on. This approach turns the problem into a search problem rather than a creative task. The solver does not need to try to solve it using strategies such as guessing what digits may have been chosen by the lock's owner or guessing numbers that are typically used, such as birthdates. No "reasoning" about the solution is involved; instead, the solver simply marches through all of the combined elements in every ordering, one by one, substituting digits, until all possible paths have been attempted. A variety of algorithms have been proposed for how to conduct this search most efficiently. Most importantly, this approach is bound to eventually discover the combination. If needed, all possible paths will be pursued, one by one, until the path with the five digits in the combination is attempted, the lock opens, and the problem is solved.

The problem space for the *KSR v. Teleflex* design is described in the opinion as including multiple design decisions, including mechanical and electronic sensors, multiple sensor placements, multiple adjustable pedal assemblies, multiple electronic sensor placements, and other comparisons across patents. In attempting to describe these choice points, a problem space becomes evident (see Figure 3). This depiction is abbreviated to focus solely on the design decisions put forward in the *KSR v. Teleflex* opinion. At each level of the problem space, more alternatives are likely possible. So, if further patents were examined, the distinctions here would have to be extended further, including multiple layers beyond the simple tree outlined here.

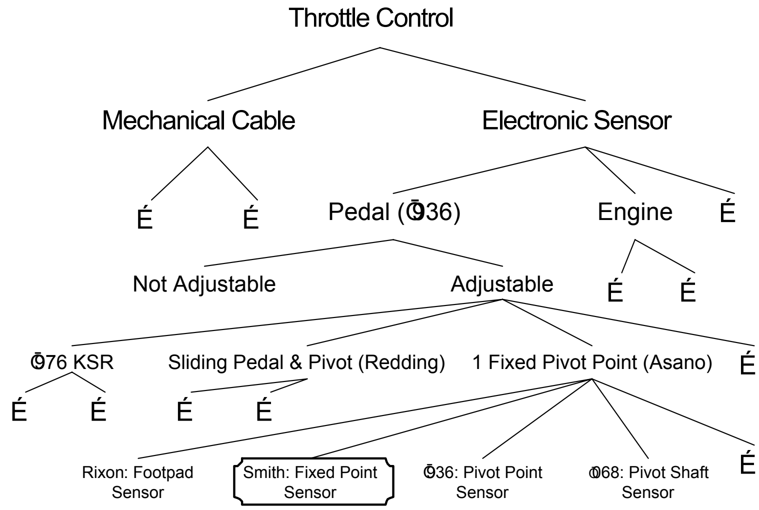

Figure 3. Partial diagram of a problem space for the KSR v. Teleflex *design.*

This diagram makes evident the multiple paths possible between only the design elements evident in the patents discussed in the opinion. Even considering just these few patents, the particular combination of Asano and Smith is not so evident in the context of considering the possible alternatives. Search of the problem space demonstrates that by working backward from the solution, a direct, short solution path can be identified. As the opinion discusses, "it was obvious to a person of ordinary skill to combine Asano with a pivot-mounted pedal position sensor." (p. 1744). However, working from the *problem* of computer-controlled throttles, the possible design choices seem much more open-ended. Are there other systems that might house the electronic sensor? Are there other ways to provide place adjustments to pedals? Are there other places on the pedal assembly that might house the sensor? Knowing a solution path, we can enumerate portions of the problem space. But, before knowing that path, constructing such a tree would be quite challenging. What are the design decisions necessary to create an electronic throttle control? What are all of the alternative methods for affixing sensors? What happens when alternatives are combined in all possible ways?

