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Innovation Heuristics: Experiments on Sequential Creativity in Intellectual Property

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All creativity and innovation build on existing ideas. Authors and inventors copy, adapt, improve, interpret, and refine the ideas that have come before them. The central task of intellectual property (IP) law is regulating this sequential innovation to ensure that initial creators and subsequent creators receive the appropriate sets of incentives. Although many scholars have applied the tools of economic analysis to consider whether IP law is successful in encouraging cumulative innovation, that work has rested on a set of untested assumptions about creators' behavior. This Article reports four novel creativity experiments that begin to test those assumptions. In particular, we study how creators decide whether to copy, or "borrow," from existing ideas or to innovate around them.

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 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. We conclude by exploring the implications of our data for innovation markets and IP doctrine.

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INTRODUCTION

Human life is full of change. And yet there is one commonplace that is as true now as it was in Biblical times: "there is nothing new under the sun."[1] However original a new idea may seem, inevitably it is derived from previously existing ones.[2] All new authors and inventors stand on the shoulders of those who came before them. Their ability to do so, however, is affected by the existence of intellectual property (IP) rights protecting existing ideas.

When an idea is protected by a copyright or patent, others who want to copy it, in whole or in substantial part, and use it for further development, evolution, and refinement must license the rights from their owner. Licensing is costly, and subsequent creators have to make decisions about whether to license existing IP rights or whether to create something that does not impinge upon those rights—an endeavor that may itself be costly when existing IP forecloses certain creative opportunities. In this way, IP law not only affects the pace of sequential innovation, but also its direction. At least at the level of theory, IP law affects innovators' decisions regarding whether to build upon existing IP rights, or whether to work around those rights.

This aspect of IP law[3] is a vital component of the law's aim: to optimize creative production by balancing incentives to current creators with access to their ideas for

1. *Ecclesiastes* 1:9.

2. Throughout this Article we use the term "ideas" to refer to the products of creative endeavor. This includes copyrightable works of authorship and patentable inventions.

3. In this Article we focus exclusively on copyright and patent law to the exclusion of trademark and trade-secret law. Also, we focus on U.S. IP law and do not consider diverging allocations of IP rights on sequential innovation in foreign IP regimes.

subsequent downstream creators. If the rights given to initial creators are too weak, incentives to create new ideas will likewise be insufficient. But if the rights given to initial creators are too strong, later development will be hindered in excess of what is required to sufficiently optimize first-stage creativity.

A wealth of scholarly literature has employed the tools of law and economics to explore sequential innovation and the proper balance between the interests of initial and follow-on creators.[4] This work has generally assumed that creators, whether first comers or followers, are rational people who act to maximize their individual welfare. As yet, however, almost no research focuses on how creators actually make decisions associated with sequential innovation.[5] This Article describes a series of experiments doing just that. It addresses the extent to which *innovation heuristics*—mental shortcuts about innovation decisions—affect creators' behavior.

In particular, the experiments reported in this Article explore how creators decide whether to copy, or "borrow" from, existing ideas or to innovate around them. IP rights associated with existing ideas never cover the entire relevant creative field. There are always opportunities for others to work around existing rights in noninfringing ways. Which strategy is optimal—borrowing or innovating—depends on a number of factors including the costs of licensing the rights and the ease of working around those rights.

We are interested in how creators actually make these decisions. Are they successful, rational judges of the costs and benefits of different options? Or are they prone to systematic biases that distort their decisions? The results of our experiments suggest that the latter is more likely the case. In particular, we find that people's innovation decisions are not strongly influenced by objective assessment of the costs and benefits of their choices. Instead, creators' internal beliefs and preferences about innovation contexts matter much more. Our data suggest the existence of innovation heuristics in which creators use mental shortcuts to make decisions about creativity. Often, but not always, these heuristics lead creators to make poor choices. Many creators choose to innovate even though they would be much better off borrowing, and many other creators choose to borrow when doing so is clearly suboptimal.

Understanding how people choose whether to innovate or to borrow from others' creativity is important; this is one of the principal decisions that IP law is intended to influence. Existing IP laws shape sequential innovation based on a broad expectation that creators will act, on balance and over time, rationally. To the extent that creators deviate from these expectations, IP law will be inefficient, and it will fail to meet whatever innovation goals we have set for it. Our experiments help deepen the law's understanding of how creators select between innovation and

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4. *See infra* Part I.C.

5. *See, e.g.*, Kevin J. Bourdreau & Karim Lakhani, *"Open" Disclosure of Innovations, Incentives and Follow-On Reuse: Theory on Processes of Cumulative Innovation and a Field Experiment in Computational Biology*, 44 RES. POL'Y 4 (2015); Julia Brüggemann, Paolo Crosetto, Lukas Meub & Kilian Bizer, *Intellectual Property Rights Hinder Sequential Innovation: Experimental Evidence* (Ctr. for European Governance and Econ. Dev. Research, Discussion Paper No. 227, 2015), *available at* http://ssrn.com/abstract=2545950 [https://perma.cc/78MC-KUGH].

borrowing in the process of sequential innovation. That guidance could help the law better distribute resources and encourage innovation.

Part I of this Article discusses the economic theory of sequential innovation, and its regulation by IP rules. The findings of four novel experiments are described in Part II. Then, Part III explores the implications of these findings for IP law and policy.

I. REGULATING SEQUENTIAL INNOVATION

From an economic perspective, the regulation of sequential innovation is the central feature of intellectual property systems. When an author or inventor creates something new, that act often opens up multiple avenues for further creative development. Books can be made into movies. Pharmaceuticals can be refined for greater efficacy or reduced side effects. This kind of evolution, development, refinement, and interpretation lies at the heart of creativity and innovation—very few creative works of any importance spring into being fully formed in the first act that leads to their creation.

IP law regulates sequential innovation in a number of ways. Copyright and patent laws affect who is permitted to engage in sequential innovation, how they are permitted to do so, and the speed with which sequential innovation takes place. In so doing, these laws attempt to optimize creative production by balancing incentives to initial creators with access to subsequent creators. How well our IP laws strike this balance, though, depends on whether creators respond to incentives in the ways that the law assumes they do.

A. Incentives and Access in Intellectual Property Law

In a world without IP rights, sequential innovation would be straightforward: if an inventor had an idea for a way to improve a smartphone, she would simply create the new version and sell it. Or if a filmmaker thought that a book would make a good movie, he could just adapt the book into a screenplay, and then hire a cast and crew and shoot the movie. IP law, however, sets up barriers to the reuse of pre-existing works by granting to initial creators certain rights in the "downstream" uses of their creations. The law establishes these rights to make sure that the initial creators bother to make their works in the first place.[6]

According to the standard account of IP rights, creators require incentives to produce and disseminate their creations.[7] The standard account views inventions and expressive works as costly to produce but relatively cheap to copy and disseminate.[8] In the absence of IP rights, others could simply copy new works and inventions and sell them at the marginal cost of reproduction.[9] Because the marginal cost of

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6. *See* Mark A. Lemley, *The Economics of Improvement in Intellectual Property Law*, 75 TEX. L. REV. 989, 994 (1997).

7. *See* WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF INTELLECTUAL PROPERTY LAW 20–21 (2003).

8. *See* Mark A. Lemley, *Ex Ante Versus Ex Post Justifications for Intellectual Property*, 71 U. CHI. L. REV. 129, 129 (2004).

9. *See id.*

reproduction does not include the initial creator's costs of research and development, she would never make any money selling works at marginal cost and would never bother to create in the first place.[10] By prohibiting others from copying the creation, IP allows the creator a chance to recoup her investment by selling the work for above the marginal cost of reproduction.[11]

But copyright and patent laws do more than prevent others from identically copying protected creations; they also prevent others from producing some similar or new versions of the protected creations. So in the example above, the author of a novel receives a copyright that covers exact duplication of the novel as well as "substantially similar" variations and other "derivative works,"[12] including translations, sequels, and movie versions of the novel. By producing these other versions or by licensing the rights to others, the novelist can make more money, and, thus, she receives a greater incentive to invest in creating the novel in the first place.[13]

While some amount of IP protection is deemed essential for creative incentives, too much protection can harm creativity. IP rights create a number of significant social costs, both static and dynamic.[14] First, because owners can charge prices above the marginal cost of reproduction, some consumers who would have purchased the goods that embody the inventions and expressions at the competitive price will not be able to purchase at the supracompetitive price that will be charged when a copyright or patent creates market power.[15] Economists refer to this as deadweight loss.[16] Second, and more importantly for this Article, IP rights raise the cost of sequential innovation and risk creating dynamic inefficiencies.[17] Because copyrights and patents grant some level of control to initial creators over downstream uses of their creations, subsequent creators will have to negotiate with them in order to produce and market their new creations.[18] If Betty wants to make and sell her improved version of Alice's patented invention, Betty and Alice will have to spend time and money negotiating a licensing fee. Depending on how costly these

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10. *See* Christopher Buccafusco & Jonathan S. Masur, *Innovation and Incarceration: An Economic Analysis of Criminal Intellectual Property Law*, 87 S. CAL. L. REV. 275, 281 (2014).

11. *See id.*

12. 17 U.S.C. § 106 (2012).

13. According to Suzanne Scotchmer, initial creators need to be able to capture some of the value of sequential innovations because much of the value of the initial innovation may come from positive externalities associated with downstream products. That is, the social benefit conferred by the idea may be that it makes the creation of other ideas cheaper. If the initial creator cannot capture some of this surplus, she may have insufficient incentives to invest in creating the idea in the first place. Suzanne Scotchmer, *Standing on the Shoulders of Giants: Cumulative Research and the Patent Law*, 5 J. ECON. PERSP. 29, 31 (1991).

14. *See* Lemley, *supra* note 6, at 996 ("Granting authors and inventors the right to exclude others from using their ideas necessarily limits the diffusion of those ideas, and so prevents people from benefiting from them.").

15. *Id.*

16. Glynn S. Lunney, Jr., *Reexamining Copyright's Incentives-Access Paradigm*, 49 VAND. L. REV. 483, 497–98 (1996).

17. Dan L. Burk, *Law and Economics of Intellectual Property: In Search of First Principles*, 8 ANN. REV. L. & SOC. SCI. 397, 402 (2012).

18. Lemley, *supra* note 6, at 998.

negotiations are, they will, at best, increase the price of the improved goods.[19] At worst, they will swamp the benefits that Betty could have realized from the improvement so that she cannot afford to make her improvement at all.[20]

Copyright and patent laws must strike a balance between the incentives given to initial creators and the opportunities for sequential innovation reserved for downstream creators. If the former are too low, the orthodox model holds that nothing gets produced in the first place, but if they are too high, there will be insufficient development and evolution. The next section discusses the various doctrines that IP law uses to strike this balance.

B. Regulating Sequential Innovation

Legal doctrines about the length and breadth of copyrights and patents as well as laws about derivative works, the doctrine of equivalents, and fair use all regulate the process of innovation. The goal of these and other doctrines—and of IP systems as a whole—is to strike a balance between the incentives provided to initial creators and the opportunities left over for subsequent creators. In this sense, regulating sequential innovation is the principal problem of IP law.

For a simple example of how this balancing works, consider the length of time that an IP right lasts. The longer the right lasts, the more money the initial inventor can hope to make from the invention and, thus, the greater the incentive to invest in the investment in the first place.[21] From that point of view, it would seem like IP rights should last forever.[22] But from the perspective of long term growth and innovation, longer IP rights might create problems. The existence of the IP right increases the costs to competitors who want to make their own newer and better

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19. *Id.* ("[T]he existence of preexisting intellectual property rights imposes a positive cost on improvers that they would not otherwise face.").

20. Scotchmer, *supra* note 13, at 32 ("If the second innovator does not get all the surplus being bargained over, he will earn only a fraction of the new product's market value and presumably only a fraction of its social value, and this fraction may be less than the cost of developing it. Hence the incentive for an outside firm to develop second generation products can be too weak."); *see also* Stewart E. Sterk, *Rhetoric and Reality in Copyright Law*, 94 MICH. L. REV. 1197, 1207 (1996) ("At some point, giving authors additional copyright protection will reduce the supply of new works because the number of marginal authors deterred from creating by the high cost of source material will exceed the number encouraged to create by the increased value of a work associated with a marginal increase in copyright protection.").

21. Of course, discounting for the present utility, the value of a dollar made on a work a century from now is not likely to provide much additional incentive for a creator today. *See* Stan J. Liebowitz & Stephen Margolis, *Seventeen Famous Economists Weigh in on Copyright: The Role of Theory, Empirics, and Network Effects*, 18 HARV. J.L. & TECH. 435, 439 (2005); *see also* Shyamkrishna Balganesh, *Foreseeability and Copyright Incentives*, 122 HARV. L. REV. 1569, 1571 (2009).

22. The musician Sonny Bono thought so. *See* Arlen W. Langvardt, *The Beat Should Not Go On: Resisting Early Calls for Further Extensions of Copyright Duration*, 112 PENN ST. L. REV. 783, 791 n.63 (2008) ("Sonny Bono had initially favored making copyright duration perpetual before learning that a move by Congress to grant perpetual copyright protection would run afoul of the 'limited times' language in the Copyright Clause.").

versions of the product. So the longer the right, the harder it is for newcomers to compete and innovate. IP law must set the duration of rights at a length that provides sufficient encouragement for initial creators without unduly burdening follow-on creators.[23]

Copyright law and patent law differ greatly in the ways that they approach problems of sequential innovation, and these differences affect how easy it is for others to reuse existing ideas. In some ways, copyright law is more protective of sequential innovations than is patent law. For example, copyright law does not impose liability on defendants who have independently created the same work without copying the plaintiff's work, while patent law imposes liability on all defendants who violate a right whether they copied from the plaintiff's invention or not.[24] Accordingly, if a new creator happens to hit independently upon a great idea that is covered by an existing copyright, the new creator is free to use it.[25] Copyright law is also limited by its central doctrine distinguishing between original creative expression, which can be copyrighted, and unprotectable ideas.[26] This means that some kinds of creativity are simply ineligible for copyright protection because they are so essential to later creators.[27] Finally, copyright does allow some "fair uses" to be made of copyrighted works, which preserves some (uncertain and context-specific) innovation space for follow-on creativity.[28] No similar limitations to the rights of the original inventor exist in patent law.[29]

In other ways, however, copyright law grants a smaller share of the value from potential sequential innovation to the downstream creator than does patent law. First, patent law provides relatively short terms (twenty years from the filing

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23. However, William Landes and Richard Posner have argued for copyright protection that could be renewed indefinitely, in order to address congestion externalities and address incentives to invest in maintaining and exploiting copyrighted works. William M. Landes & Richard A. Posner, *Indefinitely Renewable Copyright*, 70 U. CHI. L. REV. 471 (2003).

24. Clarisa Long, *Information Costs in Patent and Copyright*, 90 VA. L. REV. 465, 525–33 (2004).

25. *See* Sheldon v. Metro-Goldwyn Pictures Corp., 81 F.2d 49, 54 (2d. Cir. 1936) ("[I]f by some magic a man who had never known it were to compose anew Keats's Ode on a Grecian Urn, he would be an 'author,' and, if he copyrighted it, others might not copy that poem, though they might of course copy Keats's.").

26. *See* 17 U.S.C. § 102(b) (2012) ("In no case does copyright protection for an original work of authorship extend to any idea, procedure, process, system, method of operation, concept, principle, or discovery, regardless of the form in which it is described, explained, illustrated, or embodied in such work.").

