# IMAGINATION, INVENTION, AND PATENT INCENTIVES: THE PSYCHOLOGY OF PATENT LAW

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"[D]esigners [including inventors] are human beings first and as such are . . . subject to the failings of the species, including complacency, overconfidence, and unwarranted optimism."[1]

"The creation of . . . any . . . artifact requires, before anything else, something imagined."[2]

"Just as our eyes sometimes lead us to see things as they are not, our imaginations sometimes lead us to foresee things as they will not be . . . . [M]ost of us spend so much of our lives turning rudders and hoisting sails [to sail to future destinations imagined to be desirable], only to find that Shangri-la isn't what and where we thought it would be."[3]

*Abstract*

*Patent law is founded on the belief that outlier inventions departing significantly from present technological designs are difficult to produce. Patent incentives encourage highly talented (or specially informed) parties to generate and popularize increased quantities of such outlier inventions. Recent psychology research suggests why patent incentives are needed as spurs to difficult new thinking about highly original technology designs.*[4] *Inventing outlier advances requires inventors to imagine new designs and their impacts with little information about the untried technologies involved.*

*Unfortunately, individuals are prone to errors in such imagination projects due to imagination limitations present in all persons.*[5] *Patentable inventions are*

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1. HENRY PETROSKI, SUCCESS THROUGH FAILURE 194–95 (2006).
2. HENRY PETROSKI, SMALL THINGS CONSIDERED 242 (2003).
3. DANIEL GILBERT, STUMBLING ON HAPPINESS 24–25 (2006) [hereinafter GILBERT].
4. *See generally* Jeanne C. Former, *A Psychology of Intellectual Property*, 104 NW. U. L. REV. 1441 (2010) (summarizing the recent psychology research on patent invention).
5. GILBERT, *supra* note 3, at 24–25.

*difficult to produce for reasons embedded deep in human psychology. Special incentives are needed to promote optimal efforts to overcome psychological barriers to imagination and invention.*

*Several types of imagination weaknesses impede the production of patentable advances.*[6] *Limitations of human psychology cause many persons to err systematically in predicting the future, resulting in inaccurate projections of future conduct of others and of the actions and items that will make persons happy in the future.*[7] *In the context of inventive efforts, these systematic weaknesses in human imagination cause inventors to mistakenly project how items incorporating significant variations from present technologies will operate and serve potential users.*[8]

*These errors are especially prevalent as inventors develop outlier advances potentially qualifying for patent protections. Such advances are typically based on distinctly new and untried technologies about which inventors have little experience and background knowledge. Inventors must expand on very little knowledge and imagine a great deal to produce invention designs based on these untried technologies.*

*Inventors' imagination errors may undercut invention projects at many stages. Inventors may mistakenly imagine how significantly new technologies will function when incorporated in new products or processes, how the new functionality achieved through new invention designs will contribute to the practical tasks of invention users, or how new designs will translate into commercially viable products—that is, products that are at once manufacturable, marketable, and well-received by potential users.*[9] *Because inventors frequently make errors in foreseeing one or more of these key factors, many attempts to produce patentable advances incorporating distinctively new technologies are systematically doomed to failure.*[10] *Human psychology creates inherent barriers to these inventions through the weaknesses of human imagination.*[11]

*Obviously, not all invention efforts incorporating significantly new technologies are doomed to failure. However, given the imagination barriers involved, success in producing useful advances based on new and unproven technologies will be rare. We should have a healthy respect for the difficulty of these efforts and construct patent laws accordingly.*

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6. *See generally id.* at 75–96 (discussing the shortcomings of future projections).

7. *See, e.g.*, D. Dunning et al., *The Overconfidence Effect in Social Prediction*, 58 J. PERSONALITY & SOCIAL PSYCHOL. 568 (1990) (finding that people are highly overconfident in social prediction); *see* D.W. Griffin, D. Dunning, & L. Ross, *The Role of Construal Processes in Overconfident Predictions About the Self and Others*, 59 J. PERSONALITY & SOC. PSYCHOL. 1128 (1990) (discussing overconfident behavioral predictions); *see* Robert Vallone et al., *Overconfident Predictions of Future Actions and Outcomes by Self and Others*, 58 J. PERSONALITY & SOC. PSYCHOL. 582 (1990) (finding that self-predictions proved to be consistently overconfident).

8. *See* GILBERT, *supra* note 3, 75–96 (discussing shortcomings of future projections).

9. *See id.* at 83–211 (summarizing research on why people are biased and irrational in predicting the future).

10. *See generally* Dunning et al., *supra* note 7, at 568–81 (discussing how imagination projects often fail).

11. *See* GILBERT, *supra* note 3, at 224–32 (explaining the shortcomings of imagination).

*The rarity of correctly imagined and successfully realized inventions involving significantly new technologies has three implications for patent laws. First, patent incentives should be targeted with psychological weaknesses of invention imagination in mind.*[12] *This means that patent incentives should be greatest where imagination weaknesses are most likely to impair inventors' foresight about future invention functionality and the impacts of distinctive, non-obvious technological changes. Second, patent rewards should be sized to ensure that payoffs for rare invention successes compensate inventors for their many likely failures based on imagination barriers.*[13] *Inventors who overcome these barriers—by successfully imagining both future public needs and non-obvious technology changes that will serve those needs—deserve compensation that takes into account the probable failures of many invention attempts before one successful attempt gains a valuable patent. Third, patent rights should be enforced to promote rapid and extensive product commercialization and popularization efforts regarding patented inventions since these test and filter inventions based on their practical value.*[14] *Such enforcement should help ensure that rare successes in overcoming imagination barriers and creating valuable products based on significantly new technologies will receive the public attention and access that they deserve.*[15]

*Patent incentives encouraging hard-to-imagine inventions and the commercialization of such inventions serve the public in both the present and the future. The public benefits in the present because this combination of incentives tends to bring more hard-to-imagine, non-obvious technologies into widespread public use and potential public service.*[16] *The public benefits in the future because patent disclosures of present advances enhance the design knowledge available to future inventors.*[17] *Insights encouraged by patent rewards are added to the body of information constituting the useful arts.*[18] *Thereafter, these insights become commonly available tools for future parties to use in formulating additional product designs and engineering analyses.*

*This Article uses psychological insights into imagination processes to interpret patent laws and to advocate changes in light of imagination barriers. The Article addresses four related topics. First, it describes recent advances in psychology research regarding systematic imagination errors. Second, the Article describes how these systematic errors affect the creation of new and non-obvious inventions of the sort governed by patent laws. Third, the Article*

12. *Id.*

13. *See generally* Dunning et al., *supra* note 7, at 568–81 (discussing how imagination projects often fail).

14. *See* F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV. 697, 732–36 (2001) (describing commercialization theory).

15. *Id.*

16. Kenneth W. Dam, *The Economic Underpinnings of Patent Law*, 20–21 (Coase-Sandor Working Paper Series in Law and Economics, 1993), http://chicagounbound.uchicago.edu/cgi/viewcontent.cgi?article=1508&context=law_and_economics.

17. *Id.*

18. *See* Imperial Chem. Indus. v. Barr Labs., 795 F. Supp. 619, 625 (S.D.N.Y. 1992) (demonstrating through the enablement and best mode requirements "the public benefits by the advance of science and the useful arts").

*considers how patent standards—particularly standards for patentable subject matter and tests for the non-obviousness of invention designs—work to offset invention weaknesses by boosting the production and popularization of inventions otherwise impaired by imagination weaknesses. Fourth, the Article considers psychology-informed changes in patent laws to better offset imagination weaknesses and help to reduce the adverse societal impacts of invention imagination errors on technology development and progress.*

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## I. INTRODUCTION: PATENTABLE INVENTION IS HARD BECAUSE INVENTORS ARE SYSTEMATICALLY PRONE TO FAIL

### *A. The Role of Error in Invention*

Inventions require parties to imagine several things simultaneously: the nature of a practical problem (often someone else's), the capabilities of a technology (often a relatively uncharted one), and the ways that the new technology can address the difficulties in the problem at hand to produce a practical and valuable solution (as seen by the parties with the problem).[19] These simultaneous flights of imagination require insights about future devices and contexts of use that do not presently exist, as well as predictions about the

19. *See* HENRY PETROSKI, THE ESSENTIAL ENGINEER 34, 25 (2010) (stating "[e]ngineers . . . have to imagine the manageable. They have to come up with achievable new solutions to both new and old problems."). Imagination of new designs and their functional implications lies at the heart of device designs in many fields. For example, the following account places imagination at the heart of the development of the first atomic bomb design:

> [A] nuclear weapon, which at the time did not exist as an artifact, was in itself a real and deliberate objective. The form of a bomb did not so much fall out of equations expressing the laws of physics, however, as stem from a creative act of the imagination that specified a geometry that would result in a tractable mathematical problem. The scientists were thus doing engineering, not only in the service of testing scientific hypotheses but also with the objective of producing a new artifact, something that theretofore had not existed.

*Id.* at 25.

satisfaction and happiness of device users with results from imagined devices in imagined uses.[20]

Unfortunately, humans are systematically prone to error in imagining how they or anyone else will feel in the future. Coupled with difficulties in imagining designs for products that do not exist, often based on poorly understood technologies, difficulties in projecting the future happiness of users with imagined inventions produce high barriers to inventive success.[21] Recent psychological research has identified several reasons why persons tend to be poor predictors of future happiness[22] and, I argue, poor predictors of the happiness and satisfaction of users with newly imagined inventions.

At least four psychological factors make it difficult for inventors to produce successful inventions based on distinctively new designs. These include: 1) difficulties in projecting the capabilities of new technologies in ways that point to new and distinctively different product designs; 2) divergences in the knowledge and experience of product inventors and product users, causing inventors to imperfectly understanding the functional needs and problems of potential invention users; 3) gaps in knowledge and experience of product inventors concerning the contexts where new inventions will be produced, supplied, and used, and; 4) inabilities of inventors to fully imagine the impacts of new inventions in use and the relative happiness of users with new inventions compared with alternative means for producing similar practical results.[23]

Not all of these difficulties plague every invention. For example, the first three problems—difficulties in projecting technology capabilities, user needs, and user contexts—may be absent in situations where an inventor uses a relatively old and well understood technology (thus obviating the need for special knowledge about the technology) to solve a problem experienced personally by the inventor (who understands the problems of the potential invention users from the inventor's own experience) and the inventor designs a device or process that the inventor tests in context personally because the inventor lives or works in that context.[24] A classic example of such a personally-informed invention was the development of the liquid erasure material later marketed under the brand name "Liquid Paper."[25] This material was invented

20. Imagination of potential design features is the initial step in these design processes. For example, in developing a new bridge design:

> The first step in designing a bridge is for the engineer to conceive of a form in his mind's eye. This is then translated into words and pictures so that it can be communicated to other engineers on the team and to the client who is commissioning the work. It is only when there is a form to analyze that science can be applied in a mathematical and methodical way.

*Id.* at 47. *See also id.* at 22 ("A rocket [design] begins in the mind's eye.").

21. *See* GILBERT, *supra* note 3, at 224–32 (explaining the shortcomings of imagination).

22. This body of research has sprung out of the recognition that thinking about the future is one of the fundamentally important features that distinguishes humans from most other animals, coupled with the further insight that in carrying out this distinctive function humans often make important and misdirecting errors. The study of the errors and their sources has taken on its own significance as a branch of psychological study. GILBERT, *supra* note 3, at 3–27.

23. *See generally* GILBERT, *supra* note 3, at 224–32 (explaining the shortcomings of imagination).

24. *See, e.g.*, Mary Bellis, *Liquid Paper—Bette Nesmith Graham (1922–1980)*, THOUGHTCO (Apr. 21, 2017), http://inventors.about.com/od/lstartinventions/a/liquid_paper.htm (discussing the invention process behind Liquid Paper).

25. *See id.* (discussing the invention process behind Liquid Paper).

by a secretary repeatedly frustrated by the difficulties of retyping texts or using other correction means to fix typing errors.[26] She invented an opaque, fast drying liquid (like a white paint) to simply paint over errors.[27]

This invention was highly useful, yet based largely on widely-held old knowledge rather than new technological discoveries.[28] The inventor relied on relatively old knowledge about the functional properties of liquids such as paints that dry relatively rapidly into opaque layers which cover underlying items.[29] The inventor also relied on her extensive on-the-scene experience with both the problem to be solved (typing errors requiring correction in a visually acceptable manner) and the context of invention use (office environments with high volume typing and no opportunities to use exotic chemicals for corrections).[30] The inventor's key insight was that this old knowledge—apparently from two different areas of activity involving office work and painting—could be usefully combined to produce a new typing correction tool.[31] From this combination of old knowledge, a highly useful, commercially successful, and patentable advance was born.[32]

This invention involving relatively simple technology and a well-known problem was still subject to the fourth barrier to inventions—the limitations of human imagination. All inventions share the common denominator of one or more inventors with limited human capabilities including psychological imitations on imagination. Imagination limitations restrict inventions even where knowledge of a problem is widespread, as was the case with typing errors.[33] Even though numerous persons in office environments encountered (and were no doubt highly frustrated by) problems of typing errors and many probably also had knowledge of the capabilities of white paint to cover marks on walls, few, if any, successfully imagined the combination of typing errors with paint-like material in the manner that the originator of Liquid Paper did. Her invention—really a triumph of imagination regarding the implications of using paint in the new context of typing—was exceptional because she correctly imagined and projected both the practical advantages of paint-like material in fixing typing errors and the overall happiness of future typists with the new material when used in this way.[34]

This is the mark of a successful invention: to solve practical problems in ways valued by invention users. Yet, as psychologists are beginning to understand, individuals tend to mistakenly estimate the happiness that they or

26. ETHLIE ANN VARE & GREG PTACEK, MOTHERS OF INVENTION: FROM THE BRA TO THE BOMB, FORGOTTEN WOMEN AND THEIR UNFORGETTABLE IDEAS 39 (1987).

27. *Id.* at 41.

28. *See id.* at 39 (discussing how Bette Nesmith Graham took the idea from artists painting over their errors).

29. *Id.*

30. *Id.*

31. *Id.*

32. *See id.* at 41 ("In 1975 Liquid Paper employed two hundred people, produced twenty-five million bottles of the stuff, and distributed it to thirty-one countries.").

33. *Id.* at 39.

34. *See generally id.* at 40–41.

others will achieve in future actions or circumstances.[35] Thus, a successful inventor must go against type and overcome built-in psychological weaknesses about projecting future circumstances and future users' satisfaction with inventions.[36] To gain patents for their inventions, inventors must go even further: they must produce inventions that incorporate nonobvious, distinctive technology features that average practitioners in their fields would probably not have developed even with extensive knowledge about prior designs in their fields.[37] Hence, patentable inventions are doubly remarkable. They represent triumphs over generally-prevailing psychological weaknesses in projecting future happiness and unusual technical advances departing from past technical understanding. Producing patentable advances with both these two unusual features is understandably difficult and rarely successful.

### *B. Extending Invention Creativity Models to Accommodate Imagination and Error*

The present study of imagination and error as features of invention for purposes of patent law builds on two important lines of prior intellectual property scholarship—a group of broadly focused studies of the nature of creativity underlying protected forms of intellectual property and a more narrowly focused set of studies of the specific features of inventions for purposes of patent law. These prior studies, as summarized below, have focused primarily on the positive features of creative works and projects qualifying for intellectual property protections.[38]

The present study stands in some contrast to these prior studies in that it emphasizes negative factors—that is, the problems caused by psychological errors in attempts to construct patentable inventions and the need for strong patent incentives to encourage parties to overcome these errors and produce useful, patentable inventions. In this emphasis on sources of errors in shaping invention outcomes, the present study relies on recent psychological findings described in this Article and, accordingly, stands somewhat apart from prior

35. GILBERT, *supra* note 3, 209–10 (2005).

36. *See, e.g.*, Art Markman et al., *The Enemies of Invention*, PSYCHOL. TODAY (May 7, 2013), https://www.psychologytoday.com/articles/201305/the-enemies-invention (discussing how humans overestimate success and discount failure).

37. *See* 35 U.S.C. § 103 (2012). The Supreme Court has explained the process for assessing the necessary nonobviousness of a patentable invention as follows:

> Under [35 U.S.C. § 103], the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness or nonobviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. As indicia of obviousness or nonobviousness, these inquiries may have relevancy.

Graham v. John Deere Co., 383 U.S. 1, 17–18 (1966).

38. *See, e.g.*, Amy L. Landers, *Ordinary Creativity in Patent Law: The Artist Within the Scientist*, 75 MO. L. REV. 1 (2010) (examining a legal conception of creativity); *see* Gregory N. Mandel, *Left-Brain Versus Right-Brain: Competing Conceptions of Creativity in Intellectual Property Law*, 44 U.C. DAVIS L. REV. 283 (2010) (discussing how creativity can serve the incentive goals of intellectual property).

academic legal studies that have considered creativity and inventions based on earlier psychological research and understanding.

This Subsection describes the foundation of prior psychologically-informed studies of creativity underlying intellectual property protections and invention definitions. The remainder of this Article builds on this foundation, adding the new element of psychologically-driven systematic error to prior models of creativity in inventions under patent law. The Article describes how errors stemming from common gaps in human rationality—and particularly in individuals' abilities to imagine the future as augmented by new inventions—shape invention designs and invention failures. The Article also suggests how both definitions of patentable inventions and other features of patent law should be recast to accommodate the impacts of these errors on invention processes and invention commercialization endeavors.

### *1. Creativity Underlying Intellectual Property Protections*

Creativity in intellectual endeavors and in intellectually-generated works has certain common features shared across varying types of projects and results.[39] Summarizing the types of creativity typically found in intellectual works, researchers Christopher Buccafusco, Zachary C. Burns, Jeanne C. Fromer, and Christopher Jon Sprigman describe the psychological features of creativity as follows:

> Although there are varying colloquial understandings of creativity, the field of psychology consistently defines creativity as a process that generates a product or idea and possesses two qualities: newness and appropriateness. Newness refers to novelty or originality, and appropriateness indicates that some community recognizes the contribution as socially valuable. While the creative process is essentially psychological, the element of appropriateness can be evaluated only in a sociocultural context. As Keith Sawyer explains: "Individual-level explanations are the most important component of the explanation of creativity…. But individuals always create in contexts, and a better understanding of those contexts is essential to a complete explanation of creativity." Assessing creativity is not complete without reference to a work's effect on the relevant culture and its social judgments. According to Mihaly Csikszentmihalyi's influential framework, creativity can be appraised only at the intersection of individuals, the domain in which they are working, and

39. *See, e.g.*, MIHALY CSIKSZENTMIHALYI, CREATIVITY: FLOW AND THE PSYCHOLOGY OF DISCOVERY AND INVENTION 25, 28–29 (1996) (showing creativity produces a novel product that is accepted into a domain); *see* Howard E. Gruber & Doris B. Wallace, *The Case Study Method and Evolving Systems Approach for Understanding Unique Creative People at Work*, *in* HANDBOOK OF CREATIVITY 93, 94 (Robert J. Sternberg ed., 1999) (stating "[l]ike most definitions of creativity, ours includes novelty and value: The creative product must be new and must be given value according to some external criteria."); *see* R. KEITH SAWYER, EXPLAINING CREATIVITY: THE SCIENCE OF HUMAN INNOVATION 27 (2d ed. 2012) (showing creativity involves processes bringing novel items and social value to some community); *see* Robert J. Sternberg & Todd I. Lubart, *The Concept of Creativity: Prospects and Paradigms*, *in* HANDBOOK OF CREATIVITY (showing creativity is "the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)").