There are problems with this "combining problem elements" model of design creation. Only some of the problems occurring with patent determinations will fit the problem space analysis presented. This approach requires that the goal specifications are well known and well conceived, that there are a small number of patents, that the most relevant prior patents can be determined, and that the solution is a combination of elements requiring no alteration. In fact, the Court acknowledges this by noting:

> Following these principles may be more difficult in other cases than it is here because the claimed subject matter may involve more than the simple substitution of one known element for another or the mere application of a known technique to a piece of prior art ready for the improvement. (p. 1740)

For the search space approach to work well, a clear goal and set of operators must be evident. You must have a clear description of the target in order to recognize elements that bring you closer to a solution. Real engineering problems may have tens, hundreds, even thousands of related patents. A search through the problem space of known design elements would take very a long time. Finally, innovative designs are not often a simple combination of already-known elements. Flatfooted search through patents and trying combinations of them is in some ways the opposite of innovation in product design. The search for a better sensor system may involve trying to combine all possible previous patents to see if a superior design occurs, or it may involve an entirely novel approach (for example, a wireless sensor).

Cognitive research on problem solving shows there are many aspects of this problem space approach that do not fit with the types of problems people encounter in the world. Goals are often very hard to describe or determine, yet must be identified so specifically that you will recognize a solution or helpful element when one appears. Each step of the search process depends on being able to compare the current idea with the end goal. And in turn, this means the goal identified must be the right one. Without a set goal, the problem space approach described above cannot proceed. The possible operators needed to create a solution path are also often unknown, so new operators never before associated with a solution must be created. Finally, the search itself is not a linear algorithm guaranteed to identify a solution. The problem space perspective makes it easy to believe that others with the same problem space will easily find the same solutions. However, when reasoning during design is examined, most solutions involve search that is trial and error, hit or miss, stop and go, accidental, and nonlinear. This makes the determination of whether others would be able to traverse the same path to the solution much more difficult.

IV. FAMILIAR OBJECTS TEND TO BE USED IN FAMILIAR WAYS

The *KSR v. Teleflex* opinion notes that:

> Common sense teaches, however, that familiar items may have obvious uses beyond their primary purposes, and in many cases a person of ordinary skill will be able to fit the teaching of multiple patents together like pieces of a puzzle. (p. 1742).

This assumption about reasoning has been examined in empirical studies; in fact, they find that familiar objects are *not* often used in unfamiliar ways within designs. Consider this example item: pliers. Do pliers have an obvious use beyond the primary purpose? What differing ways can they be used? When asked this question, subjects in our studies generate an average of three uses, usually involving the act of "plying": grasping a piece of something hard to hold, usually metal, and twisting or bending. Less often, pliers may suggest a use that is less familiar, such as carrying a contaminated object or serving as a weapon. But are these alternative views of pliers as varied as for a similar object that is designed without an obvious function? Consider a cylinder of metal, about the same size and shape as the pliers (see Figure 4). How many uses can be generated for it? For this object the average is two different uses from each subject, with much more diversity in the kinds of uses generated.[11] So a designed object has more, and more familiar, uses than one designed with no function in mind. In addition, research in problem solving showed that function can actually limit generating ideas for use beyond their planned purpose.

Figure 4. A photograph of a pair of pliers, and of a metal cylinder.

Researchers from the Gestalt school of perceptual psychology created simple problems that allowed the observation of insight in their solution. One of the most famous problems is the "Two String Problem":

> The experiment was carried on in a large room which contained many objects such as poles, ringstands, clamps, pliers, extension cords, tables and chairs. Two cords were hung from the ceiling, and were of such length that they reached the floor. One hung near a wall, the other from the center of the room. The subject was told,

[11] Seifert, C. M. (2007). Functional fixedness revisited. Unpublished manuscript. University of Michigan.

"Your problem is to tie the ends of those two strings together."[12]

The subjects soon learn that if they held either cord in one hand, they could not reach the other cord. They were then told that they could use anything in the room.

When subjects arrived at a solution, they reported it, and then were told, "Now do it a different way." Several solutions are often generated by subjects, such as using the extension cord to lengthen one of the cords, using a pole as an arm extension to pull one string over, and anchoring one string in place with a chair while the other is brought over to it. The target solution is one generated by a third of the subjects: To fashion a pendulum using the pliers as a weight, and setting the cord and pendulum swinging, so that it can be caught in position near the other cord.