27. Patent employs its own limitations designed to screen out essential building blocks of invention, such as the proscription against patenting laws of nature and products of nature. *See* Mayo Collaborative Servs. v. Prometheus Labs., Inc., 132 S. Ct. 1289 (2012) (ruling on the patentability of laws of nature); Ass'n for Molecular Pathology v. Myriad Genetics, Inc., 133 S. Ct. 2107 (2013) (ruling on the patentability of products of nature).

28. 17 U.S.C. § 107 (2012). The existence of the fair-use doctrine considerably broadens the scope for some kinds of follow-on creativity, especially when the creativity engages in criticism, parody, or transformation of the existing work.

29. *See* Julie E. Cohen & Mark A. Lemley, *Patent Scope and Innovation in the Software Industry*, 89 CALIF. L. REV. 1, 6 (2001) (advocating for fair-use-like rights for reverse engineering in patent law).

date),[30] while copyright law provides incredibly long terms (often for the life of the author plus an additional seventy years).[31] This means that sequential innovators will be able to build on patented inventions much more rapidly than on copyrighted works.

More importantly, though, the scope of the rights with respect to sequential innovation differ between copyright and patent law. An author of a copyrighted work obtains the exclusive right not just to make and distribute literal copies of the work but also to create a wide range of other similar works. Thus, nonliteral but still "substantially similar" copies violate the owner's rights.[32] Even more broadly, the copyright owner obtains the exclusive rights to all actual or potential "derivative works" that arise from the copyrighted work, including all sequels, translations, recreations, and most other changes.[33] If someone writes a sequel to the *Rocky* movies, for example, the writer cannot obtain any rights in her sequel and is subject to a copyright lawsuit from Sylvester Stallone.[34] Accordingly, the would-be improver is effectively prevented from engaging in creating a new work until she has obtained the original copyright owner's permission.

By contrast, when it comes to the scope of rights and the ownership of follow-on innovation, patent law is much more responsive to downstream creators. First, patent law's counterpart to the derivative-works right, known as the doctrine of equivalents, protects a narrower range of nonidentical creations. Just as the scope of a copyright includes all works that are "substantially similar" to it, the scope of a patent extends to other inventions that are "insubstantially different" from it.[35] Despite the linguistic similarity of these standards,[36] patent's doctrine of equivalents gives patent owners a much narrower degree of control over variations on their work relative to copyright's rules regarding derivative works. Indeed, in recent years patent law's doctrine of equivalents has been narrowed substantially.[37] Moreover, when the

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30. 35 U.S.C. § 154(a)(2) (2012).

31. 17 U.S.C. § 302(a) (2012). This is the case for standard human authors. In the case of an anonymous work, a pseudonymous work, or a work made for hire, the copyright endures for a term of ninety-five years from the year of its first publication or a term of 120 years from the year of its creation, whichever expires first. 17 U.S.C. § 302(c) (2012).

32. Nichols v. Universal Pictures Corp., 45 F.2d 119, 121 (2d Cir. 1930) (stating that copyright law may not allow "plagiarist[s] [to] escape by immaterial variations"). The substantial similarity doctrine can extend protection to the work's plot, structure, characters, and "total concept and feel." Roth Greeting Cards v. United Card Co., 429 F.2d 1106, 1110 (9th Cir. 1970); Lemley, *supra* note 6, at 1016.

33. 17 U.S.C. § 106 (2012).

34. *See* Anderson v. Stallone, No. 87-0592 WDKGX, 1989 WL 206431 (C.D. Cal. Apr. 25, 1989) (dismissing the lawsuit of an author who wrote an authorized script for a new *Rocky* movie filed against Stallone for using aspects of the script in his own sequel).

35. Hilton Davis Chem. Co. v. Warner-Jenkinson Co., 62 F.3d 1512, 1521–22 (Fed. Cir. 1995).

36. *See* Martin J. Adelman & Gary L. Francione, *The Doctrine of Equivalents in Patent Law: Questions That* Pennwalt *Did Not Answer*, 137 U. PA. L. REV. 673, 703–06 (1989) (discussing the differences between copyright's substantial similarity doctrine and patent's doctrine of equivalents).

37. *See* John R. Allison & Mark A. Lemley, *The (Unnoticed) Demise of the Doctrine of Equivalents*, 59 STAN. L. REV. 955, 958 (2007) (demonstrating that the introduction of

downstream innovator's invention marks a sufficiently great improvement over the original patent, although still technically infringing it, the "reverse doctrine of equivalents" kicks in to vitiate liability.[38]

Most importantly, patent law allows follow-on creators to obtain IP rights in new improvements that use and borrow from, and thus infringe, protected inventions.[39] For example, if an inventor thinks of a way to improve the fuel economy of an existing, patent-protected engine, the inventor can obtain a separate patent on the improvement. The improver cannot make the improvement without infringing or licensing the original patent. And while the original inventor can keep making the original engine, he cannot incorporate the improvement without licensing it from the second inventor. The existence of these "blocking patents" means that both the initial inventor and the follow-on inventor must negotiate to produce the improved product.[40] This system of blocking patents gives both parties incentive to successfully complete negotiations if there is money to be made from the improved product.

For these reasons, and especially the last one, patent law is generally (but not inevitably) more supportive of follow-on innovators than copyright law is.[41] Would-be secondary inventors tend to face fewer challenges to sequential innovation than do would-be secondary authors. Why are the rules for improvements different in patent versus copyright? And do these doctrines efficiently balance rights between the two groups of creators?

Markman claim construction hearings was associated with a substantial decline in the application of doctrine of equivalents).

38. According to the Supreme Court:

> The patentee may bring the defendant within the letter of his claims, but if the latter has so far changed the principle of the device that the claims of the patent, literally construed, have ceased to represent his actual invention, he is as little subject to be adjudged an infringer as one who has violated the letter of a statute has to be convicted, when he has done nothing in conflict with its spirit and intent.

Westinghouse v. Boyden Power Brake Co., 170 U.S. 537, 568 (1898).

39. Lemley, *supra* note 6, at 1008–09.

40. *See* Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 COLUM. L. REV. 839, 860 (1990) ("Two patents are said to block each other when one patentee has a broad patent on an invention and another has a narrower patent on some improved feature of that invention.").

41. Lemley, *supra* note 6, at 1029. He writes:

> Comparing the treatment of improvers under patent and copyright law leads to a rather surprising result: copyright law is significantly more hostile to improvements than is patent law. What is surprising is not so much that the rules differ, but the way in which they differ. Copyright is traditionally thought to afford weaker, not stronger, protection than patent law, in part to compensate for the fact that copyrights are so much easier to obtain than patents and last so much longer. But in the context of improvements, the opposite result obtains.

Id. (footnotes omitted).

C. The Economics of Sequential Innovation

The economic rationales for these doctrines have been richly studied. These rationales include the benefits of having a single party direct investment in a resource, the likelihood that the initial creator or a secondary creator will produce valuable improvements, and the possibility of reducing duplicative and wasteful research. Numerous authors have assessed the different incentive effects of the patent and copyright systems' approaches to sequential innovation, often coming to different conclusions.[42]

Edmund Kitch first addressed the economics of sequential innovation in 1977.[43] Kitch analogized inventions (his sole focus) to a mineral claim,[44] and, accordingly, he emphasized the public-goods nature of technological information. In the absence of patent rights, the knowledge embodied in an invention could be easily shared with others without the inventor's consent. In Kitch's view, this would lead, inevitably, to an inefficient use of the invention in the same way that commonly owned property, like a mine, pasture, or lake, would be inefficiently used. Acting selfishly, others would try to use the invention quickly and for personal profit without thought to its long-term value and sustainability.[45] IP rights solve this tragedy of the commons, according to Kitch, by naming a manager of the invention and protecting his ability to efficiently use the invention.[46] Now, instead of allowing wasteful competing uses of an invention (such as when two competing firms attempt to develop improvements of the invention), the owner of the patent can direct and coordinate investments in sequential innovation in ways that will maximize the invention's value.[47]

As Mark Lemley points out,[48] although Kitch's analysis focused on patents, its structure is most similar to current copyright doctrine.[49] Consider its application to the author of a children's story. In the absence of copyright protection for derivative works, once the story is published and deemed successful, others will quickly race to capitalize on its value. Various authors might begin publishing sequels of the story,

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42. *See* LANDES & POSNER, *supra* note 7, at 108–15, 316–20; Lemley, *supra* note 6, at 1029–42; Merges & Nelson, *supra* note 40, at 843–44; Scotchmer, *supra* note 13, at 30–32; Deepa Varadarajan, *Improvement Doctrines*, 21 GEO. MASON L. REV. 657, 702–06 (2014); *see also* Pamela Samuelson, *The Quest for a Sound Conception of Copyright's Derivative Work Right*, 101 GEO. L.J. 1505 (2013).

43. Edmund W. Kitch, *The Nature and Function of the Patent System*, 20 J.L. & ECON. 265 (1977).

44. *Id.* at 266.

45. *Id.* at 273–74.

46. *Id*. at 276 ("No one is likely to make significant investments searching for ways to increase the commercial value of a patent unless he has made previous arrangements with the owner of the patent. This puts the patent owner in a position to coordinate the search for technological and market enhancement of the patent's value so that duplicative investments are not made and so that information is exchanged among the searchers.").

47. *Id.* ("[T]he patent owner has an incentive to make investments to maximize the value of the patent without fear that the fruits of the investment will produce unpatentable information appropriable by competitors.").

48. Lemley, *supra* note 6, at 1014.

49. *See supra* note 32.

while other companies compete to get a movie version into theaters the quickest. Still others may make toys and clothing using the story's characters. All of this investment in design, development, and marketing is potentially wasteful. The world may not need any movie versions of the story, never mind three of them. Moreover, a rational movie studio, knowing the kind of competition it will likely face from others, may simply abandon the project altogether. According to Kitch, by giving a single entity ownership over the whole field of derivative works, IP law prevents both the wastefulness and the lack of incentives. Coordinated investment in ideas is better than rivalrous investment.[50]

Robert Merges and Richard Nelson were among the first to critique Kitch's theory of sequential innovation.[51] Where Kitch saw competitive investment in potential improvements as wasteful, Merges and Nelson viewed it as a spur to creativity. They worried that granting a large IP prospect right to a creator might lead to inactivity and underinvestment as the original creator rested on its laurels.[52] In addition, Merges and Nelson were skeptical that a single owner of a broad right would efficiently manage the various and unpredictable improvements that the idea might spawn.[53] Although the firm that invents a technology had one good idea, there is little reason to think that it will have the second, third, or fourth good idea. Merges and Nelson thus favor a distributed approach to innovation that allows for many minds to tackle the possibilities created by a new idea.[54] While Kitch's prospecting inventor could certainly license all of these opportunities to others, in Merges and Nelson's account, the transaction costs of doing so would likely swamp the expected gains.[55]

Mark Lemley has also engaged in systematic analysis of IP improvement doctrines, and he too rejects the strong property rights approach favored by Kitch.[56] Lemley shares the concern that initial creators are not necessarily going to be the ones with the best ideas for improvement,[57] and he points out that it will be difficult for the optimal improvers to make themselves known to the owner of a broad IP right

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50. *See* Merges & Nelson, *supra* note 40, at 872.

51. *Id.*

52. *Id.* They explain,

> For one thing, under rivalrous competition in invention and innovation there is a stick as well as a carrot. Block rivalry and one blocks or greatly diminishes the threatened costs of inaction. Kitch assumes a model of individual or firm behavior where if an action is profitable it will be taken, regardless of whether inaction would still allow the firm to meet its desired (but suboptimal) performance goals.

Id.

53. *Id.* at 873.

54. *Id.* Because no one knows for sure what is likely to work, they argue, "[t]he only way to find out what works and what does not is to let a variety of minds try." *Id.*

55. Merges and Nelson support this contention by claiming that there is little evidence of this kind of large scale licensing of IP rights to others. *Id.* at 874–75. For recent empirical evidence, see Robin Feldman & Mark A. Lemley, *Do Patent Licensing Demands Mean Innovation*?, 101 IOWA L. REV. 137 (2015).

56. Lemley, *supra* note 6, at 1044.

57. *Id.* at 1048.

due to information-disclosure problems.[58] Lemley adds to the list of objections to Kitch's scheme concerns about transaction costs,[59] uncertainty,[60] externalities,[61] strategic behavior,[62] and noneconomic incentives.[63] Ultimately, he proposes that copyright law should adopt a system that incorporates some aspects of blocking patents by altering its derivative-works and fair-use doctrines.[64]

These economic analyses of sequential innovation attempt to answer questions about the appropriate scope of IP rights and whether copyright and patent laws should operate under different principles. Underlying all of them is a series of, sometimes explicit but often implicit, assumptions. These include some normative assumptions about the goals of IP doctrine;[65] and they also include descriptive assumptions about the behaviors of creators. The next section addresses these.

D. A Behavioral Approach to Sequential Innovation

Although the topic of sequential innovation has received sustained attention from theoretically oriented law and economics scholarship, the behavioral factors that might affect how innovators respond to the ways that legal regimes structure incentives have hardly been studied. The economic approaches that exist in the literature have generally assumed that innovators are rational actors who more or less accurately weigh the costs and benefits of behavior and respond predictably to the

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58. This is the problem known as Arrow's information paradox. See Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY: ECONOMIC AND SOCIAL FACTORS 609, 614–16 (1962). If a would-be improver cannot obtain property rights in the possible improvement, he cannot communicate to the patent owner without immediately rendering it valueless. If it is a good idea, the patent owner can simply usurp it for himself. Lemley, *supra* note 6, at 1051.

59. *Id.* at 1054–55. He writes:

> The presence of these costs in intellectual property licensing transactions leads to two types of first-order deviations from the efficient behavior predicted by economic models that do not account for transaction costs. First, some original inventors will inefficiently choose not to license potential improvers for their technology. This may happen either because the perceived value of the improvements is sufficiently small that it is overwhelmed by the transaction costs of licensing, or because the marginal value of having a third party (rather than the original inventor) develop the improvements does not outweigh the transaction costs of licensing. Second, some potential improvers who would seek a license for their improvements will no longer do so because of transaction costs.

Id. (footnote omitted).

60. *Id.* at 1055–56.

61. *Id.* at 1056–58.

62. *Id.* at 1058–59.

63. *Id.* at 1059–60.

64. *See id.* at 1073.

65. For example, is the goal faster progress towards a single optimal solution or slower development towards multiple optima? We discuss this issue *infra* note 177.

options provided.[66] Recent empirical research in the social sciences,[67] and even specific work in IP scholarship,[68] has questioned this assumption.

1. Deciding To Innovate or Borrow

This Article begins to apply the insights of the behavioral literature to some questions of sequential innovation. We begin with one of the principal decisions at the heart of sequential innovation: whether the follow-on creator should borrow from the existing creations or strike out and create something new. Of course, to a greater or lesser extent, all new creations borrow from already-existing works.[69] When the existing works are protected by IP rights, however, the secondary creator must decide whether to borrow from (and thus, usually, license) the existing works or whether to avoid the scope of the IP rights by creating something sufficiently different from the existing works. The specific question we are interested in, then, is how creators decide whether to license existing IP rights or to "invent around" that IP by creating something that does not infringe the patent or copyright. For the remainder of this paper, we will refer to licensing IP as "borrowing" and inventing around IP as "innovating."[70]

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66. *See, e.g.*, Lemley, *supra* note 6, at 994 ("In a private market economy, individuals will not invest in invention or creation unless the expected return from doing so exceeds the cost of doing so—that is, unless they can reasonably expect to make a profit from the endeavor.").