> the field (the domain's gatekeepers). In a sense, the socio-psychological definition of creativity looks similar to [intellectual property] law's aim of giving protection for products that are requisitely new, while leaving to society the question of how valuable the product ought to be considered.[40]

Intellectual property laws are, at least in part, aimed at encouraging creativity in the production of intellectual works.[41] Legal scholars have identified a number of psychological features underlying the production of creative works potentially protected as intellectual property.[42] Psychological interpretations have aided understanding of the creation of intellectual property, as well as the processes for enforcing intellectual property rights.[43] Specific features of intellectual property and related social processes that have been illuminated through psychological assessments include the processes by which creators create,[44] the methods that individuals who are potential users of works apply to decide which created works are valuable,[45] the motivations of

40. Christopher Buccafusco et al., *Experimental Tests of Intellectual Property Laws' Creativity Thresholds*, 92 TEX. L. REV. 1921, 1932–33 (2014).

41. The Supreme Court has repeatedly recognized that the promotion of creativity in the production of intellectual works is a primary goal of intellectual property laws. *See, e.g.*, Eldred v. Ashcroft, 537 U.S. 186, 223 (2003) (stating "the grant of exclusive rights [provided for in the Intellectual Property clause of the United States Constitution] is intended to encourage the creativity of 'Authors and Inventors.'"); *see* Sony Corp. of Am. v. Universal City Studios, Inc., 464 U.S. 417, 429 (1984) (granting of patents and copyrights is "intended to motivate the creative activity of authors and inventors").

42. *See generally* Jeanne C. Fromer, *A Psychology of Intellectual Property*, 104 NW. U. L. REV. 1441 (2010); *see* Gregory N. Mandel, *To Promote the Creative Process: Intellectual Property Law and the Psychology of Creativity*, 86 NOTRE DAME L. REV. 1999 (2011) (discussing how intellectual property law can promote the creative process) [hereinafter *Psychology of Creativity*].

A number of authors have used psychological frameworks and related behavioral analyses to evaluate intellectual property policies. *See, e.g.*, Dennis D. Crouch, *The Patent Lottery: Exploiting Behavioral Economics for the Common Good*, 16 GEO. MASON L. REV. 141, 142 (2008) (explaining how "the lottery" effect explains some innovation behavior); *see* Jeanne C. Fromer, *A Psychology of Intellectual Property*, 104 NW. U. L. REV. 1441, 1443 (2010) (discussing the psychology of the creative process); *see* William Hubbard, *Inventing Norms*, 44 CONN. L. REV. 369, 374 (2011) (providing a framework for patent law analysis by incorporating both traditional and social-norms perspective); *see* Eric E. Johnson, *Intellectual Property and the Incentive Fallacy*, 39 FLA. ST. U. L. REV. 623, 627 (2012) (discussing the incentive theory in the context of intellectual argument); *see* Amy L. Landers, *Ordinary Creativity in Patent Law: The Artist Within the Scientist*, 75 MO. L. REV. 1, 35–77 (2010) (discussing psychological theory behind patent law); *see* Gregory N. Mandel, *Left-Brain Versus Right-Brain: Competing Conceptions of Creativity in Intellectual Property Law*, 44 U.C. DAVIS L. REV. 283, 286 (2010) (discussing a behavioral theory of intellectual property law); *see* Gregory N. Mandel, *Patently Non-Obvious: Empirical Demonstration that the Hindsight Bias Renders Patent Decisions Irrational*, 67 OHIO ST. L.J. 1391, 1400–03 (2006) (explaining the hindsight bias behind patent decisions); *see* Laura G. Pedraza-Farina, *Patent Law and the Sociology of Innovation*, 2013 WIS. L. REV. 813, 816 (explaining the importance of a socio-historical approach to patent law); *see* R. Keith Sawyer, *Creativity, Innovation, and Obviousness*, 12 LEWIS & CLARK L. REV. 461, 464–84 (2008) (discussing psychological research and its role in explaining how ideas build upon ideas).

43. *See Psychology of Creativity*, *supra* note 42 (noting that "over the past several decades . . . a wealth of psychological research has provided new insights into creativity and the creative process. This research yields valuable lessons for intellectual property law and indicates that certain areas of patent and copyright law may counterproductively hinder the very creativity that the law is designed to inspire."). *See also* Stephanie Plamondon Bair, *The Psychology of Patent Protection*, 48 CONN. L. REV. 297, 314–29 (2015) (providing an overview of past psychological interpretations of patent law features and patent enforcement).

44. Fromer, *supra* note 42, at 1459–83.

45. *See id.* at 1459–62 (explaining a process of creation).

creators,[46] mechanisms of collaboration between creators,[47] and convergent versus divergent thought processes that may produce similar or dissimilar creative products.[48]

In analyzing the psychological features of creativity underlying intellectual property, a number of scholars have applied consistent frameworks emphasizing the role of problem solving in creativity. For example, Jennifer C. Fromer sees problem solving as the essence of creativity. According to Fromer, "[c]reativity involves finding—or formulating and constraining—a problem, followed by solving the problem. In essence, problem solving is key to creativity in the scientific and engineering domains, particularly where invention is concerned, while artistic creativity emphasizes problem finding."[49] She notes that research into the psychological processes involved in creative endeavors have identified four stages in creative processes:

> Psychological scholarship indicates that there are four stages to the creative process: preparation, incubation, illumination, and verification. Although these stages occur in sequential order in the prototypical case, psychologists think that these ought not to be viewed as stages that necessarily occur in a precise order and just once per creative process. The preparation stage consists of finding a problem and gathering necessary information. . . . Incubation, the next stage, is an underrecognized stage of the creative process and concerns the unconscious processing of information to solve the prepared problem. . . . The third stage, illumination, is the one most popularly associated with creativity. It is the "a-ha" moment of insight. As with the proverbial light bulb going off above one's head, illumination of a solution to the identified problem seems to occur suddenly and consciously. . . . The fourth stage, verification, is the part of the creative process during which a person tests ideas and fully develops them. As part of verification, the person must be able to judge whether the idea is worth pursuing further and, if so, continue to refine the idea.[50]

Gregory N. Mandel has framed the creativity underlying intellectual property in similar terms. In his view:

> Psychologists commonly view creativity as possessing at least two, and possibly three, characteristics. Creativity requires the production of something that is both novel and appropriate. Novelty for psychologists, which is also referred to as "originality," is remarkably akin to the novelty requirement in patent law and the originality requirement of copyright law. Reproducing past work or repeating existing knowledge is not novel, and therefore not creative.

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46. *See Psychology of Creativity*, *supra* note 42, at 2000–01, 2007–13 (discussing the motivations of creations).

47. *See id.* at 2000–02, 2013–16 (discussing mechanisms of collaboration).

48. *See id.* at 2002–07 (discussing convergent versus divergent thought processes).

49. Fromer, *supra* note 42, at 1459.

50. *Id.* at 1463–65.

> Appropriateness, also referred to as "adaptivity," requires that an idea be recognized as socially useful or "valuable in some way to some community." The value of appropriateness can be derived from any of a number of characteristics, such as utility, merit, importance, uniqueness, or the desirability of a product, service, process, or idea. How appropriateness is achieved can vary between science and the arts. For a technological invention, appropriateness will often require functionality; for artistic expression, it may require the ability to keep the audience's attention or cause a powerful emotional effect.
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> Some psychologists add a third element to the specification of creativity, requiring that a creative accomplishment be heuristic rather than algorithmic. Algorithmic tasks are projects where the "path to the solution [or goal] is clear and straightforward." Heuristic tasks, in contrast, are ones that lack "a clear and readily identifiable path to a solution."[51]

Mandel also links creativity in the creation of intellectual works to problem solving:

> Although there will always be exceptions, producing creative output, whether in the arts or sciences, usually requires both divergent and convergent thought, and both problem-finding and problem-solving. Not every step needs to be performed creatively in order to produce a creative result. There can be a creative solution to a known problem, for example. However, at least one of the elements must represent a creative achievement in order for the end result to provide a creative advance.[52]

### *2. Past Analyses of Creativity in Patentable Inventions*

Evaluations of the creativity underlying patentable advances have emphasized the demands for intellectual creativity implicit in several patent law requirements. For example, Jeanne C. Fromer sees the requirements for minimum levels of creativity as derived primarily from patent law requirements for novelty, nonobviousness, and utility:

> [P]atent law's novelty requirement ensures that a particular invention has not been known or used before, with limited exceptions, under the justification that the valuable patent right ought not to be awarded to an invention of which society already has the benefit. This requirement is in harmony with the emphasis in scientific creativity—particularly creativity exercised in making inventions—on solving problems. If society already has possession of a particular solution to a particular problem, a subsequently developed identical solution is not creatively valuable. Thus, there is no reason to give the patent incentive to any "Johnnies-invent-lately."

51. *Psychology of Creativity*, *supra* note 42, at 2002–04; *see also* Mandel, *supra* note 38, at 315–43.
52. *Psychology of Creativity*, *supra* note 42, at 2007.

> . . .
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> Patent law's nonobviousness requirement also emphasizes the value of problem solution to creativity for scientific and engineering inventions. Section 103 of the Patent Act removes from patentability any problem solution that would have been obvious to a person having ordinary skill in the art based on the preexisting state of the art. In so doing, patent law signifies that problem solutions that can be derived with at best a minimally creative process—possibly even absent certain steps, such as incubation—are not valuable. It is as if society already has those solutions available by virtue of having both its preexisting scientific and engineering knowledge and people having ordinary skill in the art to take direct advantage of that knowledge.
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> Utility is tightly linked to the emphasis in scientific creativity on problem solving, particularly in measuring whether a solution is valuable to society. Utility requires that an invention be operable and, moreover, that it work for a specific and substantial purpose. On this basis, a machine claiming to create perpetual motion—a scientific impossibility—cannot be patented, as it is inoperable. In cases of inoperability, what is presented as a problem solution is in fact no solution at all, even if underlying the invention is a significant found problem, such as creating perpetual motion. With inoperable inventions, then, the scientific creativity is insufficient, and thus they are not patentable.[53]

While agreeing that invention production is a version of problem solving, Gregory N. Mandel has offered a view of invention processes that emphasizes creativity through intuitive leaps (many not attributable by their originators to rational sequences of thought) combined with rational, careful screening of the merit of the leaps.[54] He describes the creativity typically involved in inventions as follows:

> Technological innovation often does not result from a straightforward linear process. There is rarely a singular "Eureka!" moment. Rather, innovation more regularly emerges from the combination of many different ideas, over long periods of time, with the meaning of each idea often not clear when it is first proposed, nor the same from the beginning to end of the innovative process. Inventors do not all-seeingly identify what they want to achieve, and then set forth on a direct, step-by-step path to achieve it. Instead, innovation involves a constantly changing course that requires a combination of generating many ideas, slowly refining selected ones, often shifting plans, and moments of intuition.

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53. Fromer, *supra* note 42, at 1485–88.
54. Mandel, *supra* note 42, at 336–38.

> . . .
>
> [One study of work in molecular biology and immunology laboratories found that] the scientific process, at least in these laboratories, did not follow a straightforward, linear, step-by-step progression. Fully half of the results obtained in the labs during the periods observed (ranging from three months to one year) were unexpected according to the scientists themselves. . . . Rather than being unusual, unexpected outcomes were the norm of this research. As Isaac Asimov remarked, "The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka' (I found it) but rather 'hmm . . . that's funny.'"
>
> This analysis should not be read to indicate that logic and reason do not play a critical part in invention—they do. Creativity researchers recognize the important role of analytical creativity to scientific and technological endeavors just as well as the intuitive. Think back to Pasteur's statement: the prepared mind is a model of analytical cognition. Similarly, the researcher who found that half the results in molecular biology and immunology laboratories were unexpected also found that half were logically predicted. This researcher further reported on observing the structured, rational way in which the scientists often reason by analogy and the meticulous way they would sometimes go about trying to search for potential methodological flaws in their experiments. The bottom line is that technological invention is not an either/or creative process but a both/and—it springs from a mixture of multiple styles of creative thought.[55]

In short, this model treats inventions as starting with variously informed insights—some derived from linear, rationally-constructed processes generating possible designs but many created through hunches or accidental discoveries—coupled with rationally-constructed testing procedures to evaluate the merit of potential designs.

Additional empiric research by Stefan Bechtold, Christopher Buccafusco, and Christopher Jon Sprigman confirms that many persons creating intellectual property depart from purely linear, rationally-constructed creation processes.[56] Bechtold, Buccafusco, and Sprigman ran a series of experiments designed to understand how people innovate subject to constraints on their choices.[57] They summarized the results of their experiments as follows:

> Our data suggest that creators do not consistently behave the way that economic analysis assumes. Instead of rationally weighing the objective costs and benefits of different courses of action, creators

55. Mandel, *supra* note 42, at 336–38.

56. *See* Stefan Bechtold et al., *Innovation Heuristics: Experiments on Sequential Creativity in Intellectual Property*, 91 IND. L.J. 1251 (2016) (discussing creation of intellectual property).

57. *See id.* at 1267–91 (addressing how people innovate).

> instead were influenced by decision-making heuristics and individual preferences that often led to suboptimal and inefficient creative behavior. Many of our subjects chose to borrow when innovating was the optimal strategy, and even more chose to innovate when borrowing was the optimal strategy. We find that subjects are only mildly responsive to external incentives. Rather, choices between innovation and borrowing correlated much more powerfully with their internal, subjective beliefs about the difficulty of innovating.[58]

This research suggests that invention processes may be highly irrational (at least in their initial, most creative phases when tentative new invention designs are generated), driven in fundamental ways by personal beliefs or individual past experience rather than the most important cost and functionality features that might shape a rational evaluation of possible invention designs.[59]

Evaluations by R. Keith Sawyer provide further context to the work of individual inventors. Sawyer points out that knowledge accumulated over time and collaborative efforts among multiple innovators often enhance invention processes.[60] While these features are not present in all inventions, Sawyer notes that inventions often reflect small contributions from multiple parties, eventually accumulated or modified to produce one useful advance.[61] According to Sawyer:

> [I]nnovation emerges from many small ideas, over long periods of time. Rarely is any one of the ideas, in itself, enough to build a successful business; in today's complex economy, profitable innovations depend on a long string of component ideas.
>
> . . .
>
> [I]nnovations today emerge over long periods of time, with contributions from many different individuals. And most important of all, the meaning of each individual idea is not clear when it is first proposed; an idea's usefulness only becomes clear later, after a new context has emerged, a context that is largely created by later ideas and their combinations.
>
> . . .
>
> The key to understanding innovation is to realize that the networks that bring people together are more important than the people themselves. Of course, creative people play an important role as the active elements of collaborative webs. But in today's economy, most

58. *Id.* at 1251. *See also* Landers, *supra* note 42, at 37–69 (summarizing research on psychological processes underlying scientific research).

59. *See* Bechtold et al., *supra* note 56 (discussing that invention processes may be highly irrational).

60. Sawyer, *supra* note 42, at 479–80.

61. *Id.*

> of the action is in the web, where everyone's creative power increases so that the whole is greater than the sum of the parts.[62]

Sawyer reminds us that, whatever the rationality of individual efforts to produce inventions, these efforts may be augmented and made more effective by steps to accumulate, consider, and supplement partial innovations from multiple sources both past and present.[63]

### *3. Extending Past Models in the Present Research*

The research project described in this Article extends past findings regarding psychological features of inventive processes in three respects. First, it includes imagination (and associated insights about imagination in recent psychological research) in accounts of invention processes.[64] Second, it gives a detailed account of the ways that errors in imagination processes may impair inventive success, leading to an account of invention projects that clarifies their difficulty among mental processes.[65] Third, it reexamines patent policies and standards in light of these systematic errors plaguing invention processes, proposing changes in specific patent standards to better offset invention errors and improve invention outcomes as measured in societal benefit.[66]

The extended psychological model adopted here is consistent with prior research of Jeanne C. Fromer, Gregory N. Mandel, Stefan Bechtold, Christopher Buccafusco, and Christopher Jon Sprigman, all of whom have emphasized problem solving as the essence of invention, but who have also questioned whether inventors solve problems through processes constructed or conducted with linear rationality.[67] The account of invention offered in this article explains one key reason why attempts to invent are not rationally constructed—inventions are flights of imagination constrained by systematic limitations on how individuals imagine the future and the effectiveness of potential invention designs in solving problems in the future.

By adding imagination to prior problem-solving accounts of invention, a large body of psychological research regarding the limitations of imagining the future can be brought to bear in interpreting invention processes and their limitations. The perspective of imagination and its limitations enables new understanding of inventions and how patent standards may affect them. Some of the key insights into inventions and associated patent law standards are presented in this article. More are certainly possible and it is hoped that the perspective provided here on invention as imagination of the future will enable many valuable patent policy evaluations in the future.

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62. Sawyer, *supra* note 42, at 479–80.

63. *Id.*

64. *See supra* Section I(A) (discussing the role of error in invention).

65. *See infra* Section III (discussing why inventive imagination fails).

66. *See infra* Section IV (discussing improving patent laws to better offset imagination barriers to invention).

67. *See* Fromer, *supra* note 42, at 1459, 1485–88; Mandel, *supra* 42, at 336–38; Bechtold et al., *supra* note 56, at 1251 (all discussing problem solving through processes constructed or conducted with linear rationality).

## II. PSYCHOLOGICAL SOURCES OF INVENTION FAILURES

### *A. Why Imagining Inventions is Difficult*

Imagining successful invention designs usually involves imagining the future satisfaction and happiness realized by persons who will use the imagined inventions. Unfortunately, basic psychological weaknesses in human analytic processes can frustrate the imagination of future happiness and, therefore, impede the creation of successful inventions.

New insights into the barriers impeding invention creation are possible because of recent physiological studies identifying widely shared types of imagination errors in projecting future events and related future happiness. These studies of imagination errors have helped researchers begin to understand why persons are predictably irrational and biased in their projections of the future.[68] This Section summarizes present psychological understanding of how persons misestimate future happiness. Section III of this Article ties this research to invention processes by detailing how each of the types of imagination errors found by psychology researchers carry over into invention projects.

In general, difficulties persons face in looking into tomorrow's unknowns reflect several innate features of human mental processes. These features hinder efforts to project future circumstances and to predict human reactions to future circumstances. As summarized by Daniel Gilbert, "it is [difficult] to predict accurately our emotional response to future events because it is difficult to imagine them as they will happen, and difficult to imagine how we'll think about them once they do."[69] At least three common errors undercut our abilities to accurately imagine future events and happiness: 1) unfounded assumptions in imagining future events that these events will be much like similar events today, leading to imagined futures that are too much like the present (unfounded presentism), 2) a tendency to treat imagined circumstances and events like real ones, leading to insufficient doubt about the accuracy of our imagined images of the future and inadequate testing of the veracity of these imagined visions (excessive realism), and 3) difficulties in projecting human reactions to future events even when we imagine the events accurately (inaccurate rationalization). Recent research findings regarding these types of imagination errors and their sources are summarized in the remainder of this Section.