Why is the pendulum solution so rare then, as in modern replications? Once the solution is known, it appears quite obvious, and subjects choose the same object—the pliers—to fashion a pendulum by affixing the pliers to the string at the bottom. In the original study, another third of the subjects were able to devise the pendulum solution once they had experienced a subtle hint: The experimenter moved near a cord to set it into a swinging motion. Soon after, these subjects created the pendulum solution. Interestingly, only one of the subjects acknowledged the role of the hint. The others said the idea had come to mind, and they had not noticed any action by the experimenter.

In a series of studies, we investigated the role an object plays in generating solution plans. In these studies, we set subjects in a room with the same setup as in the original two string problem. However, for one group of subjects, we included a softball with a small hook embedded in it, and for another group, a pendulum clock kept correct time on the wall. The results showed that those in the original two string problem found the pendulum solution using the pliers as the weight about twenty-five percent of the time. Those who had the additional object of the ball with a hook found the pendulum solution eighty percent of the time (and used the ball, not the pliers, and the pendulum weight). Seventy percent of those who saw the pendulum clock devised the pendulum solution using the pliers as the weight. From this simple comparison, it appears that familiar objects are not so obviously useful in generating unusual solutions. However, once the solution has been suggested (as with the pendulum clock), familiar objects can indeed be co-opted into new solutions.

Is it possible that the function of the pliers actually interferes with its use in novel plans? Moving to a short written-problem format, we tested subjects on this problem while varying the objects provided in the description. This time, we limited the available objects to two, so as to

[12] Maier, N. R. F. (1931). Reasoning in humans II. The solution of a problem and its appearance in consciousness. *Journal of Comparative Psychology, 12*(2), 181–194.

limit alternatives to the pendulum solution (such as extending a string using the electrical extension cord). When subjects were given this problem with two objects, a pair of pliers and a hat, around forty percent generated the "pendulum with pliers" solution. However, when told, "You think of making a pendulum with a string and a weight," the solution rate for the pendulum with pliers was eighty-five percent. So, the problem is not in using a familiar object in an unfamiliar way; instead, the problem seems to be that familiar objects do not suggest this unfamiliar plan.

When we go back to the data where subjects generated uses for a given object, we find that more uses were generated, on average, for the pliers than for the plain cylinder. However, only one in twenty subjects generated a use for the pliers involving "weight," whereas one in four subjects generated a "weight" use for the cylinder. When generating new possible uses for a familiar object, its familiarity made some potential uses more difficult to generate. This idea, called "functional fixedness," suggests it is difficult to go beyond object designs to consider new uses of old objects.[13]

This bias toward designed utility may arise from assumptions about the object design process. Perceptual psychology noted that a designed object should make its use readily apparent. Some features of designed objects "afford," or allow, particular functions, such as a handle allowing the action of carrying.[14] This concept of affordances has been important in the design world, and is espoused as a good practice in engineering.[15] In Figure 5 below, Norman points out that objects that clearly suggest their purpose, and how to use them, are more successful designs.[16]

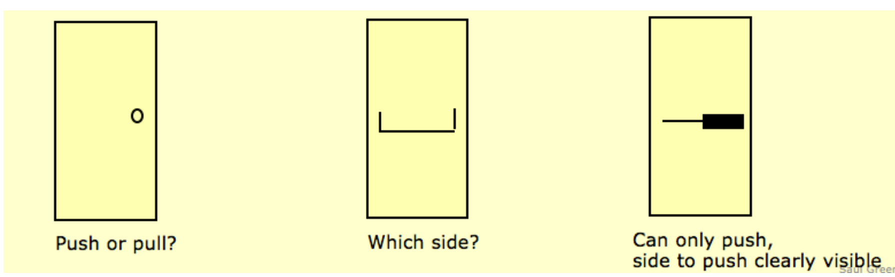

Figure 5. The question of how to open a door can be answered by well-designed handles for operation.

[13] Duncker, D. (1945), On problem solving. *Psychological Monographs, 58*(5), 89-102.