67. *See* Samuel Issacharoff, *Can There Be a Behavioral Law and Economics?*, 51 VAND. L. REV. 1729 (1998); Christine Jolls, Cass R. Sunstein & Richard Thaler, *A Behavioral Approach to Law and Economics*, 50 STAN. L. REV. 1471 (1998); Russell B. Korobkin & Thomas S. Ulen, *Law and Behavioral Science: Removing the Rationality Assumption from Law and Economics*, 88 CALIF. L. REV. 1051 (2000); Russell Korobkin, *The Endowment Effect and Legal Analysis*, 97 NW. U. L. REV. 1227 (2003); *see also* Richard Thaler, *Toward a Positive Theory of Consumer Choice*, 1 J. ECON. BEHAV. & ORG. 39, 45 (1980) (showing that people respond differently to a situation referred to as a "cash discount" than to an identical one labeled a "credit card surcharge"); Amos Tversky & Daniel Kahneman, *The Framing of Decisions and the Psychology of Choice*, 211 SCIENCE 453, 453 (1981) (showing that people's preferences for an identical situation change depending on whether people imagine saving lives or allowing people to die).

68. Christopher Buccafusco & Christopher Jon Sprigman, *The Creativity Effect*, 78 U. CHI. L. REV. 31, 36–39 (2011) [hereinafter Buccafusco & Sprigman, *The Creativity Effect*]; Christopher Buccafusco & Christopher Jon Sprigman, *Valuing Intellectual Property: An Experiment*, 96 CORNELL L. REV. 1, 23–25 (2010); Christoph Engel & Michael Kurschilgen, *Fairness Ex Ante and Ex Post: Experimentally Testing Ex Post Judicial Intervention into Blockbuster Deals*, 8 J. EMPIRICAL LEGAL STUD. 682 (2011); Christopher Jon Sprigman, Christopher Buccafusco & Zachary Burns, *What's a Name Worth?: Experimental Tests of the Value of Attribution in Intellectual Property*, 93 B.U. L. REV. 1389, 1405–20 (2013); Stefan Bechtold & Christoph Engel, *The Price of Moral Rights: A Field Study* (2015) (unpublished manuscript, on file with the authors).

69. JULIE E. COHEN, CONFIGURING THE NETWORKED SELF: LAW, CODE, AND THE PLAY OF EVERYDAY PRACTICE 87 (2012) ("[T]he well-known history of both classical and contemporary art forms illustrates the centrality of copying within creative practice.").

70. In some respects, this borrow/innovate decision bears strong parallels with the make/buy decision that animates theory-of-the-firm analysis. *See* R.H. Coase, *The Nature of*

Borrowing and innovating are both important aspects of creativity. Although narratives of creativity stress "eureka" moments and pioneering achievements that seem wholly original, these stories do not accurately capture the creative process.[71] But more than just being descriptively inaccurate, this strict preference for novelty and innovation is also normatively unjustified. Extreme innovations are not always publicly valued.[72] And, more importantly, in many situations innovation is socially costly. Although creating around existing ideas may produce new ones, these new ideas may not be better ones.[73] And the costs in terms of time, research, and experimentation that are necessary to produce innovations may vastly exceed the price of a license to borrow from existing ideas. In these cases, borrowing is the optimal strategy. Sometimes it is better to take the road less traveled and other times it is better to stand on the shoulders of giants.[74] Therefore, it is important to know whether creators are choosing accurately between innovating and borrowing in different creative contexts—and whether the law is affecting that choice for better, for worse, or at all.

According to rational choice theory, a would-be creator faced with this borrow/innovate decision should compare the costs and benefits of borrowing with the costs and benefits of innovating. Borrowing entails a variety of costs, including, primarily, licensing fees and transaction costs. Innovating, on the other hand, may involve substantial investments in research and experimentation that borrowing does not. Secondary creators must make tradeoffs between the respective costs of licensing fees versus research and development. Thus, if the costs of borrowing increase, all else equal, creators should be more likely to innovate.

In addition, because innovation always involves uncertainty, would-be innovators must consider the extent to which innovation may even be possible.[75] Sometimes developing a new idea that does not infringe the rights of existing ideas will be easy, but other times it will be incredibly difficult. Prior to experimenting, though, it can be incredibly difficult to figure out which situation pertains. We can think of the difficulty of innovating in terms of the proportion of the total "innovation space" that

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the Firm, 4 ECONOMICA 386 (1937). We have begun work on an article that spells out these insights in more detail.

71. *See* JESSICA SILBEY, THE EUREKA MYTH: CREATORS, INNOVATORS AND EVERYDAY INTELLECTUAL PROPERTY (2015) (describing the responses of interviews with dozens of creators about the processes and motivators of creativity).

72. *See* Jeanne C. Fromer, *A Psychology of Intellectual Property*, 104 NW. U. L. REV. 1441, 1479 (2010) ("In the arts, while the newness component of creativity is valued in our individualist culture, for typical audience members and in most artistic contexts—as explained herein—it is important that artists not stray too far from accepted conventions, a concern that is not present in scientific and engineering invention.").

73. It is for this reason that we prefer to focus on "creating around" rather than on "improvements," as some scholars do. *See* Joseph P. Fishman, *Creating Around Copyright*, 128 HARV. L. REV. 1333, 1351–58 (2015) (describing various scholars' views regarding improvements and inventing around and/or creating around).

74. To seriously mix metaphors.

75. Merges and Nelson explain, "In [Kitch's] models the 'fish' or the 'minerals' are out there and known (with perhaps some uncertainty) to all parties. But with the technological 'prospects,' and perhaps even real life mineral prospects, no one knows for sure what possible inventions are in the technological pool." Merges & Nelson, *supra* note 40, at 873.

the existing IP-protected ideas cover.[76] In an emerging field, innovating may be relatively easy compared to a mature field where it is much harder to produce new work. For example, coming up with an improvement in the field of grand piano technology is hard these days, as most of the technological advances for this instrument were made in the nineteenth and early twentieth centuries.[77] Compare this to the relative ease of coming up with the new instrument of the electroencephalophone, which uses brain waves to generate sounds.[78] Accordingly, the more innovation space that remains free to explore, the more likely follow-on creators should be to innovate rather than borrow.

2. Biases in Rational Decision Making

An immense body of empirical research demonstrates that people often deviate from the predictions of rational-choice theory when engaged in uncertain decision making.[79] People overweight some probabilities and underweight others.[80] They respond differently to situations that are identical except for slight differences in framing.[81] And they are sensitive to extraneous information that should not affect their decisions.[82] We are interested in the extent to which similar issues arise with respect to creators' innovate/borrow decisions.

In particular, we are interested in the role that heuristic decision making may play in creators' behavior. Making complex decisions about whether to borrow existing ideas or create around them involves compiling and assessing a variety of different information. As we described above, creators must compare the costs of innovating with the ease of doing so. Behavioral science research has consistently shown that when people are forced to make difficult decisions, they often simplify the task by substituting easy questions for hard ones. This is known as *heuristic* decision making.[83] For example, when asked which is more likely, a word that starts with the letter *K* or a word that has *K* as its third letter, people find it easier to think of the

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76. Merges and Nelson refer to this as the "patent breadth" that a given IP right covers. Ideas with lots of possible avenues for development are broad prospects, while those with few avenues are narrow. Merges & Nelson, *supra* note 40, at 880–908.

77. Keith T. Comparetto, *The Piano in History: A "Clever Bundle of Inventions"*, ALLEGRO PIANO PAGES, www.allegropianoworks.com/piano_history.htm [https://perma.cc/EA9C-KYQD] ("By [1900], the instrument had reached such a degree of perfection that no major change has occurred since.").

78. Thomas R. Henry, *Invention Locates Hurt Brain Cells*, N.Y. TIMES, Mar. 2, 1943, at 21.

79. *See* DANIEL KAHNEMAN, THINKING, FAST AND SLOW (2011) (surveying this research). For applications of this research to the law, see Jolls et al., *supra* note 67.

80. Daniel Kahneman & Amos Tversky, *Prospect Theory: An Analysis of Decision Under Risk*, 47 ECONOMETRICA 263, 263 (1979).

81. *See* Amos Tversky & Daniel Kahneman, *Judgment Under Uncertainty: Heuristics and Biases*, 185 SCIENCE 1124 (1974).

82. Nicholas Epley & Thomas Gilovich, *The Anchoring-and-Adjustment Heuristic: Why the Adjustments Are Insufficient*, 17 PSYCHOL. SCI. 311 (2006) (noting that people's judgments of numerical quantities are biased by recent but unrelated numerical information).

83. KAHNEMAN, *supra* note 79, at 97–98.

former than the latter, so they tend to say that a word that starts with the letter *K* is more probable. In fact, it is less likely.[84]

Sometimes, as in the above example, heuristics lead to substantial errors. In other cases, however, heuristics do very well and save on cognitive resources.[85] Often, the success of the heuristic depends on how well it is adapted to the situation. If the information that is ignored by the heuristic is relatively unimportant, people may make as good or even better decisions than do those using more traditionally "rational" processes.[86] If the ignored information is key to a decision, however, people employing heuristics may perform very poorly. For example, heuristic decision making can lead people to treat identical values as highly different and also to treat very different values as identical. People often treat the same number of deaths from disease differently when those deaths are referred to in the context of "lives saved" rather than simply as "deaths."[87] And, on the contrary, people are often willing to pay the same amount of money to save 2000, 20,000, or 200,000 birds.[88] When people are asked to solve complicated problems, their brains often substitute easier problems instead.

Given the complexity of innovate/borrow decisions, we anticipate that people are likely to approach them heuristically. We expect that people may ignore important information about the decision-making context, and that this ignorance may affect the quality of the decisions that they make.

Our experiments model two features of sequential innovation decision making: variations in the cost of borrowing and variations in the scope of innovation. They allow us to test the assumptions that underlie the economic theories discussed above and to study whether heuristics influence creators' innovation behavior. We ask (1) to what extent are creators' innovate/borrow decisions sensitive to the costs of borrowing IP; and (2) to what extent are creators' innovate/borrow decisions sensitive to the scope of the available solution space. To test the hypotheses generated by the rational choice account, we have designed a series of experiments in which subjects are randomly assigned to conditions that differ according to the costs of borrowing and according to the available solution space.

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84. Amos Tversky & Daniel Kahneman, *Availability: A Heuristic for Judging Frequency and Probability*, 5 COGNITIVE PSYCHOL. 207, 211 (1973).

85. *See* GERD GIGERENZER, PETER M. TODD & ABC RESEARCH GRP., SIMPLE HEURISTICS THAT MAKE US SMART (1999). For example, physicians using the correct heuristic do a better job of treating patients with heart conditions than do those who attempt to assess a wide range of factors. For an excellent treatment of the relationship between the "heuristics and biases school" and the "fast and frugal school" of heuristics scholarship see MARK KELMAN, THE HEURISTICS DEBATE (2011).

86. GERD GIGERENZER, GUT FEELINGS: THE INTELLIGENCE OF THE UNCONSCIOUS (2008) (discussing situations in which heuristics work well).

87. Tversky & Kahneman, *supra* note 67, at 453. In this study, subjects vastly preferred a medical treatment when it was described as saving people's lives compared to an otherwise identical treatment when it was described as the number of people who would die.

88. William H. Desvousges, F. Reed Johnson, Richard W. Dunford, Sara P. Hudson, K. Nicole Wilson & Kevin J. Boyle, *Measuring Natural Resource Damages with Contingent Valuation: Tests of Validity and Reliability*, *in* CONTINGENT VALUATION: A CRITICAL ASSESSMENT 91, 94 (1993). This behavior is often known as "scope neglect."

II. EXPERIMENTS ON SEQUENTIAL INNOVATION

We ran a series of experiments designed to understand how people innovate subject to constraints on their choices. This Part describes those experiments and their results.

A. Experiments 1 and 2: Sensitivity to the Costs of Borrowing and Innovating

Our first two experiments explore the extent to which creators are sensitive to the costs associated with borrowing from existing IP. Existing rights impose constraints on creators' ability to solve problems, and they should be willing to pay some amount of money to license existing rights to ease those constraints. Here, we are interested in understanding how creators respond to changes in the costs of borrowing from existing rights.

1. Experiment 1: Design

Our first experiment involved a computer-based creativity game derived from a type of combinatorial optimization math problem known as a "knapsack problem." Subjects were told to imagine that they were traders in the Old West.[89] Their goal was to fill their covered wagons with a selection of goods that had maximal value but that did not exceed the wagon's weight limit.[90] Subjects were told of the wagon's weight limit, then they were shown twelve items that may be placed in the wagon. Each item had a dollar value and a weight. Subjects were given a time limit (ninety seconds in each of these experiments) in which to play the game. The game was scored based on the percentage of the maximum possible wagon value (that is, if the maximum value of a wagon is $100 and a subject's solution is worth $80, the subject receives eighty points). Solutions that exceed the weight of the wagon received zero points.

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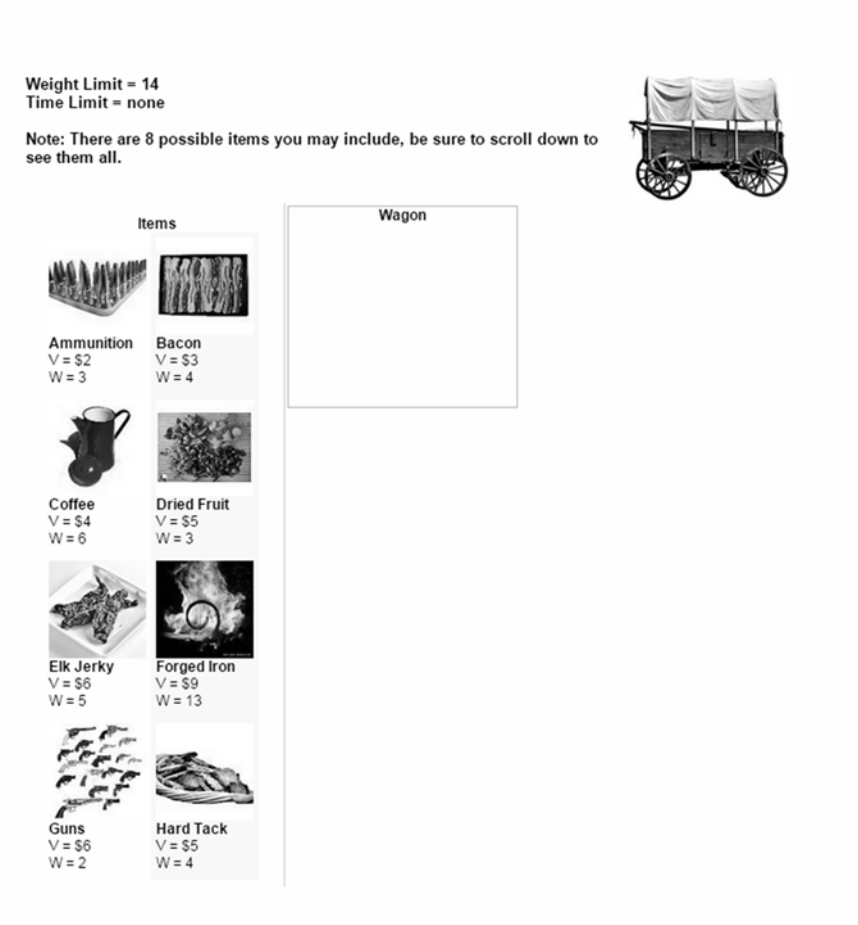
89. We hoped that some subjects might recall the Oregon Trail computer game of the 1990s and treat our game similarly.

90. We have used a similar version of this game in a recent paper. Christopher Buccafusco, Zachary C. Burns, Jeanne C. Fromer & Christopher Jon Sprigman, *Experimental Tests of Intellectual Property Laws' Creativity Thresholds*, 92 TEX. L. REV. 1921, 1949–50 (2014). To our knowledge, the first application of a knapsack problem to innovation research was in Debrah Meloso, Jernej Copic & Peter Bossaerts, *Promoting Intellectual Discovery: Patents Versus Markets*, 323 SCIENCE 1335 (2009).