### *B. Unfounded Presentism*

Present circumstances strongly influence our projections of the future for several reasons. In part, this influence stems from our desire to be accurate in making future projections by grounding our projections in what we know. This ensures that future projections have some relations to reality rather than being pure flights of fantasy. Unfortunately, while well-intentioned, these reasons for grounding future projections in present realities also lead to errors in future

68. *See generally* GILBERT, *supra* note 3, at 83–211 (describing a brief overview of this research).
69. *Id.* at 210.

projections. Grounding of imagination in the present can produce errors by biasing future projections towards easily constructed projections that are unduly similar to present circumstances.

*1. Information Limitations Producing Presentism Bias*

One reason persons emphasize present facts and circumstances in constructing future projections and imagined experiences is that individuals need settings for their imagination and draw on present circumstances as convenient settings for imagined changes. To present a complete picture of the future, even in a narrow setting, parties must work with a lot of background factual details. To get these details, many people rely on what they know. And what they know is the present.

Even some of our most fanciful projections of future or fictional circumstances have substantial doses of present factual details. While transported to a land of witches and Munchkins, Dorothy, in the Wizard of Oz, was still from Kansas, and the Wizard still traveled to Oz in a balloon. References to familiar features—"Kansas" and "a balloon"—establish a base of shared knowledge among readers of the story, framing and providing a foundation for the creative fantasies that extend or modify the known realities. Our fantasies only go so far—many key details are dictated by familiar surroundings.

This is a direct consequence of how we imagine future events. We use our imaginations to break out of our current circumstances and to imagine settings and events that vary from our present reality. Yet the varied circumstances we imagine, while different from our present settings along certain dimensions, often carry forward other, unvaried features of our present reality. Whether these elements should be carried forward (that is, whether they should be assumed not to vary over time or in new, imagined circumstances) is often not evaluated as we emphasize imagined changes in other dimensions. We are highly focused on the dimensions that we expect will change—and perhaps very creative in estimating how these reimagined dimensions will change—yet we lose track of the possibility of change in other respects. There are several information processing reasons for our unthinking and often excessive reliance on present facts and circumstances in imagining the future.

a. Power of Experienced Circumstances

Experienced circumstances have a feeling of confirmed truth that typically establishes the starting point for our imagination. We believe in the accuracy of perceptions of these circumstances because we experienced them (or they were confirmed as real by trusted sources). We tend to think that these confirmed circumstances will continue to prevail unless we are disabused of this presumption. We treat past accuracy as suggestive of future accuracy as well. "The reality of the moment is so palpable and powerful that it holds imagination

in a tight orbit from which it never fully escapes."[70] In short, we tend to affirmatively believe that the future will be like the past in many respects and act on this belief in constructing imagined versions of the future.

b. Unconscious Reliance on Memories

Our past experiences may also influence our thinking about the future through reliance on memories to fill out aspects of our imagination in unconscious ways. When we imagine items that we have encountered in the past and then imagine new uses or features of the items, our minds work unconsciously to fill in many old details about the items drawn from our experience. Hence, as we imagine how a violin might play a new tune, we are unconsciously calling on our memories of violin playing and assuming that some of the tonal and rhythmic features we know from violin playing experienced in the past will carry forward into our imagined world. If asked about our assumptions about violins, we might not appreciate that we were consciously carrying forward previously encountered information about violins and their playing. Yet, the mere fact that we are imagining a future use of a violin means that our mind will call on groups of unconscious memories of past encounters with violins and assume that many of the violin characteristics remembered from those encounters will carry forward into our imagined circumstances.[71]

c. Focused Attention and Laziness

Sometimes our reliance on the present in imagining the future occurs by design, with the aim of increasing the efficiency or lowering the costs of our imagination efforts. Frequently, we seek to imagine accounts of some particular variation from present reality. We expend our creative attention and energies on thinking about this one dimension of change that interests us. Focusing our attention this way somewhat distracts us from attention to other aspects of our imagined visions. Accordingly, we do not fully consider possible additional changes. Overlooked implications of additional changes may include the impacts of further changes caused by our contemplated change and changes in surroundings that may mean our imagined change has more negative interactions with its surroundings than were anticipated in our evaluations. We tend to minimize our attention to these sorts of additional changes to save our primary attention and creativity for the changes that are the main focus of our imagination.

In this, we may be trying to be efficient, saving our attention and resources for our best efforts and achievements in formulating good accounts of the imagined changes of greatest interest to us. On the other hand, our failures to contemplate changing circumstances beyond our primary focus of imagined

70. GILBERT, *supra* note 3, at 162.

71. *See id.* at 129 (explaining that when we imagine objects most persons have the experience of actually seeing a somewhat sketchy picture of the object in our heads. Our minds also call on our experiences with the functionality of things (such as the sounds an instrument will make) by remembering past versions of the same thing and then extrapolating or imagining the new sound of interest).

change may just stem from laziness—we just do not want to expend the resources or time to contemplate possible changes beyond the few that really fascinate us. Whether it is due to efficiency or neglect, we often focus solely on primary topics of imagined change and construct imagined projections of the future that include many present factual circumstances and details that are carried forward simply because they are not reexamined in formulating our imagined futures.

d. Lack of Better Information

Finally, we may rely on present facts in imagining the future because we have little choice if we want to imagine and consider complete pictures of future realities. We may have little basis to assume that things will or will not change from present realities, yet we need to assume some status for future circumstances in order to complete full mental pictures in our imagination. As we plug holes in our visions of tomorrow, we tend to rely on our present knowledge.[72] What else are we to do where different facts are impossible (or at least difficult) to project? If our choice is to a) assume no facts and forego imagining the future because we cannot produce complete images or b) assume many past surroundings will continue and use this assumption to paint backdrops to a few imagined changes in our circumstances, the latter option at least allows us a basis for thinking about future events and the implications of changes we might pursue in present circumstances.[73]

As a basis for various types of planning and providing for future resources and activities, such imagination of the impacts of varied circumstances is critically important.[74] Our ability to plan in this way distinguishes humans from many if not all other creatures.[75] If we assume that many present features will stay the same as a few change and know that this will produce some errors in our imagination of the future, this built-in source of errors may be a necessary evil we must accept in order to conduct valuable planning at all.[76] The resulting errors are often unavoidable given the information handling burdens (and potential impossibility) of trying to analyze all potential dimensions of change at once.[77] To move forward with valuable planning, we often accept the flawed assumption that many details of our imagined futures will be unchanged from past counterparts.[78]

*2. Mistaken Reliance on Present Measures of Utility*

Another way that excessive presentism produces mistaken projections of the future is by influencing our estimates of future values.[79] Our imagination

72. GILBERT, *supra* note 3, at 125.
73. *Id.*
74. *Id.*
75. *Id*.
76. *Id.*
77. *Id.*
78. *Id.*
79. *Id.* at 111.

about the future and what will make us (or others) happy in the future is sometimes inaccurate because we mistakenly assume that we (or others) will care for the same things in the future that we care for now.[80] "Presentism occurs because we fail to recognize that our future selves won't see the world the way we see it now."[81] We may project in our imaginations that an altered practice or device will be an improvement over present counterparts, but the evaluation of what is "better" is made in terms of present values and circumstances.[82] Our assessments of what is better—and why it is better and how much—are often heavily tied to present values.[83] We project that we will see things in the future in terms of the same values and perspectives that we have now.[84]

Unfortunately, to predict in our imagination how something will make us feel in the future, we must project our future values and sense of utility at the future point we are interested in.[85] If we are interested in the reactions and happiness of another party, we must additionally factor in how his or her values may differ (and differ over time) from our values.[86] Whether it is our future selves or others, we are very poor at gauging how parties will make value-based assessments in the future.[87]

This is largely because these future assessments depend on values derived from future experience and we cannot fully predict the experiences that will precede the evaluations of interest.[88] Value choices are heavily influenced by the background of the evaluator and the immediate past actions or experiences of that party before making a value assessment.[89]

### *3. Inaccurate Projection of Future Contexts and Activities*

Our imagination about the future may also be mistaken due to inaccurate projections of the surroundings of our activities.[90] The perceived utility of an activity is heavily influenced by the context in which the activity occurs.[91] Thus, if we inaccurately imagine the future setting in which an activity will occur, there is a high likelihood that we will also inaccurately project the benefit and happiness we or others will perceive from the activity.[92]

The impact of context on perceived utility is surprisingly strong.[93] For example, where researchers asked parties to imagine how much they would like to eat some potato chips in the future, their response was strongly influenced by whether they saw pictures of potato chips sitting next to chocolate bars or

80. *Id.*
81. *Id.*
82. *Id.*
83. *Id.*
84. *Id.*
85. *Id.*
86. *Id.*
87. *Id.*
88. *Id.*
89. *Id.*
90. *Id.* at 500.
91. *Id.*
92. Dunning et al., *supra* note 7.
93. GILBERT, *supra* note 3, at 144.

sardines.[94] The parties seeing the potato chips next to chocolate bars apparently imagined eating the chocolate bars and were accordingly not greatly impressed by the thought of eating the potato chips.[95] The others thought just the opposite, seeing potato chips as a much better thing to eat in the future than the sardines.[96] When they actually ate the potato chips (even with the chocolate bars and sardines nearby), both groups were essentially equally happy.[97] Their actual happiness in eating the chips (as opposed to their projections of their future happiness that were influenced by the contexts of chocolate bars or sardines) was similar because it was based on their shared experience of eating the chips.[98]

In short, imagination about context matters greatly in attempts to imagine future happiness.[99] The expected (or imagined) utility of an experience or action in the future will be heavily influenced by the surroundings of the party undergoing the experience or taking the action.[100] Where future surroundings differ greatly from those presumed in projecting future happiness, the accuracy of the projections can suffer greatly.[101]

Context can also produce errors in imagining future happiness by biasing the thinking of the persons engaging in imagination.[102] "Because predictions about the future are made *in* the present, they are inevitably influenced *by* the present. The way we feel right night now ('I'm so hungry') and the way we think right now ('The big speakers sound better than the little ones') exerts an unusually strong influence on the way we think we'll feel later. Because time is such a slippery concept, we tend to imagine the future as the present with a twist, thus our imagined tomorrow inevitably look like slightly twisted versions of today."[103] But if the typical circumstances of tomorrow (e.g., less hunger or use of speakers in settings where large ones are physically awkward) differ from the somewhat special ones where imagination was undertaken, the imagined results are unlikely to be obtained and the imagined happiness levels are unlikely to prevail.[104]

### *4. Underestimating Bias Against Change*

Imagination about future happiness and the actions that may influence future happiness can also be flawed due to failures to account for biases of parties in favor of maintaining past, familiar practices and against change.[105] This type of bias—often referred to as an "endowment effect"—causes parties to be marginally (and somewhat irrationally) happier with present things as they

94. *Id.*
95. *Id.*
96. *Id.*
97. *Id.*
98. *Id.*
99. *Id.* at 143–44.
100. *Id.*
101. *Id.*
102. *Id.*
103. *Id.* at 147.
104. *Id.*
105. *See generally* Daniel Kahneman et al., *Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias*, 5 J. ECON. PERSP. 193 (Winter 1991) (elaborating on the intricacies of the endowment effect).

are than with seemingly equivalent things brought to the persons via change.[106] People really value "a bird in the hand" over a "bird in the bush" even if there is no net additional cost in obtaining the latter.[107] Giving up something already possessed is valued more than gaining an equivalent thing not yet possessed.[108] The familiar is valued over the new.[109]

This means that, in imagining future happiness, a party must remember that giving up familiar solutions to tasks or problems will be disfavored in future valuations over continuing with the old solutions, all else being equal. Familiar conduct may have attractive features that influence the perceived desirability of old over new conduct.[110] A party giving up an old device will ask: "Compared to how I feel now, how will I feel if I give up my old solution and adopt a new one?" This party may view the change as a form of loss associated with giving up a desirable routine. The party may also see undesirable risks in needing to gain new information about how to use a new device. The party may also be unwilling to take on new and unknown risks of dysfunction of the new device in comparison with the relatively known risks associated with the old device. A party imagining users' projected future happiness with a new device may focus on few if any of these factors and base his or her estimate of future happiness mostly on how effective the new device is in accomplishing its targeted task.[111] This party imagining the future desirability of the device may thereby overestimate the happiness that use of the new device will produce since the estimator will have failed to take into account endowment effects and the associated marginal preference of parties for old solutions over new ones all else being equal.[112]

### *C. Excessive Presumption of Realism*

Excessive realism is another important source of errors in imagination.[113] Imagination can produce flawed visions of the future because—somewhat ironically—humans sometimes simulate reality too well in their imaginations and rely too unchallengingly on the apparent accuracy of imagined situations.[114] We sometimes unquestioningly treat imagined future events as if they were real events, attributing presumed realism to fictional circumstances.[115] When we do this, we suspend doubts and analytic processes that might reveal flaws in our imaginations and divergences of imagined circumstances from real ones.[116]

106. *Id.*
107. *Id.*
108. *Id.*
109. *Id.*
110. *See generally* Nira Liberman & Yaacov Trope, *The Role of Feasibility and Desirability Considerations in Near and Distant Future Decisions: A Test of Temporal Construal Theory*, J. PERSONALITY & SOC. PSYCHOL. 75, 5–18 (1998) (explaining the natural preference towards avoiding change).
111. GILBERT, *supra* note 3, at 53.
112. *See generally* Kahneman, *supra* note 105 (explaining the impact of the endowment effect).
113. GILBERT, *supra* note 3, at 78–80.
114. *Id.*
115. *Id.*
116. *Id.*

There are a number of sources of our excessive attribution of realism to imagined circumstances.[117]

### *1. Failure to Recognize Products of Imagination*

Imagination works so quickly that we often fail to even recognize instances of imagination or situations in which imagination has filled in at least part of our perceptions of events or circumstances.[118] We imagine events or circumstances (or at least some details of them) but instead think that we are perceiving the events or circumstances or calling them up from memory.[119] Once we lose track of the distinction between imagination and perception, we tend to believe in the veracity of all our mental images.[120] After this belief settles in, red flags are seldom raised about the accuracy of imagined images or imagined factual accounts. "[B]ecause we do not consciously supervise the construction of these mental images [of imagined circumstances], we tend to treat them as we treat memories and perceptions—initially assuming that they are *accurate representations* of the objects we are imagining."[121]

The completeness and robustness of our imaginations account for many of the qualities of mental images that lead us astray.[122] We sometimes think that imagined images reflect real experiences or memories (or accounts of real experiences or memories passed on from others that we trust) because the imagined images have the same level of detail as real perceptions.[123] The very detail of our mental images can falsely convince us that we are remembering perceived circumstances or events, not just imagined ones.[124] There is often little in the resulting mental images that distinguish imagined images and details from perceived ones.[125] Hence, we are easily confused and, in the absence of careful examination of the basis of our mental pictures and thoughts, we are willing to believe that our images are far more often based in reality and experience than is really the case.[126]

The reasons for our inattention to the lines between perception and imagination are complex.[127] Perhaps the most fundamental is that we are lazy.[128] We like to believe—for reasons of ego or sloth—that we know from perception and experience more than we actually do.[129] Where we do not know some things, we simply imagine them the way we think that they should be (or that we wish they were).[130] Our desire to proceed to other things can easily make us

117. *Id.*
118. *Id.* at 78–79.
119. *Id.*
120. *Id.*
121. *Id.* at 81.
122. *Id.* at 99–103.
123. *Id.*
124. *Id.*
125. *Id.*
126. *Id.*
127. *Id.* at 61–62.
128. *Id.*
129. *Id.*
130. *Id.* at 81.

forget that we have extended our mental images far beyond our actual experience.[131] Short of contrary evidence that forces us to reexamine our imagined images, we forget that they are imagined and give ourselves self-satisfying credit for imagined knowledge and experiences as if they were products of our actual sensory inputs and experiences.[132]

As we make these sorts of self-satisfying leaps, we lose track of the boundaries between what we have made up through imagination and what we have actually found through experience.[133] We tend to give all our mental images the same level of presumed veracity as knowledge gained from experience.[134] However, when we lose track of what is imagined and what is informed by experience, we risk overextending our attributions of truth and accuracy to mental images that are not grounded in experience.[135] We accordingly open up projections of the future to serious errors by failing to question the accuracy of our imagined images as we use those images in developing projections of future actions, values, and happiness.[136]

### *2. Mistakenly Attributing Equal Veracity to Mental Processes Underlying Imagination and Perception*

Beyond just self-satisfying tendencies to overestimate how much of our knowledge is based on perception and experience, mental images stemming from our imagination may easily be confused and treated as having similar veracity to images resulting from perception because some of the mental processes underlying imagination and perception are highly similar.[137] In particular, both imagination and perception processes involve extensive construction of image details.[138] The mind can easily lose track of the boundaries between mentally constructed images based on creative thought (as occurs in imagination) and mentally constructed images based on sensory inputs (as occurs in perception).[139]

We tend to forget that perception—while grounded in external reality and sensory measurements of reality—still involves extensive mental construction to produce the mental images and findings we act on.[140] The construction involved in normal perception entails organizing and sometimes simplifying the information brought to us from our senses.[141] Images of the present are often

131. *Id.*

132. *See generally id.* at 119 (explaining that the futures we imagine contain additional or other details created by our brains).

133. *See id.* at 97–105 (stating how our minds cannot distinguish between imagination and experience).

134. *Id.*

135. *See id.* at 119 (arguing that our mental images are not grounded in experience).

136. *See id.* at 97–105 (stating we fail to recognize the inaccuracy of our imagination).

137. WILL DURANT, THE STORY OF PHILOSOPHY 352 (1926).

138. *Id.* at 352.

139. *Id.* at 353.

140. *See id.* (stating "[t]he world as we know it is a construction, a finished product, almost—one might say—a manufactured article, to which the mind contributes as much by its molding forms as the thing contributes by its stimuli.").