[14] *See* Gibson, J. J., (1966). *The senses considered as perceptual systems.* Boston: Houghton Mifflin.

[15] Sahin E., Cakmak, M., Dogar, M. R., Ugur, E., & Ucoluk, G. (2007). To afford or not to afford: A new formalization of affordances toward affordance-based robot control. *Adaptive Behavior, 15*(4), 447-472.

[16] Norman, D. A. (1988). *The design of everyday things.* London: The MIT Press.

Objects are related in specified ways as an intention of design. Even when attempting to generate new uses for a designed object, it is difficult for people to see beyond the known function. Objects do not suggest alternative solutions that they in fact could support, and are somewhat less likely to lead to novel solutions. This apparent shortcoming in human problem solving contradicts the stated claim in the *KSR v. Teleflex* opinion that objects have "obvious uses beyond their primary purposes." Instead, generation of a solution must begin with other sources. The simplicity of objects' use within a plan may not reflect the difficulty of generating such a solution in the first place.

V. SOLUTIONS ARE ONLY RELEVANT TO A SPECIFIC GOAL

> The idea that a designer hoping to make an adjustable electronic pedal would ignore Asano because Asano was designed to solve the constant ratio problem makes little sense. (*KSR Int'l Co. v. Teleflex Inc.*, 2007, p. 1742).

> The proper question to have asked was whether a pedal designer of ordinary skill, facing the wide range of needs created by developments in the field of endeavor, would have seen a benefit to upgrading Asano with a sensor. (*Id.*, p. 1744).

The description in the *KSR v. Teleflex* opinion suggests an engineer foraging through a patent database searching for a solution. But how do you decide when the information you see, and new solutions offered, relate to your own goal? Can people readily recognize relevant information and novel solutions to problems? In a series of studies, we investigated whether people notice novel opportunities to achieve their goals in a "scavenger hunt" scenario.[17] Our participants engaged in a common-sense planning task where multiple goals were presented and then were given a cued-recall test of memory for the goals.[18] The method involved a planning scenario familiar to the college students who were our participants:

> Imagine you are visiting your friend, Chris, in her dormitory room. A neighbor summons Chris to attend a hall meeting, and she leaves you alone in her room. You decide to snoop around the room, and if you're careful to leave no signs, she'll never find out.

Within this scenario, we presented a series of twelve goals constrained by common objects, for example:

> You notice that Chris left her new college ring on her bureau. You try it on your finger, and it gets stuck. You need to get the ring off

[17] Seifert, C. M., & Patalano, A. L. (2001). Opportunism in memory: Preparing for chance encounters. *Current Directions in Psychological Science, 10*(6), 198–201.

[18] Patalano, A. L., & Seifert, C. M. (1997). Opportunistic planning: Being reminded of pending goals. *Cognitive Psychology, 34*, 1–36.

before Chris returns.

> You jump on the bed. In the process, you manage to leave scuff marks high up on the white wall next to the bed. You need to remove the scuff marks before Chris returns.

> When you open the window to get some fresh air, a breeze blows her poster off the wall. You are not sure how it was attached to the wall, but you need to reattach it before Chris returns.

First, participants were told to read and make a mental note of each goal. In addition, we manipulated the type of solution preparation performed while learning the goals. Some subjects did no planning. Participants in another group were given an object with the goal, and were asked to generate their own plan using that object; for example, for the "fallen poster" goal, they saw the cue, "You think that if only you had some tacks, you might be able to . . . ?" A third group was given both a solution plan and an object for each goal; for example, they were told, "You think that if only you had some tacks, you might be able to pin the fallen poster to the wall." These instructional manipulations were intended to create differences in how participants encoded the goals into memory.[19] Specifically, we expected that recognition of opportunities to achieve goals will be enhanced if those opportunities can be anticipated during encoding.