Figure 1. Practice Screen



Subjects were first given a simple version of the game (see Figure 1) as practice to familiarize themselves with the task. This session was untimed and unpaid. In the live game, subjects were given ninety seconds to find a solution to a significantly harder problem. This time period is generally too short to allow subjects to calculate the correct answer.[91] Instead, they must rely on heuristics to reach an answer. This kind of heuristic problem solving is similar to the kinds of innovation that take place in a number of fields, including computer science, biology, and engineering.

For our first experiment, we studied how people responded to variations in the costs of innovating and borrowing. As we described above, borrowing from existing creations is typically costly because those creations are covered by IP rights that must be licensed. Accordingly, as the cost of borrowing increases, we would expect that the rate of innovation will also increase, all else being equal. This experiment

91. Knapsack problems are NP-hard problems that are hard to solve mathematically. NP problems are problems for which a polynomial time verification algorithm exists. *See* HANS KELLERER, ULRICH PFERSCHY & DAVID PISINGER, KNAPSACK PROBLEMS 486–87 (2004).

manipulates the costs of innovating and borrowing in order to assess subjects' sensitivity to costs.

After the practice round but before they played the live game, subjects were told that another subject had already played the game. Subjects were told that they would be shown the other player's submission and that the subject's payouts would be based on how many items from the other player's submission they chose to use in their submission. Subjects would receive a bonus for innovating—in this case, using two or fewer of the items from the other player's submission. They were told that their score would be calculated as indicated in Table 1.

Table 1. Experiment 1 score calculation

Use three or more items:	Use two or fewer items:
SS	SS + X

SS indicates the subject's "submission score" as described above (percentage of maximum score). X is the size of the bonus for innovating. Subjects were not told about the quality of the given submission, but they could attempt to estimate it during gameplay.

We ran six different conditions in which X equaled 1, 8, 16, 32, 58, and 72 additional bonus points for innovating. This method allowed us to determine the implicit value that subjects placed on borrowing versus innovating. In the standard sequential innovation setting, borrowing comes with the cost of a license fee. Here, instead of charging a fee to borrow, we paid subjects a bonus to innovate.[92] The payout structure can be viewed as an offer to the subject to innovate: *Are you willing to take X additional points in order to innovate instead of borrow*? As the size of the bonus increases, the percentage of subjects choosing to innovate should also increase.

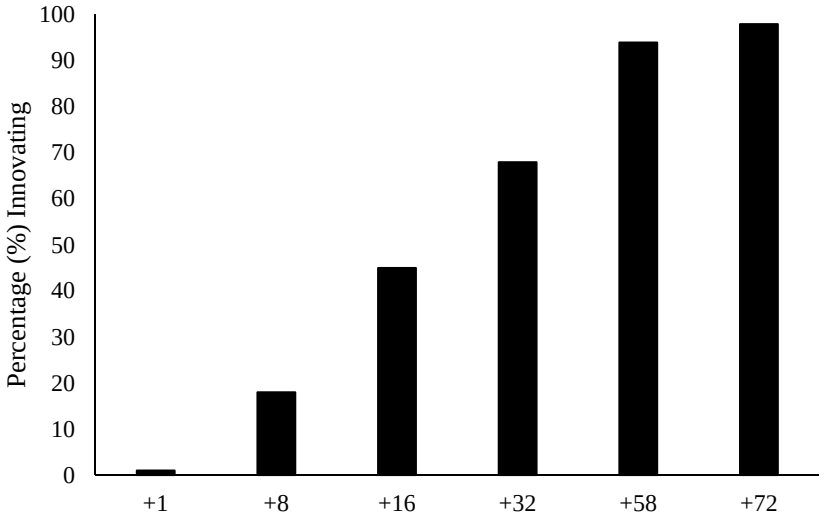
We were able to estimate a rational indifference range (albeit not a single indifference point) between borrowing and innovating by comparing the value of the available solutions that borrow to the value of the available solutions that do not borrow.[93] The range at which rational subjects should be indifferent between

92. In theory, paying subjects to innovate should have similar incentive effects, although the behavioral science research suggests that it may have different practical effects. Prospect theory predicts that people will treat potential losses as more serious than they will treat equivalent sized potential gains. This perception might affect the value that they implicitly give the opportunity to innovate or borrow. *See* Tversky & Kahneman, *supra* note 81; Kahneman & Tversky, *supra* note 80.

93. In our experiment, 442 solutions led to a higher knapsack weight than the solution provided to our subjects. If subjects decided to borrow, all of these solutions were available to them; if subjects decided to innovate, only some of these solutions were available. As it was impossible to identify these solutions in the given time frame and calculate their values, subjects had to employ search heuristics. The precise indifference point between borrowing and innovating depends on the assumptions employed regarding a rational subject's search strategy and heuristics. Possible heuristics include, among others, using items that have the highest weight; using items that have the highest ratio of value over weight; focusing on a random subset of potential solutions and selecting the best from this subset; or searching for an almost optimal solution instead of a perfect solution. For an in-depth treatment of approximation algorithms to knapsack problems, see KELLERER ET AL., *supra* note 91, at 29–42, 161–83. In general, subjects who are better at the game should be willing to accept less to innovate than

innovating and borrowing should fall between ten to twenty additional points for innovating.[94] Accordingly, we expected that very few subjects would be willing to innovate for only one bonus point and that almost all subjects would innovate when offered fifty-eight or seventy-two bonus points. In addition, we expected innovation rates would be about 50% for conditions close to the indifference point.

Figure 2. Expected results: predicted percentage innovating



subjects who are not as good at the game.

94. Among the various search heuristics that a rational subject could employ (*see supra* note 93), we considered a handful of different approaches to determine indifference points. Thus, we calculated the indifference points 1) for hypothetical subjects identifying the entire solution space available to them if they decided to innovate or borrow, then randomly picking twenty solutions from this space, choosing the best among these solutions for innovating and borrowing, and then comparing their values (indifference point: 18.69); 2) for hypothetical subjects identifying all solutions with the highest possible number of items, randomly picking one solution for innovating and one solution for borrowing from this solution space, and comparing their values (indifference point: 11.74); 3) for hypothetical subjects identifying all solutions with either the highest or the second-highest possible number of items, randomly picking one solution for innovating and one solution for borrowing from this solution space, and comparing their values (indifference point: 14.94); 4) for hypothetical subjects identifying all solutions with either the highest or the second-highest possible number of items, randomly picking five solutions solution for innovating and five solutions for borrowing from this solution space, choosing the best one each and then comparing their values (indifference point: 12.03); and 5) for hypothetical subjects identifying all solutions with either the highest or the second-highest possible number of items, randomly picking twenty solutions for innovating and twenty solutions for borrowing from this solution space, choosing the best one of each and then comparing their values (indifference point: 9.19). This is based on a calculation of the expected solution strengths if one reiterates the random selection processes described. The calculated indifference points indicate the points at which these random selection processes converge.

After the subjects played the game, they were asked two comprehension questions to ensure that they understood how the rules and payoffs worked. In addition, subjects answered a number of demographic and follow-up questions regarding their age, gender, education, primary language spoken, and self-perceived mathematical ability. Subjects were also asked a general question about their risk tolerance,[95] and they completed a fifty-item personality inventory based on the "Big Five" theory of personality.[96]

2. Experiment 1: Results

Using Amazon Mechanical Turk (AMT), we recruited subjects to participate in the experiment on creativity.[97] Subjects were paid $0.50 as a show-up fee, and they

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95. Subjects were asked: "Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?"

96. We used a fifty-item questionnaire from the International Personality Item Pool. INT'L PERSONALITY ITEM POOL, http://ipip.ori.org [https://perma.cc/6LYL-3WAP]. The precise questions were adapted from Ruth Maria Stock, Eric von Hippel & Lennart N. Schnarr, Impacts of Personality Traits on Consumer Innovation Success (July 16, 2014) (unpublished manuscript), *available at* http://ssrn.com/abstract=2467152 [https://perma.cc/E224-R3F7]. *See generally* Lewis R. Goldberg, *The Structure of Phenotypic Personality Traits*, 48 AM. PSYCHOLOGIST 26 (1993) (describing the history of the Big Five theory of personality).

97. Subjects were recruited to participate in a study on creativity. There is an extensive debate about how subjects recruited through AMT compare to traditional laboratory experiments or other population. Some of that literature is cited below in this footnote. As we discuss in Part III.C, however, we believe there are good reasons for using AMT in a study like ours. For example, many of the criticisms of AMT relate to its representativeness with respect to the U.S. population. The phenomena we are studying—creativity behaviors—are carried out largely by people who resemble the AMT population, that is, the young and technologically savvy. *See* Adam J. Berinsky, Gregory A. Huber & Gabriel S. Lenz, *Evaluating Online Labor Markets for Experimental Research: Amazon.com's Mechanical Turk*, 20 POL. ANALYSIS 351 (2012) (showing that AMT subject pools are often more representative of the U.S. population than in-person convenience samples, but less representative than subjects in Internet-based panels or national probability samples); Chien-Ju Ho, Aleksandrs Slivikins, Siddharth Suri & Jennifer Wortman Vaughan, *Incentivizing High Quality Crowdwork*, 24 INT'L CONF. ON WORLD WIDE WEB 419 (2015), *available at* http://www.www2015.it/documents/proceedings/proceedings/p419.pdf (showing how performance-based payments improve quality of AMT participant responses); John J. Horton, David G. Rand & Richard J. Zeckhauser, *The Online Laboratory: Conducting Experiments in a Real Labor Market*, 14 EXPERIMENTAL ECON. 399 (2011) (showing similar internal and external validity of online experiments, compared to laboratory and field experiments); Yanna Krupnikov & Adam Seth Levine, *Cross-Sample Comparisons and External Validity*, 1 J. EXPERIMENTAL POL. SCI. 59 (2014) (showing that AMT subjects behave differently than student and adult samples); Richard N. Landers & Tara S. Behrend, *An Inconvenient Truth: Arbitrary Distinctions Between Organizational, Mechanical Turk, and Other Convenience Samples*, 8 INDUS. & ORGANIZATIONAL PSYCHOL. 142 (2015) (discussing sampling strategy in general); Leib Litman, Jonathan Robinson & Cheskie Rosenzweig, *The Relationship Between Motivation, Monetary Compensation, and Data Quality Among US- and India-Based Workers on*

were paid an additional $0.03 per point they scored in the game. The minimum payment was $0.50 and the maximum was $4.40. Five-hundred-ninety-eight subjects participated in the experiment. From this pool, we removed 10 subjects who failed an attention check at the end of the experiment. We also removed an additional 143 subjects who failed either or both of the comprehension questions that tested subjects' understanding of the rules and payouts. After removing another 13 subjects who had gone over the weight limit, this left 432 subjects, of whom 58.8% were male. There were no significant differences in the rates of being excluded between the conditions.[98]

Our data present an unusual picture of subjects' responsiveness to innovation incentives. Overall, 68.06% of the subjects chose to innovate rather than borrow. Surprisingly, however, we see almost no evidence of sensitivity to the magnitude of the offered innovation bonus. Innovation rates for the subjects offered only one additional bonus point were somewhat lower than for those offered eight additional bonus points, but we see no significant differences in rates of innovation between any of the other conditions. Substantial increases in bonuses had no meaningful effect on innovation rates.

Table 2. Percentage innovating per bonus condition

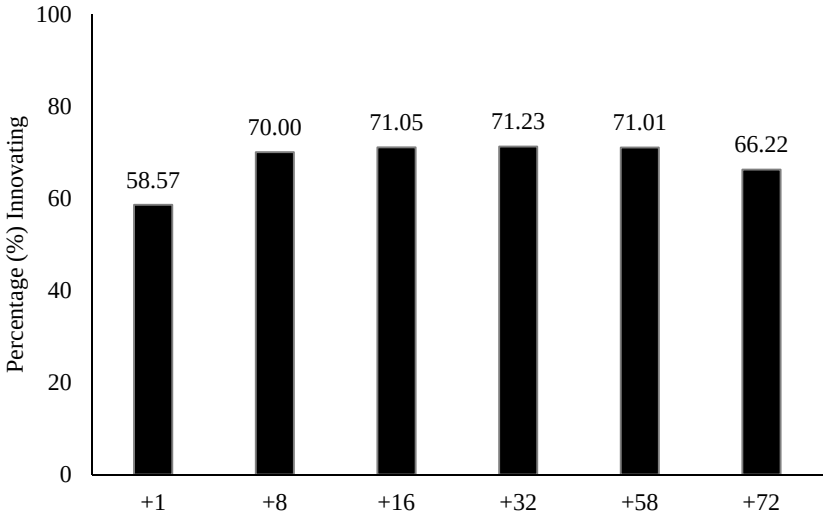
	+1	+8	+16	+32	+58	+72
Percentage (%) innovating	58.57	70.00	71.05	71.23	71.01	66.22

Note: +1 versus +8 condition: one-tail t-test, $p = 0.079$; two-tail t-test, $p = 0.159$.
+1 condition v. the mean of all other conditions: two-tail t-test, $p = 0.070$.
All other differences are nonsignificant.

Mechanical Turk, 47 BEHAV. RES. METHODS 519 (2015) (discussing optimal mechanisms for improving data quality on AMT); Gabriele Paolacci, Jesse Chandler & Panagiotis G. Ipeirotis, *Running Experiments on Amazon Mechanical Turk*, 5 JUDGMENT & DECISION MAKING 411, 417 (2010) ("Workers in Mechanical Turk exhibit the classic heuristics and biases and pay attention to directions at least as much as subjects from traditional sources."); Dan Kahan, *What's a "Valid" Sample? Problems with Mechanical Turk Study Samples, Part 1*, CULTURAL COGNITION PROJECT (July 8, 2013, 9:34 AM) http://www.culturalcognition.net/blog/2013/7/8/whats-a-valid-sample-problems-with-mechanical-turk-study-sam.html [https://perma.cc/4QU2-FAZH] (discussing the validity of study samples in general); Dan Kahan, *Fooled Twice, Shame on Who? Problems with Mechanical Turk Study Samples, Part 2*, CULTURAL COGNITION PROJECT (July 10, 2013, 9:30 AM), http://www.culturalcognition.net/blog/2013/7/10/fooled-twice-shame-on-who-problems-with-mechanical-turk-stud.html [https://perma.cc/59VN-N7B5] (discussing problems of the AMT subject pool in general). Replication of the experiments reported in this article in a social science laboratory is left to future work.

98. By condition, the number of subjects excluded for overweight wagons is as follows: +1 = 1; +8 = 4; +16 = 5; +32 = 4; +58 = 2; +72 = 1. All comparisons are nonsignificant.

Figure 3. Percentage innovating per bonus condition



In sum, our subjects were surprisingly unmoved by alterations in the size of the bonus provided for innovating. Although the bonus available for innovating increased starkly between conditions, subjects were unresponsive to these changes. Their insensitivity is striking at both the low and the high ends of the scale. At the +1 bonus level, 58.57% of our subjects chose to innovate even though the incentive to do so was minimal. The other player's submission was a good one (it scored 90% of the total points), so inventing around it was difficult. Faced with this difficulty, subjects should not have been willing to forego the opportunity to borrow in favor of a single point (equivalent to $0.03). Where we had expected to see little or no innovating, in fact, more than half of the sample chose to innovate. The inverse is true at the other end of the scale. Subjects in the +58 and +72 bonus conditions received what should have been entirely supernumerary incentives to innovate, yet barely more than two-thirds of subjects chose to do so. These subjects could have increased their payments significantly, by 50% or more. With this many bonus points at stake, subjects could have easily scored more by innovating, but many still decided not to.