141. This notion of perception as an amalgamation of sensing and mental construction—in which both play essential parts—was recognized by Immanuel Kant when he observed that "[t]he understanding can intuit

extensively constructed mental pictures based on past images of similar circumstances combined with a little additional information about presently perceived surroundings.[142] Our senses measure a very small amount of information and our minds fill in many added details to construct what is probably an accurate complete picture.[143] The objective is to construct useful pictures of the surroundings quickly and thereby speed practical conclusions without waiting for complete new information about the surroundings.[144] These abbreviated processes and the speed they enable can be the difference between life and death, although they may just cause us to make some mistakes based on inaccurate mental images.[145]

If an image of a tiger approaches us quickly, for example, our eye may pick up a few of the elements of this image and the mind may fill in the rest of the details of a tiger, including that it is dangerous if in close proximity. We may jump away accordingly. If a real tiger has escaped from the zoo and is nearby, this is an appropriate, protective response. If, on the other hand, the image has been projected by a very realistic movie system, we have just been fooled and have jumped unnecessarily. Whether the jump was helpful or not can be determined later when time is not of the essence.[146] At the time the image was perceived, the likelihood that a tiger was present and the perception that the viewer was in danger were constructed features of the perceived reality that the mind added to the eyes' information to produce practical results in a timely, useful fashion.[147] In a similar way, many features of our perceptions of the present are joint products of sensory inputs and mental constructions.[148] Such combinations can produce timely mental images with great practical benefits.[149]

However, the fact that many aspects of day-to-day perceptions of reality involve constructed interpretations of sensory inputs makes it difficult to remember that imagined constructions of reality are not the equivalent of reality-grounded perceptions of reality and do not deserve the same trust in our thinking as perceptions of reality.[150] Mental images based on perceptions tend to be more consistent with real circumstances than imagined images because we start from accurate sensing of reality even if we sometimes add inaccurate constructions of perceived scenes and events.[151] Perceived images are accurate in the starting point of reality sensing even if they are potentially flawed in imagined interpretation.[152]

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nothing, the senses can think nothing. Only through their union can knowledge arise." IMMANUEL KANT, CRITIQUE OF PURE REASON 93 (N.K. Smith trans., New York: St. Martin's Press 1965) (1781).

142. *Id*.
143. DURANT, *supra* note 137, at 353.
144. *See generally* GILBERT, *supra* note 3, at 8 (explaining the process of creating imagined images).
145. *Id.* at 7–8.
146. *Id*.
147. *Id.* at 8.
148. *Id*.
149. *Id*.
150. KANT, *supra* note 141, at 147.
151. *Id*.
152. *Id*.

By contrast, imagined events are pure constructions that are potentially flawed in both factual starting points and imagined interpretations.[153] They may be inaccurate (or at least divergent from real conditions) on two levels. [154] First, imaged events may be inaccurate because they were constructed based on mistaken factual assumptions used in creating imagined images of the events. [155] Second, our minds may build on these mistaken factual assumptions by adding additional mistaken accounts of processes and activities in constructing imagined images.[156]

### *3. Biasing of Imagined Projections Towards Favorable Alternatives*

Even where our imaginations are grounded in real circumstances, our minds may imagine future events and impacts in ways that over-emphasize favorable alternatives.[157] Our imaginations often construct and accept images that are realistic yet not representative. The mind tends to graft details into imagined images that support particular findings or values already accepted by the person engaging in imagination.[158] Even if they are realistic and plausible, our imagined images are still highly edited versions of reality, with the editing done with a very biased hand.[159] The result is often a realistic but somewhat unlikely outlier within the range of plausible future visions.[160]

This type of imagination error is particularly prevalent when we try to imagine the future.[161] In attempting to imagine the future, the events projected to occur from now until the time imagined are under the control of the party doing the imagining.[162] These constructed events accounting for change (or holding it back) tend to be chosen in imagination processes with biases leading to imagined future conditions or values that are particularly favorable to the person undertaking imagination.[163] Under the influence of such biases, it is easy to imagine a somewhat realistic scene that is still unrepresentative and unlikely to transpire.[164] Imagination about the future diverges from reality because only one of many possible scenarios has formed the basis of the imagined future, leaving out many other alternative developments of lesser interest (or greater difficulty).[165]

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153. *Id.* at 146–47.
154. *Id.*
155. *Id.*
156. *Id.*
157. D.W. Griffin et al., *The Role of Construal Processes in Overconfident Predictions About the Self and Others*, 59 J. PERSONALITY & SOC. PSYCHOL. 1128, 1129 (1990).
158. *Id.* at 1129–39.
159. *Id.*
160. *Id.*
161. GILBERT, *supra* note 3, at 100–01.
162. *See id.* at 99 (explaining images of the future are extensions of images of the present, with imagination filling in additional details projected to apply in the future setting).
163. *Id.* at 100.
164. Griffin et al., *supra* note 157, at 1129–39.
165. *See* GILBERT, *supra* note 3, at 100 (discussing that adding imagined details to the basic reality of a situation, parties can be quite creative and quite biased in how they fill in favorable factors. For example, when asked about how much they will like a dinner at a restaurant without specifying what the food would be like, subjects in a research study tended to interpolate extensive favorable details ("I am imagining eating wine-

These sorts of editing processes work subtly in imagination to produce many unrealistic visions of the future and related happiness.[166] Consider a frequently encountered example.[167] If a person is asked to imagine the satisfaction she will have from a spaghetti dinner eaten at a later time, that person will typically envision the details of a particular spaghetti dinner and give an answer based on her mental image of the imagined dinner.[168] Her imagined version of the dinner will probably include many standard features common to any spaghetti dinner.[169] However, the particular details that she imagines and bases her reaction on may be biased towards what she wants—that is, an unusually tasty and attractive version of a spaghetti dinner.[170] She will tend to imagine an excellent dinner, not a typical one. She will (perhaps out of hunger at the time the question is raised or due to pleasant memories of good tasting spaghetti dinners eaten in the past) tend to imagine a dinner with a highly tasty sauce and other attractive features. Imagining this version of the dinner, the person will likely respond that she would very much like a spaghetti dinner.[171] The individual's projection of the future dinner and her related happiness, while based on a plausible version of a real spaghetti dinner, may still rely on an atypical version of such a dinner.[172] Her image may not be fairly representative of an average or typical spaghetti dinner, meaning that her assessment of the pleasure she is likely to derive from a future spaghetti dinner may also be inaccurate.[173] She is evaluating her projected pleasure from an exceptional spaghetti dinner, yet there is no reason to believe that the actual dinner available to her will be exceptional in the ways she imagines.[174]

In this way, imagined future events are edited in the mind's eye to have favorable features unless something constrains this biased editing process.[175] This, in turn, causes imagined events—even if grounded in reality—to have unrepresentative amounts of happiness-promoting features.[176] Our confusion about the reality of these features is sometimes further complicated by our reactions to the imagined features.[177] Our minds and bodies may make real responses to the unduly-favorable details grafted into mental images by our imaginations.[178] We may salivate about an imagined spaghetti dinner with an outstanding sauce even though no spaghetti or sauce is before us. The reality of

braised short ribs with roasted root vegetables and parsley coulis . . . .") and then stated their anticipated desirability of the meal in light of these details). *See also* Griffin et al., *supra* note 157, at 1129–39 (describing how implicit bias influences imagined details).

166. GILBERT, *supra* note 3, at 100.

167. *See id*. at 99 (describing the frequently encountered example).

168. *Id.*

169. *See generally id*.at 102 (stating "when we imagine the future, we often do so in the blind spot of the mind's eye, and this tendency can cause us to misimagine the future events whose emotional consequences we are attempting to weigh.").

170. *Id*.

171. *Id*.

172. *Id*.

173. *Id*.

174. *Id*.

175. *Id*.

176. *Id.* at 45.

177. *Id*.

178. *Id.* at 99–100.

our response (and our enthusiasm about achieving it) helps us to forget that the response is based on an unrepresentative fiction that is unlikely to come true.[179] Our real response encourages us to think that we are realistically anticipating the future when our imaginations have actually already departed from likely reality.[180] Hence, when you are asked about whether you would like spaghetti for dinner later:

> "your brain behave[s] like a portrait artist commissioned to produce a full-color oil from a rough charcoal sketch, filling in all the details that were absent from my question and serving you a particular heaping helping of imaginary pasta. And when you estimate[] your enjoyment of this future spaghetti, you respond[] to this particular mental image as you respond to particular memories and particular perceptions–as though the details had been specified by the thing you were imagining rather than fabricated by your brain."[181]

In the span between real beginnings and real endings, the brain's injection of telling and potentially unreal details in the middle of this process—in this case, about the features of the spaghetti dinner under consideration—is easily overlooked, leading to unrealistic conclusions without signaling their unrealistic bases.[182]

### *4. Elimination of Inconvenient Details*

Just as the mind may inject or select attractive details among available alternatives in fleshing out imagined accounts of future events, the mind may also tend to leave out (or at least not seek out for inclusion) details about hardships or inconvenient developments that may impede the success of a process or event in the future.[183] Evaluating potentially negative occurrences or circumstances requires fact finding that the mind would prefer to skip, thereby quickly producing imagined images and related interpretations of events.[184] Furthermore, for the same reasons that the mind tends to add favorable details supporting desired future results, the mind is also biased in imagination processes towards editing out (or leaving out) inconvenient details that may make desired results less likely.[185] Hence, although these would certainly frustrate eating spaghetti for dinner, a person asked to contemplate whether they would like spaghetti for dinner may give no attention to whether there is any spaghetti in the house or whether there is an open Italian restaurant in the neighborhood where a spaghetti dinner might be purchased. These are relevant details, but mere inconveniences that will tend to be overlooked in constructing

179. *Id.*
180. *Id.*
181. *Id.*
182. *Id.*
183. *Id.* at 247.
184. *Id.* at 167–68.
185. *Id.*

an imagined image of a spaghetti dinner and in assessing how attractive the future dinner would be.[186]

Because of the bias towards imagining successful or happiness-promoting results, processes of imagining the future frequently leave out key negative details about adverse factors that may affect how future events will transpire.[187] The positive side will be overemphasized for reasons previously explained;[188] however, for essentially symmetrical reasons, the adverse side will be excessively neglected.[189] The result will tend to be overly rosy mental pictures of future events leading to overly favorable estimates of the likelihood of success of projects or of the happiness that projects will achieve.[190] The combination of an overemphasis on favorable or convenient elements and the selective elimination of inconvenient factors accounts for widespread overconfidence about success and happiness in future predictions (since less desirable outcomes are frequently not evaluated in the predictions and impediments to actions are frequently left out).[191]

The negative editing of our imagination has a remarkable latency that potentially infects and renders inaccurate our estimates of future circumstances for a long time.[192] Once we have imagined circumstances without specific negative factors, we tend to think that those adverse factors really are not there.[193] The rosy, edited picture of the imagined circumstances is fixed in our mind and affects our later thinking without reevaluation.[194] Most persons, for example, imagine that they would rather live in California than where they do live, apparently because of repeated perceptions of the favorable weather in most of California.[195] Images of favorable California weather have ongoing effects on projections of living in California.[196] Once focused on the weather, parties tend to forget other day-to-day features of living in California and project their happiness in moving to California based on continuing golden visions of life spent lounging in the favorable weather.[197] However, actual Californians experiencing all of the features of living there are no happier than persons living elsewhere.[198] Other concrete aspects of living in California (e.g., the traffic, the

186. *Id.* at 99–100.

187. *Id.* at 18–21.

188. *Id. See also* Dunning et al., *supra* note 7 (finding that people are overconfident in general when making predictions about the future, and thus, neglect to consider adverse possibilities).

189. Dunning et al., *supra* note 7, at 578–79.

190. *Id.*

191. *See* Vallone et al., *supra* note 7, at 582–92 (discussing the effects of overconfidence on future social predictions); *see generally* Dunning et al., *supra* note 7, at 578–79 (discussing the effects of overconfidence on future social prediction).

192. Dunning et al., *supra* note 7, at 578–79.

193. GILBERT, *supra* note 3, at 18–21.

194. Dunning et al., *supra* note 7, at 578–79.

195. *See* David A. Schkade & Daniel Kahneman, *Does Living in California Make People Happy? A Focusing Illusion in Judgments of Life Satisfaction*, 9 PSYCHOL. SCI. 340, 340–46 (1998) (finding that although people tend to believe that someone from the Midwest would be more satisfied living in California because they believe the weather in California is better, results show equal levels of life satisfaction in residents in both regions).

196. *Id.* at 345.

197. *Id.*

198. *Id.*

difficulties of everyday living) overwhelm the impacts of weather in the actual experiences of California residents.[199] Imagining potential California living as a possible future event, persons emphasize the desirable aspects of the weather and edit out the possibility that other features of living there (such as the traffic and other daily difficulties) are much the same in California as anywhere else. For persons experiencing California living, the full range of features of living there come into play and the advantages of the weather seem small in comparison with the difficulties prevailing across living experiences in many geographic areas.[200]

Imagined reality is a heavily edited and distilled counterpart to experienced reality.[201] Imagined reality tends to be highly skewed toward the attractive and convenient, and away from the frustrating and inconvenient.[202] It is often true that the future is just not all that it was cracked up to be in our imaginations.[203] Flawed future projections may be offshoots of desirable mental features, however.[204] The systematic but unperceived editing of our images of the future is a direct consequence of steps that our brains take to help us deal with the otherwise overwhelming amounts of information coming to us through our senses.[205] The brain edits to help us focus on the information we need to consider to make good decisions about present conduct.[206] Our brains are helping us to deal with the present, but in ways that impede us in accurately contemplating and dealing with the future. As described by Daniel Gilbert:

> The problem isn't that our brains fill in and leave out. God help us if they didn't. No, the problem is that they do this so *well* that we aren't aware it is happening. As such, we tend to accept the brain's products uncritically and expect the future to unfold with the details—and with *only* the details—that the brain has imagined.[207]

For the reasons described here, our imagined reality—especially imagined future reality—often diverges from actual events.[208] Unfortunately, we often assume that these are the same and attribute undue realism and accuracy to imagined events and circumstances.[209]

### *D. Inaccurate Projection of Responses to Future Events*

Inaccurate projections of future parties' reactions to imagined future events may produce further errors in imagining future happiness.[210] Even where we accurately imagine future events, we may inaccurately imagine parties'

199. *Id.*
200. *Id.*
201. GILBERT, *supra* note 3, at 119.
202. *Id.* at 18–21.
203. *Id.*
204. *Id.* at 235.
205. *Id.*
206. *Id.* at 119.
207. *Id.*
208. Dunning et al., *supra* note 7, at 568–81; Vallone et al., *supra*, note 7, at 582–92.
209. GILBERT, *supra* note 3, at 104.
210. Dunning et al., *supra* note 7, at 568–81.

reactions to the events.[211] We may inaccurately imagine future reactions because we do not interpret and evaluate projected future events in the same way that persons actually experiencing the events will.[212] There are several reasons why persons tend to make imagination errors in rationalizing about future attitudes and misinterpreting reactions to future events.[213]

First, in imagining future responses we may apply different values and evaluations than persons actually experiencing the future events.[214] If parties value future events for different reasons or to different degrees than we do in making projections, our projections of the future satisfaction and happiness that parties will derive from the future events will be misdirected and probably erroneous.[215] Second, future events may produce more of a mixed bag of good and bad impacts than we expect, achieving the desired reactions that we project but also producing additional adverse impacts that we overlook.[216] Parties experiencing the events will take into account both the good and bad impacts and may perceive a much lower net value in the events than we do.[217] Third, future events may occur in settings that we have not anticipated, leading to different contextual impacts than we have predicted.[218] In their actual contexts, the future events may not have the benefits we have projected or may have unanticipated negative interactions that offset those benefits.[219]

Problems in projecting the impacts of future events are particularly important in situations where one party (such as an inventor) seeks to project the benefits and happiness to be realized in future events by other parties (such as invention users).[220] Because of the potential importance of these types of errors in limiting imagination processes underlying invention projects, these three types of errors in imagining the practical impacts of future events are addressed in further detail in the remainder of this Subsection.[221]

### *1. Different Values of Persons Experiencing Events*

In projecting future values—and therefore projecting how parties will see future events and react to the events—we have strong tendencies to assume that parties will have values like our own.[222] Unfortunately, our present values may not be shared by persons encountering future events. Our values may not even be representative of average present values.[223] Rather, the values we use in making future projections are likely to reflect self-serving aspects of why we are

211. *Id.*
212. *Id.*
213. Vallone et al., *supra* note 7, at 582–92.
214. *Id.*
215. Schkade & Kahneman, *supra* note 195, at 340–46; Dunning et al., *supra* note 7, at 568–81; Vallone et al., *supra* note 7, at 582–92.
216. *Id.*
217. Dunning et al., *supra* note 7, at 568–81; Vallone et al., *supra* note 7, at 582–92.
218. Schkade & Kahneman, *supra* note 195, at 340–46.
219. *Id.*
220. Griffin et al., *supra* note 157, at 1129.
221. Fromer, *supra* note 42, at 25–34.
222. GILBERT, *supra* note 3, at 92.
223. *Id.* at 229.

imagining future events and related responses.[224] We project evaluations under criteria that produce the results we want, even if these criteria are not representative of the ways that persons are likely to view the events we are imagining.[225] In short, we edit our criteria for the merit of future events to achieve self-satisfying results in projecting future happiness.[226]

This tendency was revealed in research into how parties defined "talent"—thereby projecting how they thought talent would be evaluated in future contexts.[227] When given a chance to define "talent" in terms of particular attributes and then called upon to evaluate their own talents "[d]efiners were able to set the standards for talent, and not coincidentally, they were more likely to meet the standards they set."[228]

Our notions of the importance of various problems and gains from problem solutions reflect our particular present values.[229] We expect parties in the future to see things as we do, and assume that they will value the things we do.[230] If the values held by most parties are different from ours (or vary from ours over time), the ways that future events are perceived and evaluated when the events occur will also tend to diverge from our projections.[231] If future individuals do not share the values underlying our projections, future events we have projected as significant problem solutions and sources of gains may seem unimportant.[232]

### *2. Failures to Anticipate Adverse Factors and Responses*

In projecting future events and their impacts, we tend to "cook the facts."[233] That is, we tend to choose fact finding methods that are most likely to find the facts we want to find and that support the conclusions we favor.[234] We manage to manipulate many stages of fact finding.[235] "[W]e derive support for our preferred conclusions by listening to the words that we put in the mouths of people who have already been preselected for their willingness to say what we want to hear."[236]

What this means in projecting future satisfaction and happiness resulting from future events is that we tend to see the advantages of events that we want to succeed.[237] We also tend to overlook the disadvantages of the events.[238] We diminish the quality of our projections by skewing our fact finding away from

224. *Id.* at 97.
225. *See generally id.* at 97 (describing realism).
226. *Id.* at 67.
227. *Id.* at 59, 159.
228. *Id.*
229. *Id.* at 92.
230. *See generally id.* at 97 (describing subjectivity).
231. *Id.*
232. *Id.*
233. *Id.* at 64.
234. *Id.*
235. *Id.*
236. *Id.* at 66, 182.
237. *Id.* at 67, 183.
238. *Id.* at 67, 184.

evidence of adverse features.[239] We look for what we want to find.[240] This tends to bias both fact-finding and evidence-interpretation processes in the same direction—towards unwarranted optimism about the workability and desirability of imagined actions.[241] This bias stems from the ongoing working relationship between our senses and our brains.[242] "The brain and the eye may have a contractual relationship in which the brain has agreed to believe what the eye sees, but in return the eye has agreed to look for what the brain wants."[243]

When people nonetheless encounter facts that disconfirm their favored conclusions, they tend to ignore them or downplay their significance.[244] Sometimes we look at particular circumstances and see only the facts that support our preconceptions or desired conclusions.[245] When, for example, Dartmouth and Princeton students viewed the same football game, students from each school claimed that the team from the opposing school committed unsportsmanlike conduct, but denied that their own team played unfairly.[246] Students from each school picked up on the evidence indicating misconduct by their opponent's team and edited out the adverse evidence suggesting misconduct on the part of their own team.[247]