Next, a recall test presented a series of cues, and the participants were asked to write down any of the studied goals (of the twelve) that "came to mind." Each cue described a single everyday object (e.g., "The only thing you find in the desk is some tacks. If you could use the tacks to achieve any of your goals, record it below."). The cue presented could "match" what was studied during encoding (e.g., "pin up with tacks") or present a novel opportunity (an object involved in another plan for that goal, but not studied; e.g., "chewing gum" as a cue for "use something sticky to affix the poster to the wall").

As expected, more goals were recalled in response to anticipated cues: If "tacks" was studied with the goal of rehanging the poster, participants recalled the "fallen poster" goal given the "tacks" cue. Participants who studied "tacks" with the "fallen poster" goal were less likely to see that goal as related to a "chewing gum" cue. Unless prepared for the specific opportunity, participants did not connect a later cue to a relevant goal in memory. In fact, all participants had plenty of time during the memory test to consider the cue object, and recognize that it could be helpful for any of the twelve goals. However, only those who *anticipated* the cue were likely to notice it as an opportunity for solution.

In follow up studies, we found that anticipating the plan helped people recognize novel objects as opportunities; for example, a new cue

[19] Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review, 80*(5), 359–373.

like "glue" worked with the "use something sticky to affix the poster to the wall" plan for the fallen poster goal. So the specification of the solution plan (adhesive vs. pin) resulted in ready recognition of not just the specific objects anticipated, but also other objects that fit the same plan. For example, both "glue" and "gum" worked to recall the fallen poster if an "adhesive" plan had been prepared at the time of study.

What kinds of planning will help a product designer notice potential solutions they come across?[20] Optimally, the features are:

(a) necessary circumstances for satisfying the goal,
(b) selected as distinctive conditions for executing a plan, and
(c) formulated so as to be readily identified in the environment.

The goal must be fully specified to the level of solution types. In the engineering pedals domain, thinking about the "fixed point" solutions may indeed result in different creative connections than thinking about "pivot points." However, holding a general goal, such as "an improved design," will not produce the needed relevance from associations in memory in order to bring it to mind when needed.

The ability to generate descriptions of predictive features may improve with experience within a domain. With more experience, a "planning vocabulary" of available resources and critical constraints may be identified, leading to better anticipation of features that indicate opportunities. Individuals will vary in their success in recognizing opportunities, improving with experience within a domain, and avoiding limitations from the quality of their planning.[21]

Of course, we all miss some opportunities despite our efforts to prepare for them; however, we can maximize the detection of those opportunities we expect are most likely to arise. Relevant opportunities surround specified goals and plans we have generated. To the extent that we can plan ahead to identify specific ways to accomplish our goals, chance encounters in the world will favor our plans. But without the mental preparation of goals and plans, seeing cue after cue will not strike as relevant to a current design. As Pasteur noted, "Chance favors the prepared mind."[22] And in design, solution elements may be everywhere in the patent history, but it is the current solution effort that determines their relevance.

[20] Seifert, C. M., Hammond, K. J., Johnson, H. M., Converse, T. M., MacDougal, T., & VanderStoep, S. W. (1994). Case-based learning: Predictive features in indexing. *Machine Learning, 16*, 37-56.

[21] Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16*(4), 717–726.

[22] Louis Pasteur, Inaugural Lecture as Professor and Dean of the Faculty of Science at the University of Lille, Douai, France (Dec. 7, 1854).

VI. PEOPLE CANNOT IGNORE RELEVANT INFORMATION

> A factfinder should be aware, of course, of the distortion caused by hindsight bias and must be cautious of arguments reliant upon ex post reasoning. (*KSR Int'l Co. v. Teleflex Inc.*, 2007, p. 1742).

The Supreme Court opinion comments on the problem of "hindsight bias." This phenomenon is identified by asking people for a prediction of a future event both before and after some information is conveyed.[23] Before the outcome is known, I might say the Cowboys have an eighty percent chance of beating Philadelphia this Sunday. On Monday morning, however, knowing they lost, I will say that the Cowboys had little chance to win. People's estimates of causal forces change once information about the outcome is known. In fact, they can't seem to even accurately remember the information they had at the time and the estimate they gave before. The past is thoroughly altered by the knowledge they have gained in the present.