These anomalies in the extreme conditions had significant effects on the payouts the subjects received. The nearly 60% of subjects who chose to innovate in the +1 condition scored significantly worse than did those who chose to borrow. And the subjects who chose to borrow in the +32, +58, and +72 bonus conditions received much smaller payouts than did those who innovated.[99]

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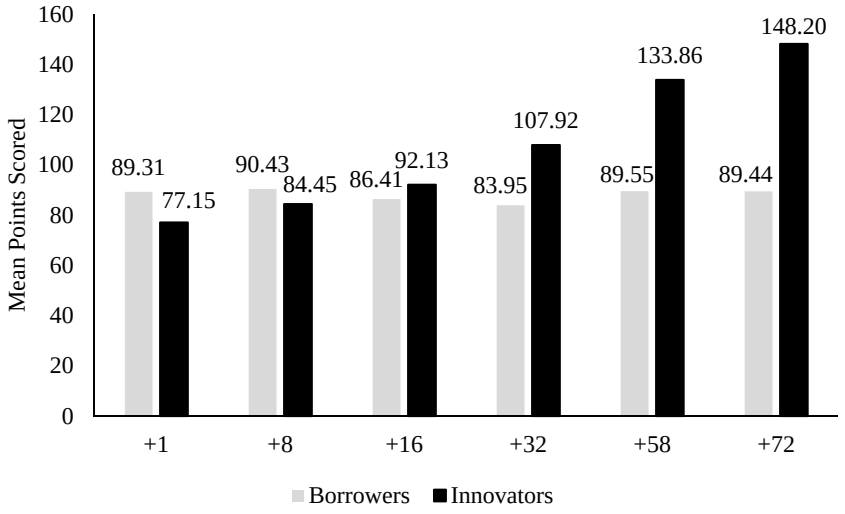
99. As with all of the previous and subsequent analyses, these exclude the players who entered submissions that exceeded the wagon's weight limit. Because these players received zero points, entering their data into this analysis would have produced unnecessary variability. Players with overweight wagons did not different significantly between conditions. *See supra* note 98.

Table 3. Mean scores of innovators versus borrowers by condition

	+1	+8	+16	+32	+58	+72
Innovators	77.15***	84.45	92.13	107.92***	133.86***	148.20***
Borrowers	89.31***	90.43	86.41	83.95***	89.55***	89.44***

Note: The stars indicate that the mean scores of innovators and borrowers within a particular condition differ significantly. *** $p < 0.01$. All others are nonsignificant.

Figure 4. Mean scores of innovators versus borrowers by condition



Significant numbers of our subjects were leaving money on the table. Their innovate/borrow decisions were clearly suboptimal from the perspectives of both individual welfare and social welfare. The scope of the individual suboptimal behavior is readily apparent. Subjects who chose unwisely had significantly lower returns.[100] We can also estimate the social loss by comparing the actual points scored for all players with the number of points that would have been scored had all of the players chosen optimally. We will assume that all of the players would have received the same scores as did those who chose optimally. In the +1 condition, the combined score of innovators and borrowers was 8218. Had all the subjects borrowed, however, they would have scored 8931 points, an 8.67% increase.[101] In the +72 condition, the combined score of innovators and borrowers was 12,835. But had all of the subjects innovated, their combined score would have been approximately 14,820, a 15.46% increase. These differences represent estimates of the lost social welfare from suboptimal decision making.[102]

100. *See supra* Table 3 and Figure 4.

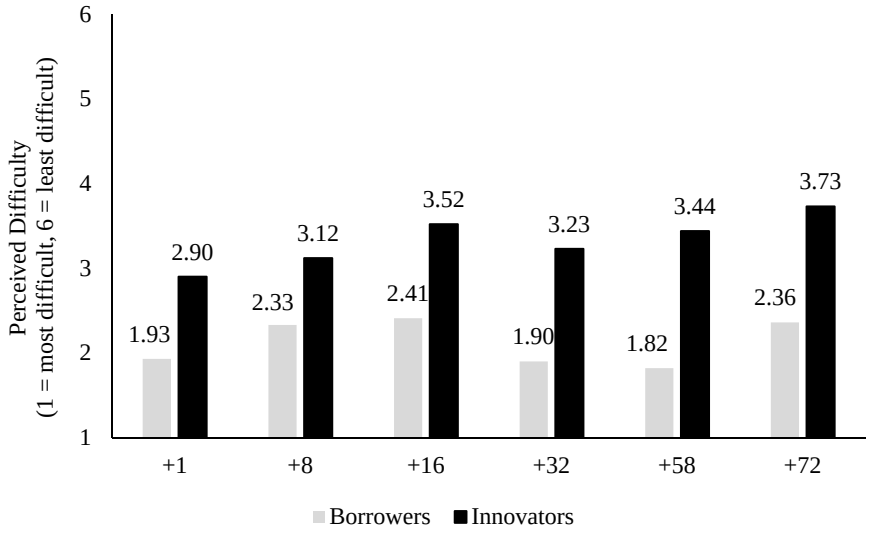
101. We arrived at these figures by adding the points scored by innovators with the points scored by borrowers. To calculate the scores if everyone had played optimally, we assigned the mean score of the borrowers to each of the innovators.

102. Creators who experience positive welfare from innovating or borrowing might offset

Given the magnitude of these effects, it is important to ask why our subjects were almost entirely unaffected by the size of the bonus offered for innovating and why so many of them made suboptimal decisions. One possibility is that they were simply not paying attention or trying terribly hard, and, thus, when confronted with the instructions, they breezed through the game without thinking. We have a number of reasons for doubting that this is the case. First, we discarded a number of subjects who failed the comprehension or attention questions. Moreover, previous experience with AMT subjects suggests that they are generally well motivated to perform these kinds of tasks, especially when performance is linked with increased payment.[103]

Most importantly, subjects were asked a follow-up question about how easy they thought it was to find a solution that did not borrow two or more of the items from the other player's submission. Looking at Figure 5, it seems that the easier subjects thought innovating was, the more likely they were to innovate.

Figure 5. Mean perceived difficulty of innovating



We ran logistic regression analyses of these and other demographic and follow-up questions. The regression tables are reported in Appendix A. They confirm that

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these estimates. Thus, for example, if creators think that it is fun and challenging to innovate their own solutions even when good ones already exist, their pleasure may help make up for the costly expenditures of resources involved in innovating. Or if creators enjoy borrowing even when a substantial share of the innovation space remains open, their enjoyment too could conceivably explain, at least in part, why many subjects chose to borrow in conditions where the bonuses heavily favored innovation.

103. *See* Sprigman et al., *supra* note 68, at 1405–11. In addition, most of our subjects took the full ninety seconds to play the game, and their self-reported motivation to score well was generally high. Over 88% of our subjects reported that they were motivated or highly motivated to score well. If they were not trying hard, they could simply move some items to the wagon and submit the game early.

subjects were paying attention and responding rationally to the problem presented to them, at least within the context of their own beliefs.[104] Those subjects who were innovating were likely doing so because they thought it was relatively easy to do (whether it was or not).[105] Accordingly, the decision to innovate in the +1 condition might have been driven by overconfidence in the subject's ability to find a noninfringing solution.[106] And the inverse is likely true for those who borrowed in the high bonus conditions. They may have been insufficiently confident of how easily they would be able to innovate and reap the large bonuses available.[107]

A further and related possibility is that our subjects' insensitivity to the bonus size suggests that there may be individual differences between people's willingness to engage in innovation. Raustiala and Sprigman have discussed the differences between "tweakers," who tend to make minor improvements on existing creations, and "pioneers," who prefer to attempt major innovations.[108] Pioneers tend to receive a lot of attention, because the scope of their innovations makes the value of their contributions seem obvious. But tweakers are important too. Their efforts refine and improve the initial pioneering innovation, helping to figure out the best way to implement it. And by altering and adapting the innovation, tweakers point out its flaws and prepare the ground for the next pioneer.[109]

Although there have been volumes of papers published on the relationship between individual characteristics and creativity, as yet, we could find no research directed to distinguishing between the creativity of tweakers and pioneers. We

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104. *See infra* Appendix A, Regressions 4 and 5. In all regression analyses of Experiment 1, the ease with which subjects believed they would be able to innovate was strongly correlated with whether they did, in fact, innovate. Interestingly, the easier subjects thought the game was in general, the more likely they were to borrow rather than innovate. This makes sense: because innovating restricts the sample of items that can be used, it should be easier to find a solution when borrowing.

105. We cannot be sure that subjects' beliefs were, in fact, causing their behavior because their beliefs were reported after they played the game. It is possible that subjects who innovated felt compelled to say that they found innovating easy and that subjects who borrowed thought they needed to say that innovating was hard in order to justify their behaviors.

106. We have seen similar kinds of overconfidence affect creators' behavior in our earlier experiments. *See* Buccafusco & Sprigman, *The Creativity Effect*, *supra* note 68, at 42 (showing that overconfidence in the quality of their work drives creators to assign high value to it).

107. One possibility is that the results of our first experiment are merely an artifact of the experimental design based on the subject's perception of the *source* of the provided submission on which the subject is attempting to improve. In the real world, follow-on innovators receive more information about existing ideas than in our first experiment. They may know, for example, whether the original innovator was a very talented and bright individual. In such case, follow-on innovators may consider it harder to "invent around" an existing idea and therefore decide to borrow rather than innovate. We ran another experiment to test whether subjects' decisions to innovate or borrow are influenced by the perceived quality of the original innovator. The design and results of this experiment are reported in Appendix F, *infra*.

108. KAL RAUSTIALA & CHRISTOPHER SPRIGMAN, THE KNOCKOFF ECONOMY: HOW IMITATION SPARKS INNOVATION 132–33 (2012).

109. *Id.* at 137.

examined responses to our follow-up questions to see if we could detect significant differences between the groups. In particular, we were interested in whether there are any specific demographic features of those people who innovated in the +1 bonus condition (where innovating was irrational) and those people who borrowed in the +58 and +72 bonus conditions (where borrowing was irrational).

One possibility is that pioneers tend to be risk takers, while tweakers are more risk averse. Tweakers may be more cautious when confronted with uncertainty about the possibilities for innovating and, thus, prefer to borrow from and tinker with existing work. This hypothesis, however, is not borne out by our data. Subjects who reported that they were generally "fully prepared to take risks" did not innovate at significantly higher rates than did those who said that they "try to avoid taking risks."[110]

In addition, we considered whether innovation behavior was predicted by variation in subjects' personality traits. According to the five-factor model of personality, variation along five different personality traits—openness to experience, extroversion, agreeableness, conscientiousness, and neuroticism—explains individuals' personality differences.[111] In particular, we focused on openness to experience and extroversion, because previous studies had shown these traits to be positively correlated with creativity.[112]

Interestingly, subjects who rated highly on openness to new experience did, in fact, innovate at significantly higher rates than did subjects who rated low on openness. In regression analysis of innovation behavior controlling for the five personality variables, as well as controlling for subject age and gender, higher

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110. *See infra* Appendix A, Regression 2. Risk preference was never close to statistically significant in any of the regression equations that we ran.

We used a single-item measure of risk preference taken from the following source. Thomas Dohmen, Armin Falk, David Huffman, Uwe Sunde, Jürgen Schupp & Gert G. Wagner, *Individual Risk Attitudes: Measurement, Determinants, and Behavioral Consequences*, 9 J. EUROPEAN ECON. ASS'N 522, 525 (2011). Recent research on risk preference suggests that it is a complex concept that may vary across domains. *Id.* For example, people may be willing to take risks with money at the betting table but unwilling to take risks with personal safety while driving a car. Because we included the lengthy personality inventory, we decided to use a smaller risk measure. Also, this research suggests that incentive-compatible techniques, where subjects are really engaging in risky behaviors, have better predictive value. Because our subjects were already engaging in one complex, risky game, we decided not to have them play another incentive-compatible risk game. Further research using broader risk measures and incentive-compatible measures is desirable.

111. *See* Paul T. Costa, Jr. & Robert R. McCrae, *Four Ways Five Factors Are Basic*, 13 PERSONALITY & INDIVIDUAL DIFFERENCES 653 (1992) (discussing support for the five-factor model including observational studies, linguistic and cultural studies, and heritability studies).

112. *See* Sun Young Sung & Jin Nam Choi, *Do Big Five Personality Factors Affect Individual Creativity? The Moderating Role of Extrinsic Motivation*, 37 SOC. BEHAV. & PERSONALITY 941 (2009); Stock et al., *supra* note 96. The fifty-item measure that we used included ten questions for each of the personality factors. Answers to these questions were used to compute factor scores using the methods described in Stock et al., *supra* note 96. Factor scores were then entered into the logistic regressions of innovation behavior reported in Appendix A, *infra*.

openness scores were correlated with increased likelihood of innovation.[113] None of the other personality factors was significantly correlated with innovation behavior.[114] A one-point increase in openness on a scale of one to ten predicted a 32.9% increase in likelihood of innovating.[115]

The relationship between openness to experience and innovation behavior makes sense. Individuals who rate highly on openness tend to have a preference for variety and change, and they tend to be intellectually curious. When faced with a creativity problem, then, it is not surprising that subjects high in openness chose to branch out in a new direction rather than continue down an already established path.

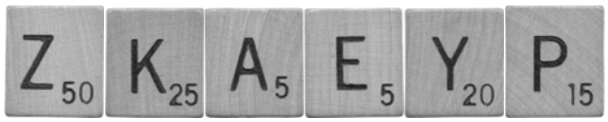
Although this finding about the relationship between personality and innovation behavior is interesting, it is important to understand it in light of the larger context of our study. When we consider the relative size of the effect of openness to experience in explaining innovation behavior, it is much smaller than the size of the effect associated with subjects' beliefs about the ease of innovating.[116] So although the personality effect is statistically significant, it is not nearly as large as the effect of subjective belief.

3. Experiment 2: Design

In Experiment 2 we attempted a partial replication of the results of Experiment 1 using a different creativity task. Instead of using a task based on mathematical creativity, we designed a game related to verbal creativity. The game is similar to the popular board game Scrabble, in which players attempt to compose words using a list of letters with varying values. Subjects were told that their goal was to use the letters to compose a list of six words with the highest possible value. They were paid $0.50 for participating and an additional $0.01 for each point their list of words scored.

Our subjects were given the list of letters in figure 6.

Figure 6. List of letters given to subjects



113. *See infra* Appendix A, Regression 3.

114. When we include in the regression analysis controls for ease of solving the game and ease of innovating, the correlation with openness becomes nonsignificant and the correlation for extroversion becomes significant, but in the opposite direction than we had predicted. People who score higher in extroversion are more likely to borrow than to innovate, controlling for these other variables. We are unsure of what to make of this finding. *See infra* Appendix A, Regression 4.

115. *See infra* Appendix A, Regression 3.

116. *See infra* Appendix A, Regressions 3 and 4. Regression 3, which only includes the personality factors and age and gender as variables, has a low R2 value (0.028). This suggests that little of the variation in innovation behavior is predicted by this model. Consider also that the size of the coefficient for ease of innovating is much larger than the (nonsignificant) coefficient for extroversion in Regression 4, which includes both.