We also apply sliding standards for proof in these situations, using easier tests for accepting the truth of favorable facts and harder ones for accepting adverse facts.[248] The result is further skewing of the set of "reliable" facts worth considering.[249] We see mostly favorable facts as the only ones sufficiently confirmed to be included in our evaluations.[250]

For these various reasons, our imagined projections of how future events will proceed and the degree to which they will produce desirable results are skewed in favor of identifying and relying on facts supporting our desired answers. Where we evaluate future events that we want to succeed or want to have positive impacts, we tend to overlook or downplay features of the projected events that are harmful or inconvenient, causing projected responses to the events to be similarly unbalanced and unduly favorable relative to the actual future impacts of the events.[251]

### *3. Mistaken Projections of Contexts of Future Events*

We also tend to mistakenly project the contexts in which future events will occur, with the result that we sometimes over- or under-estimate the significance

239. *Id.* at 68, 184.
240. *Id.*
241. *Id.* at 67, 184.
242. *Id.* at 67, 183.
243. *Id.*
244. *Id.* at 68, 184.
245. *Id.* at 183–84.
246. *Id.* at 68, 184; *see generally* A. H. Hastorf & H. Cantril, *They Saw a Game: A Case Study*, 49 J. ABNORMAL & SOC. PSYCHOL. 129, 129–34 (1954) (describing the football game case study).
247. *Id.*
248. GILBERT, *supra* note 3, at 73, 184–86
249. *Id.* at 64, 186–87.
250. *Id.* at 66, 186–87.
251. *Id.* at 66, 184–87.

of the events in context.[252] Our mistakes in this regard can produce erroneous estimates of future happiness in several ways. If we project that future events will address and solve a problem, but parties acting in the context of the events do not have that problem, we will surely overestimate the value of the events.[253] Similarly, if we project that events will proceed in a setting where the events cause few problems, but the events actually occur in different surroundings where they cause unanticipated difficulties, the net benefits from the events in their real contexts will be less than our estimates.[254] We tend to focus on certain anticipated surroundings for future events and project responses in those surroundings while forgetting that the events may have surroundings that alter or reduce the value of the projected responses.[255]

## III. WHY INVENTIVE IMAGINATION FAILS

Invention designs, as products of imagination, are subject to all of the imagination errors just described.[256] Such designs are based on projections of imagined future events (the operation of an imagined invention) and on further projections of imagined reactions of parties to future events (the perceived satisfaction and benefit of users of the imagined invention).[257] By considering inventive projects as attempts by inventors to imagine inventions that will produce positive results as adopted and perceived by invention users, invention projects can be interpreted as specialized types of imagination projects.[258] Recent psychological research indicating how imagination projects fail tells us how invention projects are likely to fail as well.[259] This Section uses the psychological findings summarized in the last Section to interpret likely sources of failures in invention projects due to weaknesses in inventive imagination.

### *A. Excessive Presentism Leading to Over-Reliance on Obvious Variations of Past Designs*

Our imaginations seldom see very far beyond present circumstances and practices.[260] In the context of engineering processes, excessive presentism can hinder inventors' efforts to imagine outlier inventions based on distinctively new designs.[261] Excessive presentism causes two different problems in the development of such outlier inventions: 1) failures to anticipate future events and problems leading to efforts to solve the wrong problems in formulating inventions and 2) tendencies to overemphasize old design approaches even when

252. *Id.* at 126–39, 212–24.
253. *See id.* at 135–39, 212–24 (describing presentism).
254. *Id.*
255. *Id.* at 18, 225.
256. *See generally* Fromer, *supra* note 42, at 25 (describing errors in imaginative invention).
257. Gruber & Wallace, *supra* note 39, at 93–94.
258. *See* Fromer, *supra* note 42, at 25–34 (discussing failures of imagination in inventing).
259. *Id.*
260. Gilbert, *supra* note 3, at 18, 25, 127.
261. *See id.* at 109–27 (describing presentism).

inventors are trying to solve the right problems.[262] This Subsection explores both these impacts of excessive presentism on the work of inventors.

### *1. Mistargeting Inventive Solutions*

Excessive presentism may impair inventors' perception of practical problems and lead to corresponding mistargeting of inventive solutions.[263] Our imaginations tend to imagine future events as being too much like present events.[264] This means that inventors tend to imagine future problems as being too much like present problems.[265] Inventors affected by this myopia will tend to design inventions that solve present problems in present contexts.[266] These inventive projects and the solutions they produce may not serve tomorrow's needs because inventors cannot project those needs accurately.[267] Inventors' efforts may be misdirected from the outset because they are simply pursuing solutions to the wrong problems.[268]

Biases causing inventors to overemphasize practical problems as they presently exist (and to underemphasize the potential for changes in these problems) can lead to two types of targeting errors in inventive efforts.[269] First, potential inventors may simply not anticipate certain problems that become major future concerns and not target any inventions towards these unperceived problems.[270] Problems that are important in the future but that are only hinted at in today's world are difficult or impossible to target in today's inventive efforts.[271] Second, inventors may perceive and target problems that do not endure, producing inventions that solve problems which have gone away or diminished in importance by the time the inventions are implemented in widely distributed products or services.[272]

Either of these types of problems can significantly impede the imagination and production of socially valuable and practically important inventions.[273] Because inventors' imaginations of future circumstances tend to be overly rooted in the present, inventors tend to excessively target and produce solutions to today's problems.[274] Like generals who are constantly refighting the last war and failing to update their military strategies to accommodate the changed circumstances of present military conditions, many inventors' perceptions of

262. *Id.*
263. *Id.* at 18, 25, 127–29.
264. *Id.* at 120.
265. *Id.* at 127.
266. *See id.* at 127–28, 138–39 (discussing people's tendency to project present problems on future predictions).
267. *Id*.
268. *See id.* (stating people's tendency to incorrectly predict future problems).
269. *Id*.
270. *Id*.
271. *See id*. (discussing how individuals imagine future problems from the present viewpoint).
272. *See generally* George Lowenstein, et al., *Projection Bias in Predicting Future Utility*, 118 Q. J. ECON. 1209, 1217 (2003) (stating that people "falsely project their current preferences over consumption onto their future preferences," therefore exaggerating future utility).
273. *See id*. (explaining how projection bias exaggerates future utility).
274. *See* GILBERT, *supra* note 3, at 127–28, 238–39.

invention targets are too tied to past problems to be meaningful solutions to the future problems encountered by potential users.[275]

### *2. Excessive Reliance on New Invention Design Approaches Based on Old Designs*

Of course, not all inventive efforts are mistargeted.[276] Inventors are often able to perceive and target practical problems of enduring significance.[277] However, even where they target problems of future significance, the present has a considerable hold on how inventors solve practical problems.[278] Inventors tend to rely on what they know and extend it in predictably successful ways to produce new invention designs.[279] Invention designs tend, therefore, to be combinations of old device or process elements having tried and true functional features augmented by a few new elements that add new functionality.[280] The new functionality is typically predictable based on established engineering or scientific knowledge.[281] Inventors simply adjust old designs in ways that established knowledge suggests will produce new functionality the inventors desire.[282]

The present dominates the selection of both the old and new elements in these inventions—the old elements because they are direct carryovers from past designs and the new elements because they are dictated by present engineering and scientific knowledge.[283]

The familiarity of present engineering and science knowledge tends to encourage (or at least to facilitate) imagination of new invention designs in terms of present device or process features and knowledge.[284] New designs based on this knowledge will frequently be relatively easy to imagine.[285] Extending past designs through obvious variations will usually require less creative thought than developing fundamentally new and previously untried design approaches and then imagining non-obvious invention designs based on these new approaches.[286] Because it is the easy path, most invention designs will be imagined within the bounds of obvious variations of past devices and processes serving similar purposes.[287]

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275. *See id*. (noting that people's conception of the future is tied to their conceptions of the present).

276. *Id.* at 127, 138–39.

277. *See* Sawyer, *supra* note 39, at 479 (noting that ideas develop over long periods of time).

278. GILBERT, *supra* note 3, at 127, 138–39.

279. Richard S. Gruner, *Everything Old Is New Again: Obviousness Limitations on Patenting Computer Updates of Old Designs*, 9 B.U. J. SCI. & TECH. L. 209, 211–12 (2003).

280. *See id*. (discussing how updates on computer are modified and developed from earlier designs).

281. *See id*. at 211–12 (explaining how earlier computer technologies are used to design new updates).

282. *Id*.*; see also* Emily Michiko Morris, *What is "Technology"?*, 20 B.U. J. SCI. & TECH. L. 24, 42 (2014) (explaining how a modified product cannot quality as patentable).

283. *See* Gilbert, *supra* note 3, at 127, 138–39 (explaining the propensity of individuals to view the future like the present)*; see also* Gruner, *supra* note 279, at 212 (stating that old computer designs are used to develop new technologies).

284. Fromer, *supra* note 42, at 1484–85.

285. *See generally id.* (explaining that identical solutions and inventions lack creativity).

286. *Id.* at 1485.

287. *See* Gruner, *supra* note 279 (stating that the scientists commonly use existing knowledge to aid in scientific progress).

Beyond being easy to imagine, new invention designs that are updates of old item or process designs, having altered functionality that is predictable and confirmed by established engineering or scientific knowledge, will also be favored by many inventors as risk-averse solutions to practical problems.[288] Design steps that take old designs and improve them along new (and easily imagined) lines of predictably successful variation will require less risk-taking (regarding the possibility of producing unsuccessful designs) than pursuing inventive approaches involving great leaps away from current engineering or scientific understanding into realms of untried and uncertain functionality.[289] Solutions based on predictable, well-tested design approaches will often be good enough to solve relevant problems without taking high risks on design and production projects adopting unproven approaches.[290] The heavy reliance on present knowledge in producing "safe," conventionally-based designs will not undercut the potential functional and commercial value of the resulting inventions.[291] Many imagined adjustments to older designs along predictable lines of change will produce significant new functionality valued by users and realize large commercial success over prior designs.[292] Hence, inventors will continue to produce these safe designs because they are functional and commercial successes.[293]

What these sorts of inventions based on predictable adjustments to earlier designs will not do is materially expand design knowledge or qualify for patents.[294] One of the basic requirements for obtaining a patent under United States law is that an invention must incorporate at least one design feature that is non-obvious to persons with average skill in the same field of technology.[295] This test ensures that patents are only awarded to designs that are materially different than prior product and process designs and that an inventor awarded a patent has contributed a significantly new and unfamiliar bit of design knowledge to his or her field of technology.[296] Foreign patent systems apply similar tests.[297]

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288. *See* Gary P. Pisano, *You Need an Innovation Strategy*, HARV. BUS. REV. (June 2015), https://hbr.org/2015/06/you-need-an-innovation-strategy (showing how innovation of existing technologies is effective).

289. *Id.*

290. *See* Bill Walker, *Innovation vs. Invention: Make the Leap and Reap the Rewards*, WIRED (Sept. 5, 2017), https://www.wired.com/insights/2015/01/innovation-vs-invention/ (explaining that not all inventions based on previous technologies, such as the iPad, are great inventions).

291. *See id*. (demonstrating that even commercially successful products like Apple products are not necessarily great inventions).

292. *See id*. (demonstrating that, while not great inventions, the iPhone and iPad are still commercially successful inventions).

293. *See id*. (explaining the success of the iPhone and iPad despite them not being great inventions).

294. Graham v. John Deere Co., 383 U.S. 1, 13–14 (1966); 35 U.S.C. § 103 (2012).

295. 35 U.S.C. § 103 (2012).

296. *See* Gruner, *supra* note 279, at 211–12 (explaining that when an invention is an extension of a prior design, it is often un-patentable).

297. *See* European Patent Convention art. 52, Nov. 29, 2000, 1065 U.N.T.S 255 (applying similar standards in determining if an invention includes a sufficient "inventive step" to qualify for patenting. For example, under the European Patent Convention, "European patents shall be granted for any inventions, in all fields of technology, provided that they are new, involve an inventive step and are susceptible of industrial application."); *see also* European Patent Convention art. 56, Nov. 29, 2000, 1065 U.N.T.S 255 (stating "[a]n invention shall be considered as involving an inventive step if, having regard to the state of the art, it is not obvious to a person skilled in the art.").

It is not enough in meeting these standards that an invention design be new—the design must also be distinctive and unusual in the sense of being non-obvious to most persons (or at least persons of average ability) in the same field.[298] The invention must reflect design insights that are outliers in this respect, departures from the prevailing, commonplace designs and design variations in the same field.[299] Yet, given that existing designs and design variations have a considerable hold on the imaginations of most inventors for the reasons described in this Article, inventors will rarely produce the sorts of outlier designs capable of qualifying for patents.[300]

The tendency of inventors to imagine new designs that incorporate large amounts of the present—both old design elements of existing items or processes and old analytic approaches based on present scientific and engineering knowledge—ensures that most new inventions are obvious adjustments and extensions of prior designs.[301] The hold of the present on the imagination of inventors leads them systematically towards old designs modified by old knowledge and away from the realm of the patentable.[302] Even where inventors overcome other imagination barriers and produce practically useful advances, the inventors' excessive presentism in imagination processes will ensure that most new inventions are obvious advances over prior technological designs and accordingly will not qualify for patents.[303] It is simply against human nature to imagine non-obvious, patentable advances incorporating distinctly new technologies.[304] Our minds can rarely imagine practical solutions that achieve results in the real world of the future, yet do so through means that depart significantly from our practical tools and knowledge of the present.[305]

### *B. Failures to Question the Apparent Realism and Functionality of Imagined Inventions*

Excessive realism attributed to imagined invention designs produces additional types of invention project failures. Characteristics of human imagination tend to cause inventors to oversimplify certain features of imagined designs and to produce invention designs that either do not work or that work with far less effectiveness and practical results in real settings than in the imaginations of the inventors.[306]

Excessive realism can cause inventors to mistakenly imagine positive features of invention functionality or to overlook invention flaws.[307] Persons

298. 35 U.S.C. § 103 (2012); *Graham*, 383 U.S. at 14.

299. *See Graham*, 383 U.S. at 14 (noting that patentability depends on novelty of the invention).

300. Gruner, *supra* note 279, at 211–12.

301. *Id.* at 214–15.

302. *See* GILBERT, *supra* note 3, at 127, 138–39 (explaining that individuals project the present into future ideas); *see also* Gruner, *supra* note 279, 211–12 (articulating that inventors' dependence on prior designs can lead to unpatentable subject matter).

303. Gruner, *supra* note 279, at 211–12.

304. GILBERT, *supra* note 3, at 127, 138–39.

305. *Id.*

306. *Id.*

307. *See generally id.* at 88–91 (explaining that individuals' imaginations create new problems when conceptualizing the future).

tend to imagine features of invention designs, and, in further thinking, then accept the imagined features as real.[308] Once an element is incorporated in a tentative design in the mind's eye, its features, functionality, and interactions with other elements are treated relatively uncritically thereafter.[309] Inventors adopt the imagined feature as desirable, for some reason, and then go on to work on other aspects of an overall invention design, believing that the imagined feature is—or at least can be—real.[310] What this process overlooks is that the assumed feature may never have had the characteristics that were imagined,[311] or that these characteristics can be attained only at costs or with further negative side effects that render the related invention design impractical or worthless.[312] Excessive, untested beliefs in the realism and functionality of imagined elements of their designs can easily cause inventors to uncritically accept problematic mental designs for inventions.[313]

The design errors resulting from this sort of overconfidence can be of varying magnitude. At one extreme, devices may not work at all. Perhaps the most famous examples of totally dysfunctional "inventions" are the various forms of perpetual motion machines that parties have proposed.[314] Many of their originators formed mental images of designs for such devices in good faith, but were not sufficiently critical in evaluating and testing their designs.[315] Upon implementation and testing, the designs were invariably revealed to have ignored some design feature or flaw that required energy inputs to keep the machines in motion.[316] The realism and functionality of the machines in the imaginations of their inventors were false but often firmly believed visions. Only the concrete reality of implementation of the designs in real world devices revealed how incomplete or misdirected the inventors' designs were.[317]

Excessive belief in the reality and accuracy of imagined designs does not necessarily produce completely unsuccessful designs, however.[318] Such imagination flaws can result in invention designs that just do not function very well when implemented in real items or processes.[319] An inventor tends to imagine a perfect form of his or her invention—or a perfect version of a particular invention element—and to presume that the invention can be realized

308. *See id.* at 225 (stating "[t]he problem is that the features and consequences we fail to consider are often quite important.").

309. PETROSKI, *supra* note 1, at 51.

310. *See* GILBERT, *supra* note 3, at 224–27 (describing the pitfalls of imagination).

311. PETROSKI, *supra* note 1, at 52.

312. *Id.*

313. *Id.* at 51.

314. *See* Fromer, *supra* note 42, at 1488 (stating "[i]n this basis, a machine claiming to create perpetual motion—a scientific impossibility—cannot be patented, as it is inoperable. In cases of inoperability, what is presented as a problem solution is in fact no solution at all, even if underlying the invention is a significant found problem, such as creating perpetual motion. With inoperable inventions, then, the scientific creativity is insufficient, and thus they are not patentable.").

315. *Id.* at 1488.

316. *Id.*

317. *Id.*

318. PETROSKI, *supra* note 1, at 63.

319. *Id.*

in that form.[320] The perfect version becomes (in the imagination of the inventor) the equivalent of a real version. Subsequent work on the invention may build on this untested base, with the result that the resulting invention design may have built in or unavoidable flaws that will ensure the ultimate failure of the invention in practical implementation and use.[321]

Even simple errors in imagining narrow invention characteristics may doom a much larger invention design. For example, if an invention relies on moving parts to produce certain functional results, the failure to imagine and provide for the heat produced by the moving parts may mean that the invention cannot be implemented in practical materials for a commercially reasonable price.[322] The use of heat-resistant materials or the inclusion of heat dissipation equipment may render the invention too expensive to build and sell profitably, even if it could be made to operate in the general manner envisioned by the inventor.[323]

The tendency of inventors to overlook such features, and to believe excessively in the reality of their imagined designs, will frequently cause them to oversimplify their designs.[324] It will also sometimes cause them to perceive net benefits in their designs that will not be realized in practical settings.[325] Inventors making these sorts of errors will believe firmly in the success of their designs, but their beliefs will be based on the undue realism they attribute to their untested, imagined designs.[326] Real surroundings and real implementations of the designs will be messier, often in ways that render inventions undesirable.[327]

Efforts to reduce imagined designs to practice, to test the success of the inventions in their operating environments, and to refine invention designs to improve functional results will eventually reveal the incompleteness or weaknesses of invention designs.[328] However, until such testing and improvement efforts proceed, inventors may rely on their excessive belief in the realism of their imagined designs and proceed down many erroneous inventive paths to expend considerable wasted efforts on completion or improvement of unworkable invention designs.[329] The tendency of an inventor to unquestionably accept the realism of imagined features tends to frustrate many projects by causing inventors to be confident in imagined designs, when they should be

320. *See* GILBERT, *supra* note 3, at 226 (stating "[w]hen imagination paints a picture of the future, many of the details are necessarily missing, and imagination solves this problem by filling in the gaps with details that it borrows from the present.").