A classic study had subjects consider possible outcomes just before President Nixon's trip to China and Russia in 1972.[24] Some outcomes were:

- The U.S. will establish a permanent diplomatic mission in Peking;
- President Nixon will meet Mao Tse-tung at least once;
- Nixon will see Soviet demonstrators.

The student is assigned a probability to each possible outcome. Then, after the trip, the students were asked in hindsight to assess the likelihoods again, and also asked to recall or reconstruct their original probabilities. With a two-week interval between tests, sixty-seven percent thought their original estimates were closer to what happened than they actually were. For example, students remembered giving a higher probability to "Nixon will meet with Mao" than they had actually given because in fact this outcome did occur. With a three-to-six month interval, eighty-four percent showed the hindsight bias.

The problem of patent law appears to fit this situation very well: However unlikely the new device, now that the new design exists, it seems more likely and more obvious. How likely is it that someone else could have come up with that same design? How is one to weigh the knowledge and circumstances at the time of invention compared to the current state, when the new information (the solution) is now available? The

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[23] Fischhoff, B. (1975). Hindsight ≠ foresight: The effect of outcome knowledge on judgment under uncertainty. *Journal of Experimental Psychology: Human Perception and Performance, 1*, 288-299.

[24] Fischhoff, B., & Beyth, R. (1975). "I knew it would happen:" Remembered probabilities of once-future things. *Organizational Behavior and Human Performance, 13*, 1–16.

nonobviousness standard requires a judgment of whether an invention would have been obvious at a time in the past. Once the invention exists, it is extremely difficult to consider that it may not have been obvious at *any* time in the past.

In studies by Mandel, this problem of avoiding hindsight bias is examined in empirical studies using actual patent law cases.[25] These studies provide the first empirical evidence of a greater hindsight effect for non-obvious determinations than for other judgments. In one scenario, around twenty-five percent of mock jurors considered an intention obvious in the foresight condition (judged before the outcome is known), while about seventy-five percent considered the same invention obvious in hindsight. The hindsight bias is clearly evident in decisions about cases regarding nonobviousness.

Can judges, patent officers, and jurors avoid this bias by knowing about its existence? As the *KSR v. Teleflex* opinion notes, one must be vigilant about avoiding this bias. However, further findings show that warning mock jurors through instruction that they must avoid the hindsight bias resulted in only small (but not significantly less biased) corrections. Groups of jurors similarly instructed were no better at warding off the impact of hindsight bias.

In a second paper, Mandel addresses the *KSR v. Teleflex* case in terms of the hindsight bias.[26] This study involves the application of the "suggestion test"—where some pre-existing suggestion must be present to motivate combining references in the non-obvious analysis. These studies show that the suggestion test fails to correct the hindsight bias, in that mock jurors were no more likely to find an invention was "non-obvious" than when no suggestion instruction was given.[27] Perhaps studies following these judgments would clarify how determinations of nonobviousness are made without making the hindsight error. It seems correcting for the hindsight bias is too difficult, and an alternative way to assess obviousness is needed.

Perhaps we can ask, as the opinion notes, that the reasoner be aware of the hindsight bias, and thus avoid its mistakes. Unfortunately, like many cognitive phenomena, knowledge of biasing factors does not mean the error will be avoided. Even when subjects were told that their original estimates will be compared to their current statements, they were unable to correctly recall their judgments before knowing the outcome.

[25] Mandel, G. (2006a). Patently non-obvious: Empirical demonstration that the hindsight bias renders patent decisions irrational. *Ohio State Law Journal, 67*, 1391–1398.

[26] Mandel, G. (2006b). Patently non-obvious II: Experimental study on the hindsight issue before the supreme court in KSR vs. Teleflex. *Yale Journal of Law and Technology*, *9*, 1–40.

[27] But, note that in Mandel's study, less than fifty percent of mock jurors judged the invention to be "obvious." In other studies, the majority of subjects commit the hindsight bias, even with warning.