As in Experiment 1, subjects were told that another subject had played the game before they did and entered a list of words. They were told, again, that they could borrow from that player's list of words, but that if they borrowed two or fewer words, they would receive an additional bonus. The list of words provided by the other subject was as follows:

zek, peak, pea, zap, key, aye[117]

Subjects were randomly assigned to one of six different bonus conditions that were similar in magnitude to those of Experiment 1.[118] They were offered +1, +5, +15, +35, +50, or +65 additional points if they used two or fewer of the other subject's words.[119] We again attempted to assess the rational indifference point for a player of moderate verbal ability, and we estimated that it should fall somewhere around +15.[120] Thus, subjects who were in the +1 condition should have been unwilling to innovate for such a small payout given the constraint of doing so, and subjects in the +50 and +65 conditions should have been very willing to innovate in order to obtain so many additional points.

Subjects were given ninety seconds to enter their list of words. The game was designed to automatically eject them from the study if they navigated off of the web page during the game. This does not mean that subjects were unable to cheat, but the short time limit should have limited opportunities to do so.

Once again, after subjects played the game they were asked two comprehension questions and a series of demographic and follow-up questions.

4. Experiment 2: Results

Using AMT again, we recruited 707 subjects. From this pool, we removed 5 subjects who failed an attention check at the end of the experiment. Of the remaining subjects, 103 opened another web page during the study and were excluded from the analysis, as they may have used outside help (such as Scrabble word finders) which could taint our analysis. We excluded another 58 subjects who failed on one or more

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117. This list scored 235 points out of a highest possible 415 points.

118. Because subjects in Experiment 1 were paid $0.03 per point while those in Experiment 2 were paid $0.01 per point, the conditions actually varied more in the first experiment than in the second. Nonetheless, our results show that subjects were more sensitive to these differences in the second experiment than in the first.

119. We decided to implement the borrowing of words and not individual letters, in order to make the game more tractable for our subjects.

120. Here, we estimated the indifference point by looking at the indifference points of three separate hypothetical players. A player who knew the full dictionary of available words and could play the best words would have been willing to innovate at any bonus higher than 0. A player who knew the full dictionary of available words but who played words drawn at random from that set would have been willing to innovate at any bonus higher than 15. And a player who knew only the six lowest scoring words would have been willing to innovate at any bonus higher than 35.

of our various comprehension checking questions.[121] This left 541 subjects, of whom 56% were male.

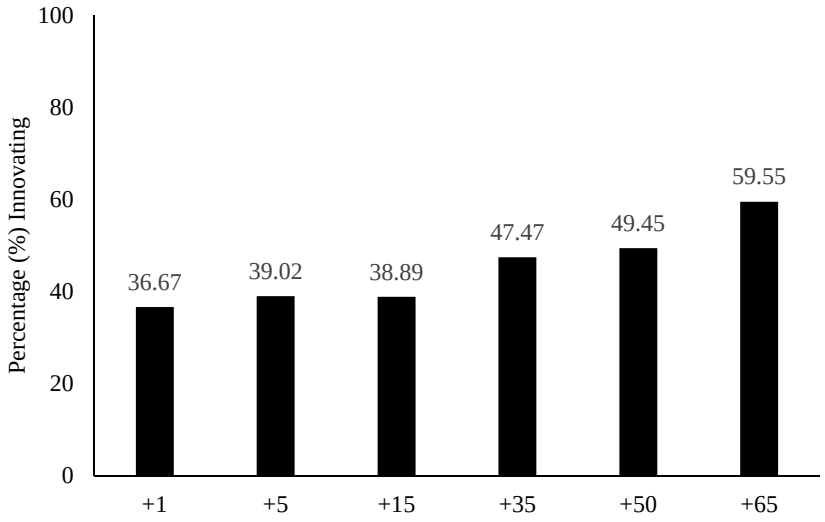
Our results in Experiment 2 are both similar and different from those of Experiment 1. This time, we find that an increase in bonus size significantly increases the percentage of subjects who choose to innovate.[122] As one would expect, the more money people are paid to innovate rather than borrow, the more likely they are, in general, to do so.

Table 4. Percentage innovating per bonus condition

	+1	+5	+15	+35	+50	+65
Percentage (%) innovating	36.67 (a)(b)	39.02 (c)	38.89 (d)	47.47 (e)	49.45 (a)	59.55 (b)(c)(d)(e)

(a) +1 versus +50 condition: two-tail t-test, $p = 0.082$.
(b) +1 versus +65 condition: two-tail t-test, $p = 0.002$.
(c) +5 versus +65 condition: two-tail t-test, $p = 0.007$.
(d) +15 versus +65 condition: two-tail t-test, $p = 0.005$.
(e) +35 versus +65 condition: two-tail t-test, $p = 0.095$.
All other comparisons are nonsignificant.

Figure 7. Percentage innovating per bonus condition



121. The excluded subjects came from the following conditions: 14 were cut from the 1 point group; 9 were cut from the 5 point group; 7 were cut from the 15 point group; 4 were cut from the 35 point group; 10 were cut from the 50 point group; and 14 were cut from the 65 point group. There were no significant differences in exclusion rates by condition.

122. Rather than comparing individual conditions against one another, we analyze the effect of bonus size in regression analyses that control for other variables as well. *See infra* Appendix C. In these regressions, bonus condition is a significant predictor of subjects' innovation behavior. This was not true for Experiment 1.

That we found a positive relationship between innovation and bonus size in Experiment 2 and not in Experiment 1 is somewhat surprising because the actual magnitude of the differences between the conditions was smaller in the second experiment. In Experiment 1, each "point" was paid $0.03, while in Experiment 2, each "point" was paid $0.01. For some reason, though, subjects were more responsive to the size of the bonus here than in the prior experiment.

Despite the positive effect of bonus size, subjects' innovate/borrow decisions were, as in Experiment 1, far from what one might have predicted. Importantly, the results in Experiment 2 track those in Experiment 1 in that far too many subjects innovated at low bonus amounts, while too many subjects borrowed at high bonus amounts. At the +1 bonus level, 36.67% of our subjects chose to innovate even though the incentive to do so was minimal. Given that the other player's solution already scored 56% of the total points, subjects decided to forego the opportunity to borrow in favor of a single point (equivalent to $0.01 in this experiment). While the rate of innovation was lower than in Experiment 1, we still saw more than a third of our subjects innovate at the +1 bonus level. And similar to Experiment 1, the reverse is true at the other end of the scale. Subjects in the +65 bonus condition had a large incentive to innovate, but still 40% of our subjects in this condition decided to borrow.

As in Experiment 1, these anomalies had effects on the subjects' payout. The third of our subjects who chose to innovate in the +1 bonus level condition scored worse than did those who chose to borrow. And borrowers in the +65 bonus level condition performed worse than innovators.[123] Accordingly, we observed that subjects who chose the wrong strategy lost money relative to those who chose the optimal strategy.

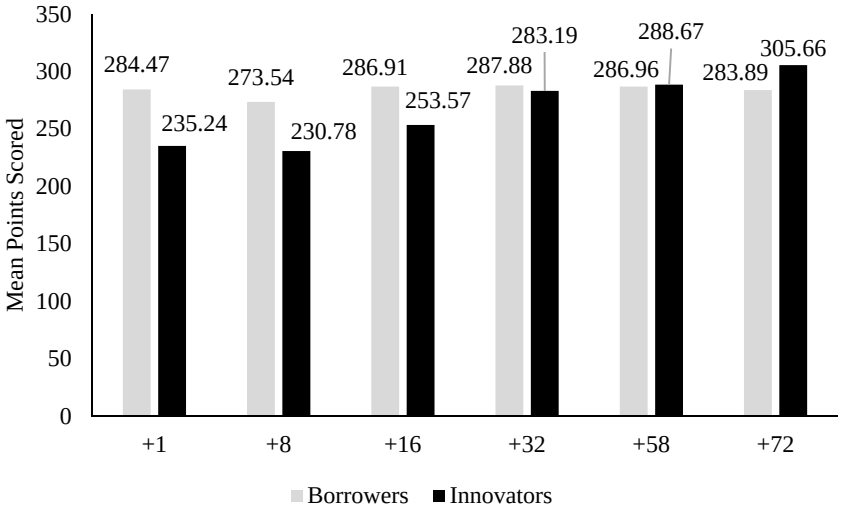
Table 5. Mean scores of innovators versus borrowers by condition

	+1	+5	+15	+35	+50	+65
Innovators	235.24***	230.78***	253.57***	283.19***	288.67	305.66
Borrowers	284.47***	273.54***	286.91***	287.88***	286.96	283.89

Note: The stars indicate that the mean scores of innovators and borrowers within a particular condition differ significantly. *** $p < 0.01$. All other comparisons are nonsignificant.

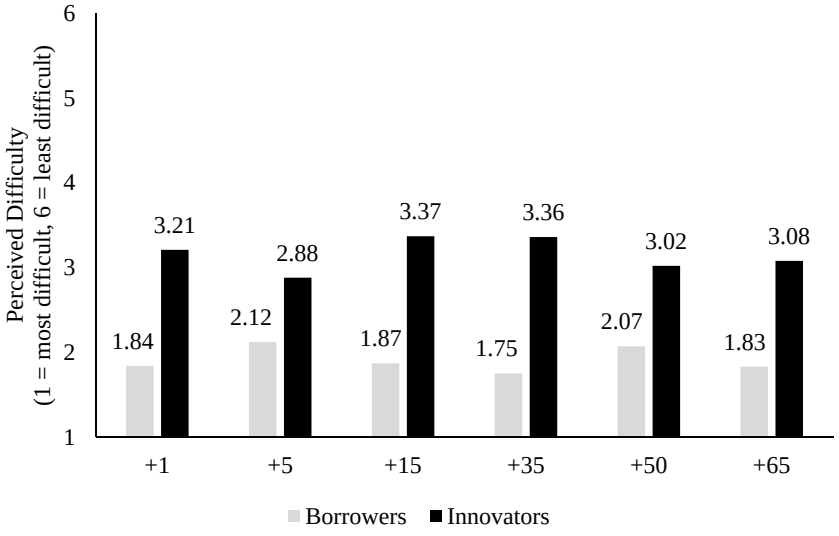
123. Interestingly, these results suggest that we may have underestimated the indifference point for our subjects. It was not until the +35 condition that innovators scored about as well as borrowers did. Our subjects apparently found coming up with their own nonborrowing words more difficult that we had initially predicted. Nonetheless, many of them still chose to innovate in the low bonus conditions.

Figure 8. Mean scores of innovators versus borrowers by condition



In Experiment 1, the principal driver of subjects' innovate/borrow decisions appears to have been their subjective belief about how easy innovating was. The easier they thought it was to innovate, the more likely they were to do so.[124] We found the same to be true in Experiment 2.[125] Participants who said they found it difficult to innovate tended to borrow from the provided solution, across all conditions. In fact, subjective beliefs were a much stronger predictor of innovation behavior than was bonus size.

Figure 9. Mean perceived difficulty of innovating



124. *See supra* note 104.
125. Again, we cannot be sure about the causal effect of subjects' beliefs. *See supra* note 105.

The visual impression from both figures is confirmed by the regressions in Appendix C. The perceived ease of solving the game and of innovating are significant predictors of whether a subject chooses to innovate or not.

Similar to Experiment 1, it seems that subjects who were innovating were doing so because they thought it was relatively easy to do (whether this was correct or not). However, none of our other follow-up or demographic questions was a significant predictor of behavior, including, in this experiment the personality factors.[126]

5. Bringing Experiments 1 and 2 Together

The results of Experiments 1 and 2 are illuminating. We interpret them as suggesting that creators can be modestly responsive to objective changes in the costs and benefits of innovating versus borrowing. Far more important, however, are creators' subjective beliefs about innovation environments. What seems to matter most to creators' innovate/borrow decisions is whether they believe that innovating will be easy or difficult. This implies that our subjects are performing in a way that is rationally consistent with their own beliefs, but, as these experiments show, those beliefs often lead to suboptimal behavior when they are not combined with other relevant information.

We think that our subjects were confronting the innovate/borrow problem at the heart of these experiments using a heuristic based on the ease of innovating. Heuristics typically involve the substitution of an easier question for a harder one.[127] In these experiments the question of whether to innovate or borrow required subjects to think about both (1) how easy it was to come up with an innovative (nonborrowing) solution and (2) how valuable the innovative solution was compared to how valuable the borrowing solution was. Our subjects, however, seem to have only focused on the first of these. Thus, subjects in the low bonus conditions who thought it was easy to develop nonborrowing solutions chose to innovate even though doing so limited their options without substantial compensation. And some subjects in the high bonus conditions who thought it was difficult to find nonborrowing solutions borrowed despite the very strong inducement to play an innovating solution.

The innovate/borrow decisions in our game were not particularly complex, but many subjects still seem to ignore relevant information that would help them make these decisions better. Partly, this is the result of the short time period they had to solve the problems. Perhaps, if they were given more time, they would have been able to combine all of the information necessary to optimally play the game. Although real-world creators typically have far more time to engage in these sorts of decisions, the information that they have to assess is substantially more complex. Given the difficulty of the decisions they face, they might be just as likely to rely on heuristics to solve problems as our subjects were.

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126. *See infra* Appendix C.

127. See *supra* notes 79–86 and accompanying text.

B. Experiments 3 and 4: Sensitivity to the Quality of Existing Ideas

The previous experiments explored the extent to which subjects' innovation behavior was influenced by the costs of borrowing or innovating. Our data suggest that the costs of borrowing played a relatively little role in their decisions to borrow or innovate. But these are not the only relevant factors this decision involves. Rational people should also consider how difficult it will be to make a new discovery that does not infringe upon existing ideas. We refer to this as the scope of the innovation space.[128] When the scope of the innovation space is large, people should be more willing to innovate (all else equal) than when it is small, because it will be easier to find a noninfringing solution.

Two variables affect the scope of the innovation space: the quality of the existing ideas and the strength of the IP rights protecting them.[129] For example, a new discovery may open up an entire field of research that is only barely touched by existing IP rights. The early days of most fields look like this. But as the field matures, it will tend to be harder and harder to produce new works or inventions that do not overlap with existing ones. In the same way, if the breadth of the existing IP rights increases, such that new creators have to produce ideas with fewer similarities to the existing ideas, innovation will become harder, and borrowing from the existing ideas will be more attractive.

The prior two experiments suggested that people were particularly sensitive to their own beliefs about how large the innovation space was. The easier they thought it would be to innovate, the more likely they were to do so. Those experiments used subjects' self-reports about the scope of the innovation space. Here, in Experiments 3 and 4, we test the extent to which subjects are responsive to changes in the innovation space derived from the quality of the underlying ideas by objectively manipulating the quality of the given solutions.

1. Experiment 3: Design

Experiment 3 used the same wagon-creativity task and experimental software program as in Experiment 1. Whereas Experiment 1 manipulated the costs and sources of the underlying ideas, Experiment 3 manipulated the quality of the underlying ideas. After going through the practice game, subjects were given the same instructions about the nature of the game and the distribution of points. Subjects were told that they would receive an additional sixteen points if their submission did not use three or more of the items from the existing submission.

Then subjects were randomly assigned to one of three conditions based on the strength of the underlying submission. Depending on condition, subjects were either shown a submission that was 60%, 80%, or 100% of the maximum possible score. Subjects were not told how strong the submission was, but they should have been capable of making informed judgments about it.[130] While the 60% solution afforded

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128. *See supra* note 76 and accompanying text.

129. See *supra* notes 70–76 and accompanying text.

130. For example, as submission strength increased, so too did the number of items used in the submission.

many valuable options that subjects could choose that did not involve borrowing, the 100% solution offered very few, and the 80% solution was in the middle. Subjects then played the game, answered two comprehension questions, and answered a series of follow-up and demographic questions similar to those used in the previous studies.[131]

The sixteen-point bonus offered to all subjects should fall near subjects' rational indifference point in the 80% condition. In this condition, the offer of sixteen points for innovating produced options that were about equally good for either choice. In the 60% condition, though, because the innovation space was so much larger, subjects should tend to accept the bonus at very high rates, and we should see near universal innovating. On the contrary, in the 100% condition, the available innovation space was very small (although not zero),[132] so almost all subjects should eschew the bonus and borrow.