321. PETROSKI, *supra* note 1, at 51.

322. *See id.* at 78–79 (focusing on design flaws in the Oldsmobile).

323. *See id.* (describing the reliability of car engines, specifically design problems leading to the removal of a GM product line).

324. *See id.* at 56 (focusing on the unintended consequences from the application of a supposed benefit).

325. *Id.*

326. *Id.*

327. *Id.*

328. *Id.* at 64.

329. Ethan Edwards, *Be an Inventor: The Importance of Prototyping for e-Learning Design*, ALLEN INTERACTIONS (Jan. 6, 2015), http://info.alleninteractions.com/be-an-inventor-the-importance-of-prototyping-for-e-learning-design.

more cautious.[330] Excessive belief in the realism of imagined invention designs is a threat to successful invention projects because it tends to blind inventors to the full range of factors that may influence the operation of their inventions and reduce the functional results the inventions could achieve.[331]

Inventive errors due to oversimplification and excessive belief in the reality of imagined invention elements may be particularly prevalent—and produce particularly large barriers to successful inventions—in settings where inventors are attempting to work at or beyond the limits of well-tested knowledge in their fields.[332] This will be the case where inventors try to incorporate non-obvious approaches in their invention designs and produce outlier technology designs that are potentially patentable.[333] Imagined designs that incorporate distinctly new elements departing substantially from past designs may easily verge into unrealizable domains, because their lack of grounding in past designs and knowledge impairs mental testing and challenging of the distinctly new features.[334] Inventors may base their imaginations (and their imagined invention designs) on initial, partially informed understanding of the characteristics or functionality of relatively untested technologies only to find upon additional study that the anticipated characteristics or features cannot be achieved reliably or can be achieved only at great cost or with other negative features.[335]

Reliance on highly new, non-obvious technological approaches often means acceptance of risks of partial knowledge about the relevant technology.[336] As knowledge and experience with a technology increases, the likelihood of unanticipated and unimagined attributes and problems with the technology will decrease.[337] Widely known and implemented technologies generate their own bodies of experience and sound prediction principles.[338] The more widely understood and implemented a technology is, the more that will generally be known about the functional features of designs relying on the technology and the less likely it will be that inventors are surprised by unanticipated, unimagined invention characteristics that frustrate the success of an invention design based on the well-known technology.[339]

Conversely, gaps in knowledge about distinctly new and non-obvious technology designs of the sort that can qualify for patents can easily lead to imagination errors and failed inventions.[340] These designs are less grounded in reality and experience than designs based on well-known technology approaches

330. PETROSKI, *supra* note 1, at 64 (describing the importance of thinking critically about product design).

331. Griffin et al., *supra* note 157, at 1129.

332. Philip Ball, *The Tyranny of Simple Explanations*, ATLANTIC (Aug. 11, 2016), https://www.theatlantic.com/science/archive/2016/08/occams-razor/495332/.

333. Steven Johnson, *Why Inventors Misjudge How We'll Abuse Their Creations*, WIRED (Oct. 15, 2014, 6:30 AM), https://www.wired.com/2014/10/technological-innovation-oversights/.

334. *Id.*

335. *Id.*

336. *Id.*

337. *See* Landers, *supra* note 42, at 48–52 (discussing the differences between a strong and weak methodology for problem solving).

338. *See id.* (tracing the development of the lightbulb).

339. *See* Landers, *supra* note 42, at 48–52 (discussing the development of the lightbulb as an example of a strong method of problem solving).

340. Johnson, *supra* note 333.

and are consequently are more heavily products of pure imagination.[341] They are accordingly also subject to more errors due to excessive realism.[342] Exercising their imaginations to a great degree in the absence of relevant experience with past implementations of similar technology features, inventors relying on previously non-obvious design approaches may easily creatively imagine and tentatively pursue numerous design features that overlook diverse problems in implementing their poorly understood design approaches.[343] The tendency of inventors to engage in excessive realism regarding imagined invention designs will therefore be particularly prevalent and an especially important impediment to successful invention projects in the relatively unknown territories of invention designs based on new and non-obvious technologies.

### *C. Failures to Anticipate How Users Will React to Inventions*

Inventors' imperfect abilities to imagine invention users' responses to inventions can also produce invention errors. Inventors' imaginations can misdirect invention projects because the inventors do not accurately foresee the circumstances of invention use and do not imagine the practical problems of invention users as the users see those problems.[344] This source of invention errors leads to two types of problems: 1) failures of inventors to properly interpret the features of users' practical problems and to target invention projects accordingly, and 2) failures of inventors to understand how users will employ inventions and to accurately project the net benefits from invention use perceived by users.[345]

#### *1. Failures to Perceive Problems as Seen by Invention Users*

Imagination errors can frustrate invention projects because inventors misperceive the needs and problems of potential invention users.[346] Due to such misperception, inventors may mistakenly identify or characterize problems worth solving with invention designs.[347] Inventors may project imagined future problems yet persons acting in the future may perceive no such problems.[348] Persons may be happier than expected in the future and perceive no problems, either because actual future circumstances have unforeseen advantages that make them more attractive than anticipated, or because there are other factors in

341. *Id.*
342. *Id.*
343. *Id.*
344. PETROSKI, *supra* note 1, at 73.
345. *See Psychology of Creativity*, *supra* note 42, at 2010 (stating "[u]ser innovation refers to innovation produced by technology users as opposed to individuals whose profession it is to develop technology. User innovation occurs when users modify products they have purchased in an effort to provide a more enjoyable user experience.").
346. PETROSKI, *supra* note 1, at 73.
347. *Psychology of Creativity*, *supra* note 42, at 2010.
348. *See id.* (describing how users modify their products in practice, outside the innovator's initial considerations).

the lives of the parties involved that overshadow the problems projected by the inventors and make those problems simply insignificant in context.[349]

These types of errors in projecting values and contexts can cause inventors to misidentify problems or to mistakenly treat minor problems as serious ones.[350] Inventors' failures to anticipate the values and broader lives of the parties they target as potential invention users can cause the inventors to overestimate problems and, as a corollary, to overestimate the probable interest of potential invention users in solutions to the misperceived problems.[351]

Beyond errors stemming from the difficulty of projecting future problems and circumstances, additional errors in imagining and understanding the problems of potential invention users can result because inventors and users are different parties with different values and different perspectives on the contexts in which inventions will be used.[352] An inventor's efforts will typically begin with the diagnosis of a practical problem which the inventor hopes to solve.[353] If an inventor has different values than those of potential invention users, the inventor may see a problem where the targeted users see none.[354] Or the inventor may fail to see a problem that users see clearly.[355] Similarly, by focusing on only some aspects of a context where an invention will be used, an inventor may diagnose a problem in simple terms whereas users see the real problem as far more complex because of interactions between the problem and its context.[356]

Amidst these sorts of misdiagnoses of problem characteristics, problem significance, and problem interactions, inventors can easily mistarget their inventive projects, aiming at imagined problems that are illusory or misconceived.[357] Beginning from such flawed starting points, inventors' subsequent efforts to imagine useful invention designs are likely to be widely off target.[358]

Unfortunately, inventors' failures to accurately anticipate the future values and concerns of other parties are products of basic human nature.[359] Errors in estimating future values and related perceptions of problems are built into

349. Sawyer, *supra* note 42, at 480–82.

350. *Id*.

351. PETROSKI, *supra* note 1, at 79.

352. *See generally* V.H. Carr Jr., *Technology Adoption and Diffusion*, AIR U., http://www.au.af.mil/au/awc/awcgate/innovation/adoptiondiffusion.htm (last visited Oct. 10, 2017) (discussing how new innovation addressed earlier will be better perceived if peoples' different perceptions and needs are addressed).

353. *See* PETROSKI, *supra* note 19, at 34 (explaining that in engineering processes, form follows failure. Recognition of a problem with some earlier device or process is often the spur to new design efforts. New engineering designs typically spring from an initial recognition and diagnosis of the functional failure of an existing item or process, followed by the conception and implementation of a fix to this problem through a newly designed item or process).

354. *Id*.

355. *See id*. at 54 (describing a situation where the inventor fails to see a problem others saw clearly).

356. *See id*. at 172 (describing solutions to problems in simple terms).

357. *See id*. at 74 (showing ill-conceived projects).

358. *See id*. (explaining the misdiagnosis of a specific problem).

359. *Cf*. Paul Saffo, *Six Rules for Effective Forecasting*, HARV. BUS. REV. (July–Aug. 2007), https://hbr.org/2007/07/six-rules-for-effective-forecasting ("[H]uman nature is hardwired to abhor uncertainty.").

human imagination processes.[360] Even when we are trying to imagine our own problems and actions that will make us personally happy by solving those problems, we tend to forget that our future values and contexts for activities may differ from our present ones.[361] When inventors try to anticipate the future problems of others as precursors to efforts to solve those problems through inventions, the inventors are even more likely to mistakenly perceive problems through lack of full familiarity with the circumstances of the potential invention users being targeted.[362]

### *2. Failures to Understand Evaluation Criteria of Invention Users*

Inventors may also mistakenly imagine the criteria that invention users will apply when evaluating inventions in use. Without a correct understanding of these criteria, inventors may produce inventions that are regarded as worthless by targeted users and unlikely to be widely adopted.[363] It is not enough that inventors can point to objective reasons why inventions are superior to prior devices or processes used for the same purposes.[364] Ultimately, the success of new inventions depends on how much invention users value the inventions as solutions to practical problems.[365] The success of an invention is in the eye of the user.[366]

Unfortunately, imagination processes are flawed in ways that cause inventors to frequently misperceive the criteria that persons will use in evaluating future events, including the values that invention users will apply in assessing benefits of inventions.[367] Inventors tend to imagine their current selves as invention users and think that future users will value inventions the same way that the inventors do.[368] But this simple projection of values may be incorrect.[369] Users may find that an invention achieves enhanced functionality that the users do not care much about. Or, users may feel that an invention is hard to use and accordingly is of little net advantage. Users could also conclude that an invention is too expensive given the modest advantages the invention provides. The aggregate criteria used by invention users to evaluate a new advance may be highly complex and vary across a group of somewhat dissimilar users.[370] The

360. *Cf*. Longbing Cao, *Data Science: Challenges and Directions*, 60 COMM. OF THE ASS'N FOR COMPUTING MACHINERY 59, 67 (Aug. 2017), https://cacm.acm.org/magazines/2017/8/219605-data-science/fulltext ("Human imagination is intuitive, creative, evolving, and uncertain.").

361. *See generally* Jim Taylor, *Personal Growth: Your Values, Your Life*, PSYCHOL. TODAY (May 07, 2012), https://www.psychologytoday.com/blog/the-power-prime/201205/personal-growth-your-values-your-life (evaluating life's values).

362. *See* PETROSKI, *supra* note 353, at 192 (showing an example of a mistakenly perceived problem).

363. Tamara Monosoff, *Researching the Inventions Market*, ENTREPRENEUR (Apr. 10, 2007), https://www.entrepreneur.com/article/176834.

364. Richard S. Gruner, *Why We Need a Strong Patent System and When: Filling the Void Left by the Bilski Case*, 28 SANTA CLARA COMPUT. & HIGH TECH. L. J. 499, 598–99 (2012).

365. *Id.* at 600.

366. *Id.* at 539.

367. *Id.* at 505.

368. *See* PETROSKI, *supra* note 19, at 154 (giving an example of a difference of values).

369. *See id.* (showing how this example of a projection of values could be incorrect).

370. *See generally* Gruner, *supra* note 364, at 591–92 (describing the complexity of patentability criteria).

scope and complexity of these criteria will make it difficult for inventors to imagine them accurately and to evaluate imagined inventions as users will.[371]

Mistakes about these evaluation criteria can lead inventors to pursue invention designs that have little real meaning to invention users.[372] If inventors cannot perceive what potential invention users view as desirable solutions to practical problems, the inventors cannot know how to properly imagine attractive solutions and develop corresponding inventions in invention projects.[373] Inventors also cannot gauge when their work is still not finished but instead needs more refinement to produce meaningful advances that serve user interests in desirable ways and that have corresponding commercial appeal.[374] Without proper understanding of users' values and desires, invention projects may lead to dead ends, producing no more than intellectual designs for new advances having few users and no meaningful social impacts.

### *D. The Cumulative Impacts of Imagination Errors*

As described above, recent psychological research points to several substantial psychological barriers inventors must overcome to accurately imagine inventions and reactions to inventions. Potential inventors face especially great challenges in imagining patentable inventions involving unfamiliar, non-obvious leaps away from prior technological designs.[375] The following imagination errors all impede the production of patentable advances:

1. Failures to imagine and understand practical problems as perceived by potential new invention users;
2. Difficulties in imagining new invention design approaches diverging from obvious extensions of existing technologies, coupled with frequent acceptance of such obvious extensions as low-risk design solutions since the extensions are based on widely-held and well-tested engineering knowledge;
3. Mistakes in imagining the future contexts and methods of use of proposed new inventions and the net gains that will result; and
4. Inaccurate imagination of the values of potential invention users, leading to mistaken interpretations of users' responses to devices or processes based on new designs.[376]

371. *Id.*

372. *Id.*

373. *See id.* at 506 ("These rewards flow directly from the demand for new inventions coupled with patent rights, which ensure that patent rights holders are the sole parties capable of providing certain technological solutions to societal needs (by providing products or services based on a patented advance)").

374. *See id.* (providing examples of an incorrect gauge of appeal by various parties).

375. *See id.* ("Difficult commercial challenges concerning patented advances may stem from the new and sometimes very unusual features of these advances and the potential difficulties of new product design, manufacturing, and marketing that popularizing the patented advances may entail."); Andrew Dillon & Michael G. Morris, *User Acceptance of Information Technology: Theories and Models*, 31 ANN. REV. INFO. SCI. & TECH. 3–32 (1996), http://arizona.openrepository.com/arizona/bitstream/10150/105584/1/ AdArist96.pdf.

376. *See* Dillon & Morris, *supra* note 375, at 3–32 (explaining the Technology Acceptance Model, which predicts user acceptance).

These barriers posed by imagination errors are cumulative.[377] Any one barrier can derail an invention project; all must be overcome to complete a project successfully.[378]

Successful inventions with non-obvious, patentable features are still possible despite these impediments, but such outlier advances will probably be rare given the psychological hurdles that must be overcome.[379] Present patent standards reflect the rarity of patentable inventions resulting from imagination problems and include a number of features that promote the creation and commercial testing of advances that overcome imagination problems.[380] Section IV of this article describes features of current patent standards that partially offset imagination barriers to invention imagination and creation. Section V addresses related patent reform proposals, presenting a normative account of changes in patent laws that might enhance their impacts in offsetting imagination barriers to invention.

## IV. COUNTERACTING BARRIERS TO IMAGINATION AND INVENTION WITH PATENT INCENTIVES

Present patent laws provide a partial solution to invention imagination problems by incentivizing increased numbers of invention projects aimed at advances that are difficult to imagine.[381] This Section describes several features of present laws that focus patent incentives on advances that are difficult to imagine. The descriptions interpret the operation and impacts of the present patent system as seen from an invention imagination and production perspective.

Patent laws selectively increasing the potential value of certain inventions create incentives encouraging more efforts to create such inventions.[382] Applied to inventions that are hard to imagine, patent rights selectively encourage more

377. *See* Gruner, *supra* note 364, at 515 (describing general barriers to inventions).

378. *See id.* (explaining how inventors must overcome barriers).

379. *See id.* at 501 ("Since an advance that is not patentable subject matter can never qualify for a patent no matter what other features the invention may have, this standard places outer boundaries on the patent system.").

380. *See id.* ("Over the past two decades, federal courts have struggled to define the boundaries of the patent system.").

381. Thomas Cheng, *Putting Innovation Incentives Back in the Patent-Antitrust Interface*, 11 NW. J. TECH. & INTELL. PROP. 385, 387 (2013), http://heinonline.org/HOL/Page?handle=hein.journals/nwteintp11&start_page=[xxxv]&collection=journals&id=419 ("[T]he patent system provides incentives for innovation by granting the innovator a period of exclusivity, during which he or she may be able to charge a *supra*-competitive price for its technology or for products incorporating this technology.").

382. *See* Kenneth W. Dam, *The Economic Underpinnings of Patent Law*, 23 J. LEGAL STUD. 247, 247 (1993), http://heinonline.org/HOL/Page?handle=hein.journals/legstud23&start_page=247&collection=journals&id=253 (explaining that patents are granted to reassure inventors that they will be able to appropriate the value of their inventions and thereby overcome concerns over "free riders" who might take the value of inventions without compensation to the inventors. The ultimate aim of this reassurance is to encourage greater research and development expenditures, which in turn promotes increased numbers of invention projects and more inventions. As stated by Kenneth W. Dam:

> [I]t is important to recognize the primary problem that the patent system solves. This problem—often called the appropriability problem—is that if a firm could not recover the costs of invention because the resulting information were available to all, then we could expect a much lower and indeed suboptimal level of innovation. In short, the patent system prevents others from reaping where they have not sown and thereby promotes R&D investment in innovation. The patent law achieves this laudable end by creating property rights in inventions.).

attempts to produce advances despite the imagination barriers involved.[383] Patent laws thereby create forces offsetting the psychological weaknesses constraining invention imagination.[384] Patent incentives tend to boost numbers of invention projects aimed at outlier inventions even as psychological factors impede the success of such projects.[385] Seen this way, patent laws are desirable responses to psychological restrictions on inventions, adjusting net success rates in light of those restrictions.[386]

Various features of present patent laws ensure that patent incentives encourage the types of invention projects that are impeded by psychological limitations on imagination.[387] Present patent laws offset each of the three types of invention imagination errors previously described, including 1) tendencies to overly emphasize past and present circumstances in imagining future settings; 2) tendencies to give undue credence and realism to imagined circumstances and events; and 3) tendencies to misinterpret the values and analytic frameworks persons will use in evaluating inventions in the future and thereby misestimating their happiness with various inventions. Particular aspects of present patent laws responding to each of these potential problems are described in this Subsection.

### *A. Boosting Numbers of Non-Obvious Inventions Departing Substantially from Past Designs and Knowledge*

Patent rights encourage inventors to avoid excessive presentism and pursue inventions incorporating distinctly new technology features.[388] To meet non-obviousness tests for patenting, an advance must incorporate a non-obvious design feature differing from earlier similar designs.[389] A feature will be considered non-obvious in this sense if some aspect of the feature would not have been obvious to a person of average skill in the same technology field having full knowledge of publicly available information about prior technology in that field and other fields with analogous design problems.[390] Non-obvious designs potentially qualifying for patents are thus designs that most technology

383. *See id.* at 270–71 ("One of the main reasons for the Patent Code is to encourage inventors to make the necessary disclosures to permit others to advance the art; inventors may not keep secret information intended for that purpose." (quoting Imperial Chemical Industries v. Barr Laboratories, 795 F. Supp. 619, 621 (Fed. Cir. 1992))).