(Fischhoff, 1975). Knowledge of the hindsight bias is far from sufficient to avoid its influence.

Other research has demonstrated that knowledge of bias does not lead to correction in reasoning. For example, in a series of studies, we had participants read (line by line) a "breaking news" story about the death of a family of four after eating in a local Chinese restaurant.[28] Of course, food poisoning is suspected, but the story goes on to note that the coroner had definitively ruled out food poisoning as a cause of death. The readers accepted the finding; however, how did they feel about eating at that restaurant? Even while acknowledging that food poisoning was not actually the cause of death, readers were more likely to recall story features related to food poisoning—as if it had in fact been the actual cause—in their accounts of what happened. Having heard a good explanation, even though known to be untrue, made people cling to it in their explanations of events.

A further study showed the impact of processing erroneous information, even if immediately followed with a correction. Subjects read stories on a computer and were interrupted during reading with a probe recognition task: Was the presented probe in the story they were reading? The story reported on a playoff game and a star player who skated for the Boston team; actually, he was traded, so he played for the New York team. When subjects were interrupted after reading the words "the team," both Boston and New York were quickly recognized, even though subjects only reported that the star player was with New York. Even the brief history of having considered the player as a Boston team member was enough to change the associations, and therefore the memory, of the events.[29] Correction appears to require more than simply knowing the correct answer; instead, the processing of the initial information had to be counteracted in order to avoid the effects of the information in memory.

Given this bias, can case examiners "set aside" the new design and consider the nature of its discovery? Considering the time of invention and what was known at that point, is it possible to ignore the new design? Or will we see a solution path as leading inexorably toward that existing solution? The evidence from hindsight and memory correction studies suggests it is almost impossible not to be biased by knowledge of outcome. Our memory is organized around the information we take in and consider; consequently, it cannot be the same after understanding the new design.

[28] Johnson, H. M., & Seifert, C. M. (1998). Updating accounts following a correction of misinformation. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 24*(6), 1483–1494.

[29] For a similar example, *see* Johnson, H. M., & Seifert, C. M. (1994). Sources of the continued influence effect: When misinformation in memory affects later inferences. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*(6), 1420–36.

VII. CONCLUSION

In sum, the Supreme Court opinion in *KSR v. Teleflex* describes a process for determining the obviousness of a design. The decision suggests the inquiry into nonobviousness should be conducted:

- Using the goal created by the patentee;
- Providing specific resources selected by patentee as relevant;
- Performing all combinations of the selected resources;
- Ignoring the most relevant information (the new design).

This proposed process has several points of departure from what we know scientifically about the problem solving process. It assumes that designers' goals are all the same, or that they do not have any, or that they have just the general goal of improving on prior patents. It assumes that the relevance of patents to the task at hand is trivial. It assumes that the mind of the ordinary person, with a knowledge base designed for understanding basic terms, is comparable to experts with well-specified plans and experience built in the domain. It assumes that the situation at the time of invention can be simulated by minds already knowing the outcome (the actual design). Under these circumstances, the art of the practice—identifying and refining goal specifications, identifying relevant past patents, and the actual solution generated—is handed over to "bystanders" who determine whether the final design follows from its carefully crafted precursors.

This process appears to have built-in biases that are well-established in the psychological literature. Given the nature of human problem solving presented here, how much confidence do you have in the ability of anyone to find that the outcome is novel?

What to do? My best advice is to do the experiment: Take a patent claim like KSR's. Select actual "ordinary minds"—subjects (engineering undergraduate students) with the needed expertise—as designers. Re-create the world at the time of the invention by seeding a problem context with many ideas from its time, through a database of patents up to the time of the invention. Finally, provide a general goal, such as, "to produce a better product," and leave them alone for a while. The experiment excludes the knowledge of the patent application, and of the designer's goal, while recreating the world before its submission using "ordinary minds with ordinary creativity."

Will they create something patentable? At least now the outcome in this simulation is no longer obvious.