2. Experiment 3: Results

We recruited 303 subjects via AMT to participate in the study. As with the previous experiments, subjects were paid $0.50 for participating and $0.03 for each point that they scored in the game. We excluded 62 subjects from the final data analysis for missing one of the comprehension questions, not being native English speakers, or missing an attention question. Exclusions did not differ significantly between the three conditions. Of the remaining population of 241 subjects, 143 (59.34%) were male, with a mean age of 33.04 (range 19–68).

Our results are partly consistent with our expectations and partly inconsistent with them. As predicted, when confronted with a smaller innovation space, subjects were less likely to innovate and more likely to borrow. Subjects in the 60% condition innovated more than those in the other conditions. Although subjects in the 80% condition innovated more than those in the 100% condition, we cannot say that the result was statistically significant. In general, then, we observe some degree of sensitivity to the scope of innovation space, but it is not as great as we would have predicted.[133]

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131. Experiment 3 did not include the fifty-item personality inventory.

132. In addition to the 100% solution provided to the subjects, three other 100% solutions to the knapsack problem exist. If a subject chooses to innovate and comes up with one of the other 100% solutions, he will always be better off than by choosing to borrow, as he not only receives the payoff for the 100% solution but also the sixteen point bonus for innovating. But the likelihood that a subject will come up with one of three other 100% solutions is small, given that there are over 3000 possible solutions to the knapsack problem, whose quality ranges from 0 to 100%.

133. We also do not observe statistically significant differences between the mean scores of innovators versus borrowers:

Table 6. Mean scores of innovators versus borrowers by condition

	60%	80%	100%
Innovators	94.32	90.58	88.38
Borrowers	85.40	86.22	85.54

All differences between innovators and borrowers within a condition are nonsignificant.

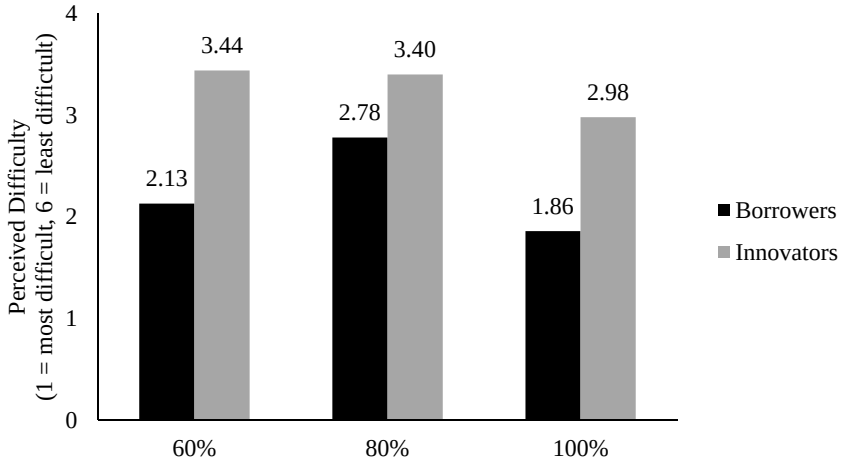
Table 7. Percentage innovating per condition

	60%	80%	100%
Percentage (%) innovating	80.77 (a)(b)	69.33 (a)(c)	60.23 (b)(c)

(a) 60% versus 80% condition: two-tail t-test, $p = 0.102$.
(b) 60% versus 100% condition: two-tail t-test, $p = 0.004$.
(c) 80% versus 100% condition: two-tail t-test, $p = 0.231$.

Moreover, as in our previous studies, innovation rates are still unusually distributed. Although innovation rates were higher in the 60% condition, they did not reach the nearly universal level that rational choice theory would have predicted. And on the opposite side of the spectrum, in the 100% condition, more than half of the subjects still chose to innovate even though doing so was incredibly difficult. So although the scope of the innovation space is affecting subjects' decisions, the magnitude of its effect is still relatively small.[134] Again, when we look at our follow-up and demographic data, we can tell a richer story about innovation behavior. The changes in innovation rates across conditions and subjects' within-condition innovation behavior are related to their perceptions of how easy they thought it was to innovate (for example, find a solution using 2 or fewer previously used items). Within each condition, those subjects who innovated believed that doing so was significantly easier than did those who borrowed (see Figure 10 below).[135]

Figure 10. Mean perceived difficulty of innovating



134. Regression analysis of the three conditions with no other controls yields an R^2 value of only 0.029, indicating that differences between the conditions explain very little of the overall variation in subjects' decision making. *See infra* Appendix C, Regression 1.

135. All p's < 0.05.

Logistic regression analysis of a full set of these data indicates that the strongest correlation with innovation was subjects' beliefs about how easy it was to innovate.[136] For every one-point increase (on a six-point scale) in how easy subjects thought it was to find a solution using two or fewer items from the other submission, they were 280.1% more likely to innovate.[137] This is important for two reasons. First, it suggests, again, that our subjects were playing the game rationally and consistently with their perceptions of how easy it was to innovate. Second, it suggests that subjects' perceptions of the ease of innovating were much more important than the objective ease of innovating when it came to their actual behavior. When deciding whether to innovate or borrow, subjective beliefs appear to be much more influential than the actual state of the world. That said, we cannot say that subjects' perceptions about ease of innovating caused them to innovate or borrow. It is at least possible that subjects' responses to our question about ease of innovation were driven by what they chose to do, rather than the other way around.

That said, the strength of the correlation between the choice whether to innovate or borrow and perceived ease of innovation suggests to us that subjects are playing the game consistently with their subjective beliefs about the difficulties of innovating. For that reason, we do not wish to label their behavior "irrational." But their strategies were not necessarily optimal.[138] Consider the subjects in the 60% condition, where innovating was relatively easy and most subjects innovated. Those who did not innovate, approximately one-fifth of the group, scored much lower than did those who innovated (innovators mean score = 94.32; borrowers mean score = 85.40).[139] Although the borrowers may have been playing consistently with their own beliefs, those beliefs may have led them astray.[140]

Comparing these results to those of our previous experiments, it appears as though subjects' innovation decisions are more sensitive to changes in the quality of existing solutions to a problem than they are to the costs of innovating or to information about the source of an existing solution. Whereas Experiments 1 and 2 showed small differences in innovation behavior despite large differences in cost, Experiment 3

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136. *See infra* Appendix C, Regression 4.

137. *See infra* Appendix C, Regression 4.

138. Their behavior is consistent with what is often referred to as "bounded rationality." *See* HERBERT A. SIMON, 1 MODELS OF BOUNDED RATIONALITY: ECONOMIC ANALYSIS AND PUBLIC POLICY (1982); Gerd Gigerenzer & Reinhard Selten, *Rethinking Rationality*, *in* BOUNDED RATIONALITY: THE ADAPTIVE TOOLBOX 1, 4 (Gerd Gigerenzer & Reinhard Selten eds., 2002) ("[M]odels of bounded rationality describe how a judgment or decision is reached (that is, the heuristic processes or proximal mechanisms) rather than merely the outcome of the decision . . . ."); Russell Korobkin, *Bounded Rationality, Standard Form Contracts, and Unconscionability*, 70 U. CHI. L. REV. 1203 (2003).

139. One-tailed t-test, $p = 0.059$.

140. The scores of the two groups in the other two conditions were much closer together. 80% Condition: innovators = 90.58; borrowers = 86.22 ($p = 0.12$). 100% Condition: innovators = 88.38; borrowers = 85.54 ($p = 0.13$). The success of the innovators in the 100% condition is also interesting. Here, even though innovating should have been a suboptimal strategy given the strength of the provided submission, innovators were still able to score at least as well as borrowers. Perhaps this suggests that some of these innovators were rationally choosing to innovate because, at least for them, it was more promising. Further research is necessary to understand this issue.

produced some significant differences in innovation with changes in the actual quality of the underlying solution. In none of these cases, however, is innovation behavior fully consistent with rational choice predictions: when innovation is costly or difficult many subjects still choose to innovate, and when innovation is cheap and easy some subjects still choose to borrow. This suggests that there may be strong individual differences or other unobserved variations affecting innovation behavior. Moreover, these innovation decisions often lead to suboptimal outcomes for significant portions of our subject pool.

3. Experiment 4: Design

To more fully understand the nature of creators' decisions, we chose to run another experiment as a partial replication of our findings in Experiment 3. As above, we shifted from a mathematical creativity task to a verbal creativity task, using the Scrabble-style game described in Experiment 2. The game worked the same way that it did in Experiment 2. Subjects were given the same set of letters and point values and were instructed to create a list of words that maximized their value. They were paid $0.01 per point.

Again, subjects were told that another subject had played the game before them and entered a list of words. If they borrowed two or fewer words from the other player's list, they would receive an additional sixteen points. Subjects were randomly assigned to one of three separate conditions that varied in the quality of listed words. In one condition, the list scored 60% of the maximum score; in the second condition, it scored 80% of the maximum score; and in the third condition, it scored the maximum number of points possible.[141]

Because the provided list covered an increasing percentage of the available innovation space across the conditions, we anticipated that subjects would be less willing to innovate for the same bonus in the 100% condition than they would in the 60% and the 80% conditions.[142]

After completing the game, subjects answered two comprehension questions and a series of follow up and demographic questions.

4. Experiment 4: Results

We recruited 372 subjects to participate in the study via AMT. As in the previous studies, subjects were paid $0.50 to participate, and they were capable of earning more money based on their performance. Of the original pool, 54 were automatically eliminated from the experiment for violating the rules and opening up a separate

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141. The word lists were as follows. 60% Condition: zap, aye, kea, pay, key, pea (60.2% of the maximum score). 80% Condition: zek, pay, zap, key, peak, yep (79.5% of the maximum score). 100% Condition: zek, peaky, zap, zep, kype, zea (100%, the maximum score).

142. In fact, the innovation space is effectively zero in the 100% condition. As opposed to Experiment 3 (*see supra* footnote 132), only one 100% solution existed in Experiment 4. That solution scored the maximum of 415 points. If a subject decided to innovate in this condition (i.e., borrow only up to two words from the given solution), the best solution he could produce would score 350 points and 16 bonus points (for borrowing). As a result, subjects in the 100% condition are always better off borrowing than innovating.

Internet browser window during the creativity game. Of the remaining subjects, two subjects who did not speak English as their primary language were cut, as were 43 subjects who failed one of the comprehension questions or the attention check. This left 273 subjects, of whom 46.9% were female, in the final pool.

Between the 60% and 80% conditions, our results look like what we would expect based on Experiment 3. In the 60% condition, 46.81% of subjects innovated a word list that borrowed two or fewer words, while in the 80% condition, only 40.91% innovated. This is consistent with a rational approach to playing the game. When the innovation space shrinks, creators should be more willing to borrow from the existing IP rights.

Table 8. Percentage innovating per condition

	60%	80%	100%
Percentage (%) innovating	46.81 (a)(b)	40.91 (a)(c)	85.71 (b)(c)

(a) 60% vs. 80% condition: two-tail t-test, $p = 0.426$.
(b) 60% vs. 100% condition: two-tail t-test, $p = 0.000$.
(c) 80% vs. 100% condition: two-tail t-test, $p = 0.000$.

A strange thing happened in the 100% condition, however. Here, although innovating a solution that would score better than the existing solution was impossible, 85.7% of subjects chose to innovate rather than borrow. Not only did the percentage of innovators fail to decrease as expected, it actually doubled in size compared to the 80% condition.

We believe that the oddness of these results was caused by subjects' response to the words in the other player's submission. In the 100% condition, the word list included words that would not have been familiar to many subjects (zek, peaky, zap, zep, kype, zea). Coming up with words that did not borrow from this list was comparably easy, since many of the more familiar words (for example, peak, pea, key, pay) were still available. When subjects began to contemplate whether to innovate or borrow, they likely assessed how easily they could come up with words that did not borrow from the existing solution. Because this was relatively easy in the 100% condition compared to the 60% and 80% conditions, subjects probably concluded that innovating was the optimal strategy. In doing so, however, they ignored the relative value of the words that were in the existing solution compared to the value of the words that they were creating.

The failure of this strategy is starkly apparent in the scores of innovators and borrowers in each of the conditions. In each of the conditions, borrowers scored significantly more points than innovators.

Table 9. Mean scores of innovators vs. borrowers by condition

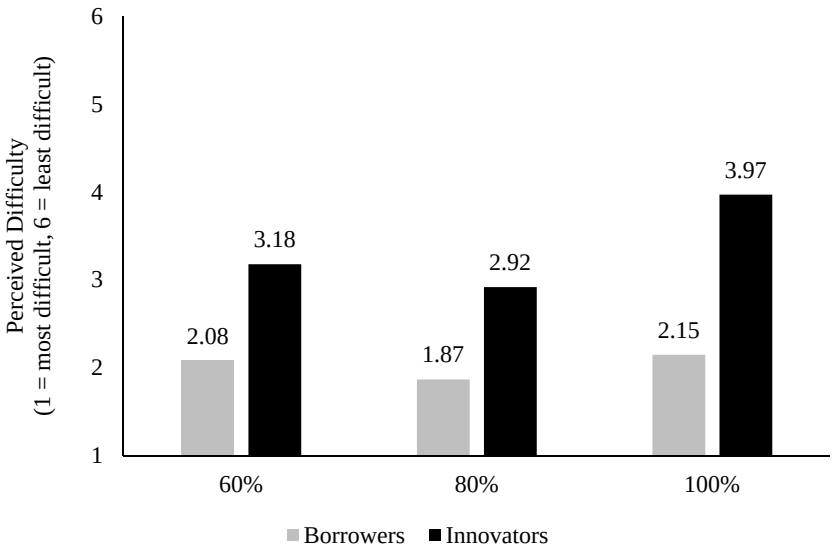
	60%	80%	100%
Innovators	223.86	216.67***	263.59***
Borrowers	248.20	287.50***	390.00***

Note: The stars indicate that the mean scores of innovators and borrowers within a particular condition differ significantly. *** $p < 0.01$. The other comparison is nonsignificant.

But in the 100% condition, borrowers scored more than 100 points higher than innovators (390.0 versus 263.50). This represents a huge loss in welfare for the participants, and by proxy, for society.[143] These innovators faced a perfect solution already available to them and chose to create new ones anyway.

When we analyze our follow-up and demographic data, we again see that subjects' estimates of the ease of innovating a solution were the strongest predictor of innovation behavior.[144]

Figure 11. Mean perceived difficulty of innovating



This suggests that subjects were once again playing according to their own sense of what was rational to do. And, once more, we failed to find any significant effects of age, gender, education, risk, language ability, or previous experience with Scrabble. When we examine the personality data, we did, this time, detect a significant although not very strong relationship between the personality factor of openness to new experience and innovation.[145] The significance disappears, however, when other variables are considered in the regression, so we are hesitant to put substantial weight on it.

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143. Again, if creators receive positive welfare from innovating versus borrowing, it could offset the magnitude of these estimates. *See supra* note 102. There is, however, no reason to think that subjects in the 100% condition would value innovating so much more than would subjects in the other conditions. Presumably, whatever benefit subjects receive from innovating should be fairly consistent across conditions, so while it might make sense for some creators to take less money to innovate than they would receive to borrow, they should not presumably be willing to take so much less money in the 100% condition as they appear to.

144. *See infra* Appendix E.

145. *See infra* Appendix E.