384. *See* MICHELE BOLDRIN & DAVID K. LEVINE, AGAINST INTELLECTUAL MONOPOLY ch. 4 (Nov. 11, 2005), http://levine.sscnet.ucla.edu/papers/ip.ch.4.m1004.pdf (arguing that inventions are the driving force of economic growth and prosperity).

385. *See* Gruner, *supra* note 364, at 504 ("The special rewards of patent rights are attached to non-obvious advances that are intellectual outliers in their respective technical fields in order to encourage more such advances and to diversify the technological approaches used in various fields.").

386. *See generally* Jessica Bregant & Jennifer K. Robbenolt, *Intellectual Property Law and the Psychology of Creativity*, 44 AM. PSYCHOL. ASS'N 21 (2013) (providing background on psychological creativity in intellectual property law).

387. 35 U.S.C. § 103 (2012).

388. *See* President Abraham Lincoln, *Second Lecture on Discoveries and Inventions*, COMPLETE WORKS OF ABRAHAM LINCOLN 113 (John G. Nicolay & John Hay eds., 1894) (Feb. 1859) ("The patent system . . . added the fuel of interest to the fire of genius, in the discovery and production of new and useful things.").

389. 35 U.S.C. § 103 (2012).

390. *See generally*, DON CHISUM, CHISUM ON PATENTS ch. 5 (2003) (describing the non-obvious test).

designers will have difficulty in projecting and imagining.[391] The lack of supporting knowledge making the new designs non-obvious will also make them difficult to imagine. The bulk of designers in a field, having no obvious basis to predict the functionality of the designs, will also have no reason to imagine these designs as probably successful solutions to invention users' problems.[392] Hence, non-obviousness tests embedded in present patent laws focus patent rights and rewards on inventions that are especially difficult to imagine.[393]

This targeting of patent rewards through non-obviousness tests achieves two valuable results. First, parties with greater than average imagination skills or with greater than average information to use in imagination processes are specially encouraged by the promise of patent rewards to use their unusual skills or information for the creation and disclosure of distinctly new invention designs.[394] Second, where persons produce distinctly new invention designs through rare triumphs over imagination barriers, patent rights create commercial incentives helping to ensure that the rare triumphs are not overlooked.[395] Rather, the exclusivity provided by patent rights promotes commercial backing for the popularization of these inventions and thereby increases the likelihood that these rare outlier inventions will be brought to wide spread public attention and availability.[396]

In these ways, patent incentives promote increased public access to outlier advances involving difficult to imagine design insights.[397] At the same time, the limits on patent rights drawn by non-obviousness tests leave other everyday inventions outside the patent system, untouched by patent constraints and subject to normal competitive incentives and commercial forces.[398] The patent system encourages inventors to "go big" in exercising their imaginations to produce distinctly new invention designs and selectively privileges commercial efforts to popularize successful designs produced by these risk taking inventors.[399] It thereby helps the inventive community to untether the evolving body of invention designs from the normal dominance of present circumstances and old designs that continually limit inventive constructs and the imagination of new invention designs. By encouraging inventors to depart substantially from present designs and specially privileging the commercialization of inventions

391. *See* Gruner, *supra* note 364, at 555 ("For the sorts of non-obvious advances that patents can reward and potentially influence, only a small number of exceptional innovators in a field may have the domain-specific knowledge or analytic abilities needed to achieve unusual insights leading to non-obvious advances.").

392. *See id.* at 506 ("These rewards flow directly from the demand for new inventions coupled with patent rights, which ensure that patent rights holders are the sole parties capable of providing certain technological solutions to societal needs (by providing products or services based on a patented advance.")).

393. Dam, *supra* note 382, at 253.

394. *Id.*

395. *Id.*

396. Fromer, *supra* note 42, at 1457.

397. GILBERT, *supra* note 3, at 99.

398. John H. Barton, *Non-Obviousness*, 43 J. L. & TECH. 475, 495–96 (2003).

399. D. Encaoua et al., *Patent Systems for Encouraging Innovation: Lessons from Economic Analysis*, 35 RES. POL'Y 1423, 1431 (2006).

based on such departures, present patent laws represent a direct attack on excessive presentism in inventions.[400]

### *B. Demanding Workable and Complete Advances*

Patent law requirements also push inventors to avoid excessive realism in imagining and creating inventions by requiring inventors to test their invention designs and to produce designs that are workable and complete. Tendencies on the part of inventors to give undue credence and realism to imagined designs cause inventors to frequently imagine invention designs that are incomplete or unworkable.[401] This tendency towards undue confidence in invention designs can produce designs that lack key parts or that incorporate parts in unworkable ways.[402] It may also cause inventors to believe that imagined results from using their inventions can actually be achieved even though they have not submitted the inventions to realistic testing (or even serious mental challenges) that might reveal the inability of the inventions to produce the imagined results.[403] Mental images resulting from imagination processes—including images of imagined inventions—are frequently more complete and successful than their real counterparts.[404]

Patent standards force inventors to focus on gaps in their invention designs.[405] They provide patent rewards only where inventors can describe their inventions completely and point to at least some practical benefits from using the inventions.[406] These restrictions on patent rewards are implemented by 1) standards that require a reduction to practice of a mentally designed advance to complete an invention,[407] 2) enablement and claim specificity requirements that compel inventors to understand and describe invention elements and invention results with sufficient completeness such that other parties are able to use the inventors' descriptions to recreate the inventions,[408] and 3) utility tests that require inventions to be sufficiently complete and practically implemented that inventors can point to some benefits from invention use.[409] These tests preclude patents and patent rewards for imagined inventions that do not produce

400. *See generally* Richard D. Nelson & Roberto Mazzoleni, Economic Theories About the Costs and Benefits of Patents, *in* INTELLECTUAL PROPERTY RIGHTS AND THE DISSEMINATION OF RESEARCH TOOLS IN MOLECULAR BIOLOGY: SUMMARY OF A WORKSHOP HELD AT THE NATIONAL ACADEMY OF SCIENCES, 3 (National Academies Press ed., 1997), https://www.ncbi.nlm.nih.gov/books/NBK233535/ (stating that "patents induce the investment needed to develop and commercialize inventions").

401. D. B. Resnik, *Scientific Realism and the Patent System*, J. GEN. PHILOS. SCI. 69, 74 (2016).

402. *Id*.

403. *Id.* at 73.

404. SIMON LACEY & REBECCA LAWSON, MULTISENSORY IMAGERY 1, 265 (2013).

405. *See* CHISUM, *supra* note 390, part I, ch. 7, §7.03 (discussing the application of patent law requirements for admitting new patent).

406. *Id.*

407. A reduction to practice entails the creation of at least one physical embodiment of an invention (or the completion of one example of the invention sequence in the case of new processes). *E.g.*, Burroughs Wellcome Co. v. Barr Lab., Inc., 40 F.3d 1223 (Fed. Cir. 1994).

408. *See* 35 U.S.C. § 112(a) (2012) (listing the specific requirements for admitting new patent).

409. *E.g.*, Brenner v. Manson, 383 U.S. 519, 534–35 (1966).

functional results or that produce functional results lacking practical benefits to invention users.[410]

These requirements encourage inventors to translate imagined invention designs into workable, real counterparts.[411] Patentable advances must be complete designs, capable of implementation in real world settings and having practical consequences in those settings.[412] Patent rights are denied for imagined inventions that suffer from excessive realism—that is, which seem complete and practically important in inventors' imaginations but which are not in real world implementations. Patent rewards are reserved for inventors who have avoided these common missteps and produced complete invention designs with functional outputs and practical consequences—that is, for imagined designs implemented in real, practical, describable, and replicable forms with identifiable public benefits.[413]

### *C. Tying Invention Rewards to User Values and Satisfaction*

Patent rewards also discourage inaccurate rationalization of invention users' responses to inventions.[414] Patent interests and related commercialization processes strongly encourage inventors to measure the merit of their invention designs in terms of invention users' values and satisfaction.[415] Psychological limitations often cause inventors to mistakenly project invention users' problems or values, resulting in inventions imagined by inventors that are complete in engineering terms, but that are failures with users and in commercial marketplaces.[416] Patent laws create countervailing forces, encouraging greater attention by inventors to the value of inventions as perceived by users.[417] They achieve this by scaling the size of patent-influenced rewards to the scope of marketplace success of related products or services.[418] Inventions perceived as having high value by users tend to be large marketplace successes, producing large patent rewards.[419]

Patent laws do not scale patent rewards to user values directly, but achieve this result indirectly by enabling market tests of patented advances that match the size of inventor rewards to user values. Patent laws extend patents to advances without regard to whether the advances are projected to be marketplace successes or failures.[420] If an inventor can describe an advance completely in a patent application and the advance has some practical utility, the inventor can

410. CHISUM, *supra* note 390, part III, part 1, ch. 1.
411. *Id.* at part I, ch. 3, SCG-5313.40.
412. *Id.* at part I, § 23.03.
413. *Id.* at part I, ch. 6, § 6.02.
414. *See generally* Greg A. Stevens & James Burley, *3,000 Raw Ideas = 1 Commercial Success*, 40 RES. TECH. MGMT. 16 (Jan. 27, 2016) (discussing the process of inventing a commercially successful invention).
415. *Id.*
416. *Id.*
417. Bill Walker, *Innovation v. Invention: Make the Leap and Reap the Rewards*, WIRED (Jan. 2015), https://www.wired.com/insights/2015/01/innovation-vs-invention.
418. *Id.*
419. Bair, *supra* note 43, at 299.
420. Gene Quinn, *The Successful Inventor: Patenting Improvements*, IPWATCHDOG (May 3, 2014), http://www.ipwatchdog.com/2014/05/03/the-successful-inventor-patenting-improvements.

generally gain a patent[421] regardless of whether the advance appears to provide a better way for accomplishing a task than other available means or has other features suggesting that the advance will be a marketplace success.[422] Some utility is required, but not superior utility.[423] Indeed, superior utility would be difficult if not impossible to measure as different parties might assess a single device under different utility standards and accordingly rank it differently in utility comparisons with competing devices.[424] Utility (and hence best or greatest utility) is in the eye of the invention user.[425]

Even though patent rights are not limited to advances perceived as having value by users, patent rights enforcement, coupled with commercial market forces, tend to scale the size of patent rewards to the satisfaction of invention users' desires.[426] By attaching property-like rights to patented inventions, patent laws create in patent holders exclusive opportunities to commercialize their patented inventions and to realize whatever commercial gains they can reap from provision of the inventions to users during the lives of their patents.[427] The patent-influenced amounts they can gain from commercialization opportunities are directly related to the aggregate value that invention users see in inventions.[428] Highly useful advances will produce high commercial rewards under patent influence.[429] Users will tend to pay amounts for patented inventions up to (but not beyond) the enhanced gains that the users can produce through use of the patented inventions.[430] Patent enforcement makes patented advances available to users only upon payment of access fees (paid either through patent-influenced product sales prices or via royalties for use of the patented items).[431] By establishing an access control system, patents serve to link the interests and values of inventors and invention users.[432] The biggest rewards for invention producers are linked through patent enforcement to payoffs for inventions that match and serve the biggest (or at least most subjectively compelling) user needs.[433] While patent rights are available for a broad range of non-obvious inventions with some documentable utility, patent enforcement tailors patent rewards to inventions that are valuable to invention

421. *See* 35 U.S.C. §§ 102, 103 (2012) (discussing how a patent is not guaranteed in these circumstances since a patent applicant must still meet other patent law requirements, including requirements that an advance have a design that is both new and a non-obvious departure from prior, publicly revealed designs of items and processes known to parties in the same field).

422. CHISUM, *supra* note 390, ch. 3, part 1.

423. ALEN L. DURHAM, PATENT LAW ESSENTIALS: A CONCISE GUIDE 1, 91 (4th ed. 2013).

424. Bair, *supra* note 43, at 300.

425. *Id*.

426. Richard S. Gruner, *Dispelling the Myth of Patents as Non-Rivalrous Property: Patents as Tools for Allocating Scarce Labor and Resources*, 13 COLUM. SCI. & TECH. L. REV. 1, 6 (2011).

427. *Id.*

428. *Id.* at 40–41.

429. *Id.* at 42.

430. *See id.*, at 42–43 (discussing rewards assist patent inventors to structure their inventions).

431. *See id.* at 1 (discussing the impacts of the patent system in creating invention access controls and the related ways that patent rewards prioritize invention efforts in accordance with the values of invention users).

432. *Id.* at 6.

433. Buccafusco et al., *supra* note 40, at 1948.

users and causes the amounts of those rewards to increase with the net value achieved for invention users.[434]

The results of limiting and scaling patent rewards in these ways are twofold. First, inventors are given strong incentives to identify the needs and values of invention users in targeting invention efforts.[435] Inventors are encouraged to serve as agents of potential invention users, seeking invention designs that will achieve results valued by their invention user principals.[436] Inventors have personal reasons to perceive inventions as users will perceive the inventions.[437] Inventors can serve as better agents (and realize greater patent-influenced rewards for themselves) if the inventors properly identify user needs and then produce inventions that serve those needs both effectively and efficiently.[438] Patent incentives encourage inventors to overcome their inherent weaknesses in imagining the future values and circumstances of other parties and to instead identify potential invention users' needs and desires as accurately as possible.[439] Inventors will not always be able to put themselves into the minds of potential invention users (particularly at the future points when the users will employ inventions), but patent rights give inventors strong incentives to try.[440]

Second, patent rights offset inventors' frequent failures to correctly imagine invention users' needs by attracting investment and resource backing towards those rare invention designs in which user needs have been correctly imagined and successfully served.[441] Patent rights help ensure that significant advances like these are not lost amidst the many mediocre inventions designed and promoted by innovators.[442] Imagination gaps cause innovators to produce many misconceived inventions that serve user interests poorly.[443] But a few inventions do not suffer from these problems.[444] Those few advances that successfully serve user needs might easily be overlooked amidst the sea of inventions that are worthless to users because they are no better than presently available items or processes used for similar purposes.[445]

Patent rights give investors and other parties with large resources such as major corporations reasons to seek out patented advances with broad public

434. Gruner, *supra* note 426, at 9.

435. Crouch, *supra* note 42, at 143.

436. Buccafusco et al., *supra* note 40, at 1925.

437. *Id.* at 1935.

438. *See generally* Gruner, *supra* note 426, at 40–42 (discussing how future rewards incentivize inventers to identify the needs of users).

439. *Id.*

440. *See id.* at 19 (arguing that patent law provides incentives to create to highly talented inventors with distinctive understanding of technological fields and consumer needs).

441. *See* Sean B. Seymore, *The Null Patent*, 53 WM. & MARY L. REV. 2041, 2050 (2012) (stating "[i]n fact, negative results comprise the bulk of knowledge produced in scientific research."); *see* Buccafusco, *supra* note 40, at 1980 (stating "IP law . . . provides sets of exclusive rights that potentially provide creators greater returns on their investments.").

442. *See* Gruner, *supra* note 426, at 9 (suggesting that patent rights "influence upstream decisions about the allocation of resources as inputs to inventions" depending on the value of the invention).

443. *See* Crouch, *supra* note 42, at 172 (stating that "[e]vidence suggests that many potential innovators overweight the potential value of a successful innovation but tend to ignore the low probability chance of reaching that success.").

444. *See id.*

445. *See* Gruner, *supra* note 426, at 37 (discussing various reasons causing an invention to fail).

impacts and large commercial potential. Patent rights encourage these parties to support the development and popularization of those advances with sufficient resources to bring the advances into widespread usage.[446] The exclusive commercialization opportunities guaranteed by patent rights reassure parties with resources that if they invest in the development of products incorporating patented advances and then commercialize those products, they will reap the associated commercial rewards and not be undercut by free riders who gain from the advances without investing in the steps to bring the advances to the public.[447] Patent rights make risk-taking regarding publicly important and commercially valuable advances attractive to the business community.[448] Such rights ensure that attentive eyes within that community look hard to pluck out commercially promising advances from the vast numbers of advances obtaining patents.[449] Patent rights also encourage businesses to develop the large projects and enterprises needed to transform promising advances into socially useful and broadly available products and services.[450]

By making patented advances with large user value particularly attractive for subsequent business development, patent rights help to enhance the likelihood of public access and benefits from patented advances that, unlike the bulk of misimagined and mistargeted advances, serve public needs on a large scale and have significant commercial potential.[451] Patent rights give businesses potential stakes in the public's benefits from receiving and using patented advances.[452] This, in turn, establishes special market forces pulling patented advances with large potential impacts forward in product development and commercialization processes.[453] Patent rights are fundamentally important to the success of this positive selection process.[454] They wrap commercial potential

446. *See* Fromer, *supra* note 42, at 1446–47 (stating that "[t]he theory is that the public benefits by rewarding inventors for taking two steps they likely would not otherwise take: first, to invent and possibly commercialize; and second, to reveal information to the public about these inventions to stimulate further innovation."); *see, e.g.*, Johnson, *supra* note 42, at 661 (providing an example of a large corporation, Intel, spending substantial resources on development of microprocessors).

447. *See* Dam, *supra* note 382, at 1 (stating that "the patent system prevents others from reaping where they have not sown and thereby promotes R&D investment in innovation.").

448. *See id.* (explaining that the patent system incentivizes invention by ensuring that investors recover the cost of invention).

449. *See id.* (explaining that the patent system incentivizes invention by ensuring that investors recover the cost of invention); *see* Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J. L. & ECON. 265, 290 (1977) (discussing the incentive to invest created by the patent system).

450. *See, e.g.*, Johnson, *supra* note 42, at 661 (providing an example of Intel who had announced "it would spend $5 billion to build a new fabrication facility in Arizona to manufacture chips with a new level of nanoscale miniaturization.").

451. *See* Dam, *supra* note 382, at 17 (stating that "the disclosure required in a patent application, once made public by the issuance of the patent, may convey important technical information that will allow other firms to climb onto the patentee's shoulders in seeking improvements or wholly new inventions.").

452. *See* Buccafusco, *supra* note 40, at 1924 (stating that "[p]ublic benefits accrue by rewarding inventors for taking two steps they likely would not otherwise have taken: first, to invent, and possibly commercialize, and second, to reveal information to the public about these inventions that stimulates further innovation.").

453. *See* David S. Olson, *Removing the Troll from the Thicket: The Case for Enhancing Patent Maintenance Fees in Relation to the Size of a Patent Owner's Patent Portfolio*, 68 FLA. L. REV. 519, 524 (2016) (discussing the benefits of the monopoly position that the owners of commercially successful innovations enjoy).

454. *See* Fromer, *supra* note 42, at 1446–47 (suggesting that the protection of the patent rights is necessary to incentivize inventions and their commercialization).

around the advances that the rights protect.[455] Where particular advances have great public interest and value to users, the commercial potential is typically equally great.[456] Commercial interest, enhanced and focused on advances through patents, aligns with the public's interest, varying upward as public perception of value increases.[457] This alignment means that commercial development tends to seek out and push forward into public marketplaces and public access those advances with high perceived value to users.[458]

If imagined inventions accurately serving users' values are rare because of systematic psychological weaknesses in inventors' imaginations and the corresponding mistargeting of many invention projects, it is particularly important that the few advances which correctly target user values and satisfy important public needs are not neglected by investors and corporations with the resources needed to produce the inventions in quantity. Society has a clear stake in the positive selection process that patent rights enable, causing patented advances with broad impacts to be seen as having especially high commercial potential and great attraction to parties with backing resources.[459] Patent rights attached to advances with social significance help businesses to obtain the funding needed to develop the advances into products, set up manufacturing operations, market the resulting products, and bring those products into widespread usage.[460] By favoring advances with broad public impacts and commercial potential in these ways, patent rights tend to enhance the likelihood of commercial development and public access to such advances.[461]

In short, as inventors produce many failed inventions due to poor imagination of public needs and problem solutions, rare inventive successes in serving those needs are given particularly easy paths to public access through attractive commercial forces enabled by patent rights. This positive selection process driven by patent rights ensures that inventors' rare successes in accurately projecting users' needs and serving those needs are recognized in commercial processes and brought to public access in widely produced and marketed goods and services.

## V. IMPROVING PATENT LAWS TO BETTER OFFSET IMAGINATION BARRIERS TO INVENTION

Improvements in patent laws could heighten the impacts of patents in offsetting imagination barriers to invention. This Section describes some of

455. *See id*. (discussing the relationship of patent rights protection and commercialization).

456. *See* Buccafusco, *supra* note 40, at 1924 (connecting public benefits and commercialization of the inventions).

457. *See id.* (connecting public benefits and commercialization of the inventions).

458. *See* Dam, *supra* note 382, at 6 (providing an example of the development of the high-technology industries that yielded broader public access to the technologies at a lower price).

459. *See* Buccafusco, *supra* note 40, at 1924, 1980 (discussing the patent system benefitting the public by creating incentive to invent and commercialize).

460. *See* Dam, *supra* note 382, at 1 (explaining that the patent system incentivizes invention by ensuring that investors recover the cost of invention).

461. *See id.* at 20 (explaining that the patent system promotes future innovation through public disclosure).

these patent law changes and why they are desirable as means to offset psychological limitations on invention imagination.

### *A. Emphasizing Predictability of Functionality in Assessing Invention Obviousness*

One valuable change would be to alter non-obviousness standards in United States patent laws to focus explicitly (and perhaps exclusively) on the predictability of the functionality of an invention as an indicator of invention obviousness. An advance with new functionality (in results or operation) that is predictable by most parties working on advances in the same field at the time of the advance should be treated as obvious and unpatentable. Patent rights would be reserved through this change for advances that go beyond the prevailing principles for predictable functionality in the relevant fields, thereby prompting greater searches for previously unpredictable functionality and correspondingly diminishing presentism in patentable advances.

The aim of this change is to bring obviousness tests better in line with the difficulty of imagination of various inventions. Inventions with predictable functionality (in light of prior designs and engineering principles at the time the inventions were originated) will be relatively easy to imagine. These can be imagined as functional wholes since their functionality can be predicted and projected.

By contrast, new invention designs with functional features that are not predictable to most parties in a field will be unlikely to be imagined by many parties. Most potential inventors will not imagine and design this type of invention because, as they try to consider the functional features of the invention and the impacts of the invention in solving some practical problem, they will not see in their minds the functionality that they cannot predict. Instead, they will either not focus on the elements producing the unpredictable functionality or will think that these elements do not produce the functionality they need. Even if they consider an invention design incorporating elements with unpredictable functionality, they will tend to reject that design because they imagine (incorrectly as it turns out) that the invention lacks some needed functionality. They will project and imagine the invention as a failure because they mistakenly project the functional features of the invention design.

Those few designers who make unusual functional predictions and design corresponding inventions are imagining inventions that most parties in their field would expect not to work. These designers are seeing what is not obvious to most of their peers—that is, that their inventions will work in a different manner than most parties in their field would have predicted and imagined. Because of their rare insights, these designers with unusual predictions can imagine functionality and impacts for their inventions that most of their peers cannot. Hence, these designers can produce advances that are rare and deserving of special promotion via patent incentives. By equating unpredictable functionality among average innovators with non-obvious inventions and allowing patent protections only for the latter, we can cause non-obviousness tests to track the difficulty of imagining inventions. The predictability of the functionality and

practical success of an invention would serve as a workable substitute for direct measurements of invention imagination difficulty under this revised version of non-obviousness tests.

### *B. Withholding Recognition of Inventions Lacking Clear Functionality*

Patent standards can better offset excessive realism in imagined invention designs by withholding patents from inventions lacking clear functionality. This can be accomplished by increasing demands on inventors to establish the completeness and functionality of advances before the advances are recognized as potentially patentable inventions.

Imagination errors tend to cause inventors to incompletely specify the functional features of their inventions, resulting in designs that include unchallenged and untested functional assumptions and operating features that are excessively presumed to be real. Inventors tend to be overly optimistic about how well their designs will work due to the inventors' failures to correctly imagine all of the implementation details of the inventions and to see how some of these details may impede the functionality of their ideally-conceived advances.[462] To avoid patent rewards for inventions with these errors and to give potential invention users greater insights into the good and bad functional attributes of new advances, patent applicants should be required to more fully describe the functional attributes of their invention designs and the results achieved by those designs (at least as understood by the inventors at the time of their patent applications). These required descriptions will be disclosed to the public and made available to potential invention users for evaluations of benefits from adopting the advances, provided that patents for the advances are granted (or that the relevant patent applications are published without patents being granted).

Present patent laws obligate inventors to describe advances in sufficient terms to enable others to make and use the patented inventions.[463] Enhanced patent disclosure standards might require inventors to describe their understandings of the functional features and flaws they have observed in producing operating versions of their advances.

These sorts of enhanced disclosure requirements would have impacts on both invention processes and invention use. The preparation of the necessary disclosure statements would help to reveal imagination gaps and flaws in the inventors' designs. Requiring such disclosures would also encourage inventors to look for functionally important weaknesses in their own imagined designs and to go further in the perfection of their designs to eliminate the weaknesses before they file for related patent protections and must reveal the weaknesses.

Increased disclosures of known invention weaknesses and adverse operating characteristics would also alter processes surrounding the adoption of

462. *See* Crouch, *supra* note 42, at 172 (stating that "[e]vidence suggests that many potential innovators overweight the potential value of a successful innovation but tend to ignore the low probability chance of reaching that success.").

463. 35 U.S.C. § 112 (a) (2012).

new inventions. These disclosures would aid invention users in understanding and improving the advances. Disclosures balancing descriptions of invention functionality strengths with equal descriptions of known weaknesses would also help potential adopters of the advances to better understand and evaluate the net utility and value of the advances. Invention users may be able to determine quite quickly that a revealed weakness represents a major invention flaw even if this flaw was not accurately imagined or characterized in an inventor's imagined invention design.

Balanced information about invention strengths and weaknesses may also help to overcome mistaken inventor targeting of the wrong invention user values. This information is needed properly activate market forces propelling valuable advances into generally available products and leaving less valuable advances behind. Absent this sort of balanced information, potential invention adopters (or parties considering commercial backing of invention development) may be misled by overly favorable (and self-serving) descriptions of advances by patent applicants. Without a requirement of balanced information, invention descriptions by patent applicants will tend to be biased towards overemphasis on the positive features of advances without similar attention to known problems or limitations. The resulting overly positive, one-sided pictures of inventions will omit key negative information needed to assess the net value gained from invention use.[464] Adding information about known problems with inventions will permit invention users (and companies considering whether to commercialize an advance on behalf of such users) to better assess patented inventions and strengthen market forces rewarding most strongly those patented advances that have accurately met user needs and values.

### *C. Interpret Patent Scope to Protect and Reward Invention Value*

Patent laws can additionally tie the size of inventor rewards to accurate imagination and service of user values by shaping patent rights to encourage commercial processes testing and evaluating the value of advances to invention users. Inventors frequently misconceive these values in their imaginations, leading to mistaken images of the reactions that users will have to new inventions.[465] As a result, inventors often imagine and design inventions that have modest or no functional impacts and value as seen by users.[466] Such inventions have sufficient minimal utility to qualify for patents but will not be of substantial interest to potential invention users.[467] The commercial attraction of patent rights can subject inventions to evaluations by companies and

464. *See* Crouch, *supra* note 42, at 172 (discussing the over-optimism of inventors with regard to "potential value of a successful innovation").

465. *Id.*

466. *See id.* (discussing the over-optimism of inventors with regard to "potential value of a successful innovation").

467. *See* CHISUM, *supra* note 390, § 4.02 (Matthew Bender, 2017) (stating that "[n]either the Patent Office nor the courts, in determining the utility requirement, inquire whether the invention of a new means is better than existing means of achieving the same purpose or is commercially feasible.").

marketplaces that tend to separate advances with user importance and commercial traction from poorly imagined advances lacking these features.[468]

Patent law changes can strengthen these invention filtering processes relying on market testing. Patent rights will have their greatest influence in activating market tests of invention value and popularity if these rights attach to the full range of commercial products and services incorporating a patented advance. This will give a patent rights holder[469] a stake in developing and popularizing a patented advance that tracks the commercial value and public benefits of the advance. Patent rights of this scope will tend to cause the commercial value of an advance to drive decisions about how to develop and market the advance. This linkage of patent rights to user value should help to ensure that advances with high value to the public attract commercial attention and are transformed into widely available products.

Interpreting patent rights sufficiently broadly to apply to all commercialization opportunities will heighten the likelihood of commercialization attempts for high value inventions. Confidence in exclusive commercialization opportunities for all implementations of a patented advance will both create greater interest of resource holders in seeking out publicly-important advances for potential commercialization and bring more publicly-significant advances to market. Together, these impacts will make more patented advances widely available, allowing potential users to consider the desirability of these advances and to adopt those advances that seem attractive. This strengthening of patent-based commercialization processes should propel more correctly imagined advances with user value to public availability and help to offset failed invention projects stymied by inventors' frequent errors in imagining public needs and mistargeting related inventions.

### *D. Strengthen Working Requirements to Encourage Commercialization Attempts*

As a further means to increase commercialization testing of patented technologies and identify more successfully-imagined advances—and to avoid holding successfully-imagined technologies in limbo by threatened patent rights enforcement despite a lack of commercialization by the rights holders—United States patent laws can be strengthened by incorporating working requirements for patent rights maintenance. Under such requirements, patents would be

468. Market forces determining the recipients and size of patent-based rewards are key parts of the patent system. As noted by Kenneth W. Dam:

> [The policy underlying the patent system] can be thought of as an industrial policy in today's terms because it uses legal intervention to decide what technologies to promote. But unlike most industrial policies it creates property rights in order to allow a market system to function. And it chooses these technologies not by a process of bureaucratic or political evaluation of which technologies are the most worthy of government support but rather through a set of prior rules that create a system determining when property rights will be created in inventions.

Dam, *supra* note 382, at 2 (footnote omitted).

469. The relevant rights holder may by that point be the original innovator, but is more likely to be a business that is a successor to ownership of the patent or an exclusive license under the patent and that is seeking to bring related items or processes to market within the exclusive commercialization opportunity protected by the patent.

voided upon failures to seek commercialization of patented technologies over long periods. These sorts of working requirements can promote prompt invention commercialization and thereby further the identification of successfully-imagined inventions through commercial processes. The need for prompt commercialization will speed evaluations of patented advances for commercial potential, thereby also speeding the propagation of patented advances with significant value to users. These impacts should boost the availability and widespread use of those few inventions that are exceptions to the general tendencies of most inventors to mistakenly imagine public needs and correspondingly mistarget inventions.

In addition to promoting more active commercialization of patented advances by patent holders, enhanced working requirements can also encourage more active and prompt commercialization of patented advances by other parties where patent holders neglect commercialization. If patent holders do not meet working requirements, their patent rights will terminate, giving other parties opportunities to commercialize the advances involved. The result should be more frequent assessments of patented advances for commercial potential (by both patent rights holders and others who are ready to step in upon lapses in patent rights) and more frequent instances of commercialization bringing patented advances to public review and potential widespread usage. Patent working requirements can help to increase the number of parties with commercial interests in seeking out publicly-important wheat among the all too frequent chaff of useless patented advances. This involvement of more commercializing parties should help to bring more successfully-imagined inventions—in which inventors have accurately imagined and served public needs—into widespread public use.

### *E. Alter Maintenance Fees to Discourage Neglect of Valuable Inventions*

Altered patent maintenance fees[470] are another means to better offset inventors' errors in successfully imagining inventions that serve the interests of invention users. Increased maintenance fees (particularly large fees assessed early in patent terms) can encourage rapid evaluation and filtering of patented inventions in terms of potential user value. Patents on inventions evaluated as not serving user interests (and having little commercial potential accordingly) will be allowed to lapse to avoid paying the threatened fees. Pressures encouraging this type of evaluation will advantage those rare, successfully-imagined inventions that have avoided imagination errors regarding invention users' values and that are instead properly targeted to serve users' interests.

Two types of maintenance fee changes will be desirable—acceleration of the due dates for such fees to earlier points in the life of applicable patents and increases in patent maintenance fees. Both types of changes can influence and

470. Maintenance fees must be paid periodically during the life of a patent in order for patent rights to continue for the full patent term. Patent holders failing to pay these fees lose their patent rights, resulting in an opening up of the technologies involved for unconstrained commercialization by others. *See* 35 U.S.C. § 41 (2012).

structure how patent rights holders approach evaluations of patented advances for commercialization potential.

Acceleration of the timing for fee payments would increase pressures for prompt evaluation of the potential user value and commercial potential of patented advances. By shortening the periods between patent issuance and maintenance fee due dates, patent holders can be encouraged to make quicker and more complete commercialization analyses at earlier stages in the lives of patents.

Increases in the amounts of maintenance fees would encourage the voluntary relinquishment of patent rights for more advances that rights holders feel do not have sufficient commercial potential, thereby making these additional advances available for commercialization by others. Increased fees will tend to raise the minimum projected commercial potential needed to justify retaining patent rights, thereby causing rights holders to release more interests by deciding not to pay applicable maintenance fees.[471]

Both of these changes in maintenance fees will improve processes for screening patented advances, bringing more valuable advances to the public. Pressures to make prompt commercialization decisions will force patent holders to focus intensely on commercialization or to release their rights; increases in the number patented advances released from patent controls under heightened maintenance fee pressures will allow broader numbers of parties to consider and pursue commercialization of once-patented advances.[472] Both types of changes should help to identify and bring to public availability more inventions that serve public needs and interests. By ensuring that more inventions with successfully-imagined utility are not lost in the patent system, these changes will better offset the imagination errors of many inventors in producing patented advances that fail to serve the desires and needs of invention users.

## VI. CONCLUSION: PATENTS AS MEANS FOR INCREASING PUBLIC ACCESS TO VALUABLE PRODUCTS OF INVENTORS' IMAGINATIONS

This Article has described how patents can influence the quantity, quality, and commercial potential of successfully-imagined inventions serving public interests. Patents encourage inventors to imagine invention designs serving user needs and to implement those designs through unconventional departures from present items and processes.[473] In this, patents encourage inventors to "dream big" and imagine invention designs that are more than easily imagined variations on present items and processes, having more than just predictably altered functionality suggested by well-established engineering experience and scientific knowledge. Patents also encourage inventors to complete their invention projects—that is, to go beyond tentative designs (that are often

471. *See* Olson, s*upra* note 453, at 545 (suggesting that one of the goals of maintenance fees is to encourage the owners of patents that are of little value to let those patents lapse).

472. *See id*. (stating that "[b]y taking low-value patents out of force sooner, society benefits because others can use and build on the formerly patented technology without having to worry about being sued.").

473. *See* 35 U.S.C. § 103 (2012); Graham v. John Deere Co., 383 U.S. 1, 13–14 (1966).

oversimplified and under-tested in mental images) and reduce imagined designs to practice in ways that force inventors to deal with real invention details and implementation problems.[474] Once inventions are formulated, reduced to practice, and described in issued patents, patent rights activate commercial forces that promote the perfection and popularization of the patented advances, thereby enhancing public access to non-obvious advances that are difficult to imagine and correspondingly rare.[475] Commercial processes activated and supported by patent rights promote commercial interest and inventor rewards in direct proportion to invention valuation by users, thereby ensuring attention to such valuation and offsetting tendencies of inventors to mistakenly imagine how users will perceive and value inventions in use.[476]

Understanding how patent laws influence these factors permits us to appreciate the importance of patent laws in altering invention and commercialization processes to offset fundamental psychological weaknesses that impeding invention processes. All persons tend to imagine the future imperfectly, committing predictable errors in projecting the future happiness to be produced by tomorrow's events.[477] Inventors do not escape these errors.[478] They regularly commit the same types of imagination errors in formulating their mental visions of invention designs, in projecting the uses of products and services based on their invention designs, and in estimating the satisfaction that future parties will gain from use of inventions.[479] By understanding these likely errors, we can shape patent laws in ways that encourage inventors to avoid or correct these errors. We can also use patent laws to ensure that inventors' rare successes in accurately imagining widely held problems and in further imagining inventions that solve these problems through fundamentally new technical means are not lost as mere mental accomplishments but are instead given privileged commercial standing and driven forward into broadly available products and services.

Inventors make our technological future first in their imaginations and then in real items and processes. Where they imagine mental images of inventions with broadly helpful and attainable designs, the public has a large stake in the successful translation of these mere mental images into widely available

474. *See* CHISUM, *supra* note 390, § 4.04 (Matthew Bender, 2017) (stating that "[i]n order to meet the utility requirement, a new product or process must be shown to be 'operable.' It must be 'capable of being used to effect the object proposed.'").

475. *See* Dam, *supra* note 382, at 6 (providing an example of the patent system yielding a broader public access to the technologies).

476. *See* Buccafusco, *supra* note 40, at 1924 (connecting public benefits and commercialization of the inventions).

477. *See* Dunning, *supra* note 7, at 568 (finding the subjects of the study to have been consistently highly overconfident in their predictions); *see, e.g.*, Cass R. Sunstein, *Behavioral Analysis of Law*, 64 U. CHI. L. REV. 1175, 1183 (1997) (citing a survey which shows that students tend to think they are "far less likely than their classmates to be fired from a job, to have a heart attack or get cancer, to be divorced after a few years of marriage, or to have a drinking problem").

478. Sunstein, *supra* note 477, at 1183 (stating that "[u]nrealistic optimism appears to characterize people in most social categories.").

479. *See* Crouch, *supra* note 42, at 172 (stating that "[e]vidence suggests that many potential innovators overweight the potential value of a successful innovation but tend to ignore the low probability chance of reaching that success.").

advances. A patent provides a bridge between the fantasy world of an inventor's imagination and the real world of public access to an invention. By focusing inventors on inventions that numerous persons need and value and then helping to bring these sorts of inventions into widespread use, patents encourage inventors to imagine better, yet attainable, technological futures and help all of us gain access to those rare, accurately imagined visions by inventors of a better world.