The results of Experiment 4 shed interesting light on our findings from Experiment 3. In both cases, we found some evidence of subjects responding rationally to changes in the scope of the innovation space. But, rather than engage in the complex comparison of the relative values of the innovating and borrowing solutions, subjects seem to have relied on a heuristic assessment of ease of innovating. For the most part, this was a wise choice. It was no longer the wise strategy, however, for the 100% condition of Experiment 4. There, subjects could easily generate a list of words that did not borrow from the given solution. In choosing to innovate at such high rates, however, they ignored the value of their own words compared to the words in the given solution. Although innovating was easy, it was not smart. In this case the heuristic led them astray.

III. DISCUSSION AND IMPLICATIONS

Regulating sequential innovation is perhaps the most important challenge IP law faces. In one sense, all IP doctrine and theory come down to the fundamental issue of balancing incentives for initial creators and opportunities for subsequent creators. In order to determine how to do so efficiently, the law needs an accurate understanding of how people make decisions about innovating and borrowing. More research needs to be done in this area, but our findings have interesting implications for IP law and policy. We will break them out into four separate sections. First, we will discuss the implications of our findings for the efficiency of innovation markets. We will then consider how (and how well) IP law affects creators' incentives. Then, we will address issues associated with the production and acquisition of creativity. Finally, we will discuss some limitations to our study design and future research that we plan to undertake.

Before we discuss the implications of our findings for IP law, we should keep two important points in mind. First, when we think about "creativity," we tend to think about the kinds of ideas that represent substantial advancements from existing knowledge: Edison and the light bulb, Picasso and cubism, Perry and "Firework." This kind of pioneering creativity is obviously important; it is the source of Nobel prizes and MacArthur genius grants. Yet despite all of the attention that it receives, it represents a relatively small percentage of human creative endeavor.[146] At least as important are the innumerable tinkerers and tweakers whose only goal is to refine and adapt existing ideas.[147] Quantitatively, and perhaps qualitatively, this kind of creativity is responsible for at least as much scientific and artistic progress as the pioneering kind. For every Edison, Picasso, and Perry, there are dozens, hundreds, or thousands of others who have continued to develop, interpret, and repurpose their ideas.[148]

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146. *See* RAUSTIALA & SPRIGMAN, *supra* note 108, at 132–33.

147. Eric von Hippel has done important research on the social value of user innovation which often takes the form of tweaking existing products for new uses. *See* ERIC VON HIPPEL, DEMOCRATIZING INNOVATION (2005); Joachim Henkel & Eric von Hippel, *Welfare Implications of User Innovation*, *in* ESSAYS IN HONOR OF EDWIN MANSFIELD 45 (Albert N. Link & F.M. Scherer eds., 2005).

148. Consider, for example, the large and growing arena of fan fiction. Fans write their own stories using existing (often copyrighted) characters, placing them in new settings or

Second, when we think about innovation we tend to ascribe to it a positive normative valence. But as Kitch pointed out, sometimes innovation is costly and wasteful.[149] If one drug successfully treats a disease, the addition of a second or third drug to treat the same disease may not be that valuable, especially compared to the use of those resources elsewhere.[150] Innovation races and inventing around patents often lead to duplicative expenses without actual improvements in idea quality.[151] Our creativity games allow for this. Subjects might choose to innovate rather than borrow, but their innovation does not necessarily produce a higher score. IP and innovation scholars need to be clear about when innovation is valuable and when it is costly.

A. The Efficiency of IP Markets

Similar to other areas of the law, the fundamental structure of U.S. IP law is premised on the assumption that the people affected by it—creators, owners, and users—are rational. In this sense, rationality means seeking to maximize one's welfare by comparing the costs and benefits of decisions and acting consistently with that calculus.[152] Rationality does not mean that people don't make mistakes, only that those mistakes will tend to be randomly distributed over time or in a society. If a person overestimates the costs of an action this time, he is likely to underestimate those costs the next time, and may improve his estimates in the long term.[153] Or if a market participant always overestimates the costs of an action, another market participant will always underestimate them.[154] In markets where there are both

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changing other aspects of their identities and relationships. *See* Anupam Chander & Madhavi Sunder, *Everyone's a Superhero: A Cultural Theory of "Mary Sue" Fan Fiction as Fair Use*, 95 CALIF. L. REV. 597 (2007); Rebecca Tushnet, *Legal Fictions: Copyright, Fan Fiction, and the New Common Law*, 17 LOY. L.A. ENT. L.J. 651, 655 (1997) ("'Fan fiction,' broadly speaking, is any kind of written creativity that is based on an identifiable segment of popular culture, such as a television show, and is not produced as 'professional' writing.").

149. Kitch, *supra* note 43, at 278–79.

150. The existence of multiple drugs to treat the same disease will have some possible social welfare effects by increasing competition and thus reducing monopoly pricing. But competition will occur inevitably once the patents expire.

151. For a discussion of these issues see Michael Abramowicz, *The Uneasy Case for Patent Races over Auctions*, 60 STAN. L. REV. 803, 817–18 (2007).

152. *See* Russell B. Korobkin & Thomas S. Ulen, *Law and Behavioral Science: Removing the Rationality Assumption from Law and Economics*, 88 CALIF. L. REV. 1051, 1063 (2000) ("[T]he basic requirement of expected utility theory is that decision makers conduct an explicit or implicit cost-benefit analysis of competing options and select the optimal method of achieving their goals . . . .").

153. *See* Richard A. Epstein, *Behavioral Economics: Human Errors and Market Corrections*, 73 U. CHI. L. REV. 111, 114–18 (2006) [hereinafter Epstein, *Behavioral Economics*]; Richard A. Epstein, *The Neoclassical Economics of Consumer Contracts*, 92 MINN. L. REV. 803, 810–14 (2008); Jeffrey J. Rachlinski, *Cognitive Errors, Individual Differences, and Paternalism*, 73 U. CHI. L. REV. 207, 219–21 (2006); Alan Schwartz, *How Much Irrationality Does the Market Permit?*, 37 J. LEGAL STUD. 131, 143 n.17 (2008).

154. *See* RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 18–19 (9th ed. 2014) ("The fact that people do not always make rational choices does not invalidate rational choice theory;

rational and biased actors, marginal buyers and sellers who determine equilibrium prices in the aggregate will often be rational individuals. Their rational behavior can wield sufficient influence to lead to an efficient market, from which biased individuals can also profit.[155] Over time and on balance, learning and imitation strategies lead rational actors engaged in market transactions to converge toward optimal behavior.

In an ideal world, in which people act rationally and there are no transaction costs, innovation markets should function efficiently to direct resources to their highest value uses.[156] As we described in Part I, rational follow-on creators will weigh the costs and benefits of innovating and borrowing and select the optimal approach.[157] If the owner of the underlying IP right insists on too high of a price to license it, the rational creator will innovate; or if the scope of the remaining innovation space is exceedingly narrow, the downstream creator will be willing to pay more to borrow from existing ideas. In this ideal world, the role of the IP system is simply to establish clear rights and allow people to transact. Social welfare is optimized by individuals rationally pursuing their private good.[158]

Our experiments examine how people choose between innovating and borrowing. The hypothesis that undergirds IP law is that the choice can be shaped by external incentives. But the subjects in our experiments were, at best, mildly responsive to external incentives. Choices between innovation and borrowing correlated much more powerfully with their internal, subjective beliefs about the difficulty of innovating than with the optimal balance of costs and benefits. Our findings in these experiments suggest that markets for innovation may be less efficient than standard economic analysis assumes. Moreover, these inefficiencies may produce significant social costs. Although our data are far from conclusive, they are consistent with a growing body of research noting similar departures from rationality in other aspects of innovation, which raise the possibility of inefficiencies inhering in those aspects as well.[159]

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random deviations from rational behavior will cancel out."); Epstein, *Behavioral Economics*, *supra* note 154, at 121; Richard A. Posner, *Rational Choice, Behavioral Economics, and the Law*, 50 STAN. L. REV. 1551, 1556–57 (1998).

155. Oren Bar-Gill & Elizabeth Warren, *Making Credit Safer*, 157 U. PA. L. REV. 1, 12–13 (2008). On a similar problem involving information asymmetries between producers and consumers, see Elizabeth Hoffman & Matthew L. Spitzer, *Experimental Law and Economics: An Introduction*, 85 COLUM. L. REV. 991, 1021 (1985); Alan Schwartz & Louis L. Wilde, *Intervening in Markets on the Basis of Imperfect Information: A Legal and Economic Analysis*, 127 U. PA. L. REV. 630, 638 (1979); Louis L. Wilde & Alan Schwartz, *Equilibrium Comparison Shopping*, 46 REV. ECON. STUD. 543, 543–44 (1979).

156. This is simply an application of the Coase Theorem to innovation markets. *See* R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1 (1960) (establishing the conditions in which markets will function to efficiently distribute resources through society).

157. *See supra* notes 70–76 and accompanying text.

158. Eldred v. Ashcroft, 537 U.S. 186, 212 n.18 (2003) ("[C]opyright law serves public ends by providing individuals with an incentive to pursue private ones.").

159. *See* Brüeggeman et al., *supra* note 5, at 14 (finding that property rules lead to inefficient distributions of creative goods compared to liability rules); Buccafusco & Sprigman, *The Creativity Effect*, *supra* note 68, at 42 (finding that creators' optimism about the quality of their works leads to overpricing and market inefficiencies); Andrew W. Torrance

The results of our experiments indicate that many of our subjects were making suboptimal innovate/borrow decisions, at least in the sense of reducing their payoffs,[160] and that these decisions had significant effects on the total "welfare" produced in the games. For example, in the +1 condition of Experiment 1, where the rational choice was borrowing, more than half of our subjects innovated, and in the +72 condition, where the rational choice was innovating, almost a third of our subjects borrowed. Implicitly, this means that the least amount of money that these subjects were willing to accept to innovate was significantly skewed from what rational choice would predict. This seems to be due primarily to the overoptimism of the first group and the "underoptimism" of the latter about how easy it would be to create a noninfringing solution. The setup of our experimental task even allowed us to provide a rough estimate of the social welfare losses accrued due to these deviations from rational behavior.[161]

Experiment 4 demonstrates very clearly one way in which creators' decisions may fail to conform to welfare-maximizing expectations. Decisions about creating are complex, and when faced with complex decisions, people often substitute easy questions for harder ones.[162] They use what we call innovation heuristics. Sometimes this works well, but as our experiment showed, sometimes it fails miserably. Many subjects in the 100% condition thought it was easy to come up with new words, but they neglected to consider how valuable the available words were. Accordingly, they made substantially less money in the game than did those who chose to borrow from the existing solution.

To appreciate how these heuristics might affect a real IP transaction, consider a situation in which a research scientist is trying to develop a gene therapy treatment for a disease. She knows that another inventor owns a patent on a technology that relates to her work and that the inventor is willing to license it for a small fee. Our scientist, however, is exceedingly confident that she can work around the existing patent and avoid paying the fee. She can see an available method that might not infringe the existing patent. As it turns out, however, her confidence is misplaced. The new method, while easy to achieve, is not very successful, and the amount of resources she spends trying to avoid the patent dwarfs what she would have paid to license it. Although the market for the rights should have resulted in their efficient transfer, the scientist's overconfidence produces an inefficient outcome.[163]

Now consider how this situation interacts with how initial innovators are likely to price access to their ideas. As we have demonstrated in previous empirical research, creators tend to overvalue their creations because they overestimate their quality and likelihood of market success.[164] We call this the "creativity effect." If the inventor

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& Bill Tomlinson, *Property Rules, Liability Rules, and Patents: One Experimental View of the Cathedral*, 14 YALE J.L. & TECH. 138, 159–61 (2011).

160. Maximizing their payoffs in the game is not the only motivation that subjects could rationally have. They might find one or the other strategy intrinsically more enjoyable, for example.

161. *See supra* note 101 and accompanying text.

162. KAHNEMAN, s*upra* note 79.

163. Of course, the inverse would be the case for those situations in which borrowing is very expensive and innovating is the optimal choice.

164. Buccafusco & Sprigman, *The Creativity Effect*, *supra* note 68, at 42.

owning the relevant patent in the above example suffers from a similar phenomenon, the inventor is likely to charge a higher price for borrowing the patent than appropriate, because the inventor is overoptimistic about the patent's quality. This will further drive a wedge between the lowest amount of money that the inventor is willing to accept to license the patent and the highest amount of money that the overoptimistic scientist is willing to pay. If overoptimistic improvers consistently meet up with overoptimistic initial creators, we would expect to see suboptimal levels of IP transactions relative to rational choice expectations.

The opposite will be true for underoptimistic improvers like those who borrowed in the +72 condition of Experiment 1. These subjects demonstrate a high implicit willingness to pay to borrow. But while this might lead to higher levels of IP transactions, it will not necessarily lead to optimal levels. Recall that these subjects are borrowing when there were strong incentives to innovate. In a real world scenario like the one described above, an insufficiently optimistic scientist would tend to overpay for the patent license when it could be easily invented around. The excessive licensing costs would then get passed along to consumers of any resulting discoveries, thereby increasing product prices and decreasing the number of consumers who can benefit from the discovery.

As we explained above, the assumption of rationality in rational choice theory does not entail perfect behavior. Mistakes are inevitable, and, with enough chances, things could simply balance out. However, there are reasons to be skeptical that learning strategies and market forces are sufficient to overcome the effects of heuristics. On a general level, individuals who are subject to behavioral biases are often unable to overcome these biases even with training. Many behavioral biases are systematic and robust against learning.[165] Just telling an inventor that he may be too overoptimistic with regard to the prospects of his own invention will not necessarily reduce his overoptimism. Furthermore, in innovation markets, invented products and processes are often hard to compare. This impedes the ability of overoptimistic inventors to imitate and learn from more rational competitors.[166] Finally, the market may not be able to compensate for all mistakes and biases creators make and suffer from.[167]

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165. Ernst Fehr & Jean-Robert Tyran, *Individual Irrationality and Aggregate Outcomes*, J. ECON. PERSPECTIVES, Fall 2005, at 43, 54; Howard Latin, *"Good" Warnings, Bad Products, and Cognitive Limitations*, 41 UCLA L. REV. 1193, 1253–55 (1994); Rachlinski, *supra* note 154, at 219–22; Amos Tversky & Daniel Kahneman, *Rational Choice and the Framing of Decisions*, 59 J. BUS. S251, S274–75 (1986).

166. *See* Oren Bar-Gill, *The Behavioral Economics of Consumer Contracts*, 92 MINN. L. REV. 749, 756 (2008) (noting that learning and imitation strategies work best in markets in which products are standardized).

167. In particular, market forces cannot eliminate the impact of behavioral biases if all market participants are subject to these biases or if sellers cannot determine which buyers are subject to biases and which are not. In these and other cases, even if only a small number of market participants are subject to biases or even if these biases are small in size, they can have significant consequences for competitive equilibria. On this theoretical debate in general, see Latin, *supra* note 166, at 1255–57; Schwartz, *supra* note 154. For specific economic models, see George A. Akerlof & Janet L. Yellen, *A Near-Rational Model of the Business Cycle, with Wage and Price Inertia*, 100 Q.J. ECON. 823 (1985) (concerning market participants with different reaction rates and applying the envelope theorem to aggregated market behavior);

To the extent that we are correct, this suggests that economic predictions about the efficiency of innovation markets could be too optimistic. In real-world situations in which borrowing is optimal, we will tend to see excessive investment in innovation because downstream creators overestimate how easy it will be to invent around existing ideas. Conversely, in situations in which innovating is optimal, we will tend to see excessive borrowing for the opposite reason. Market signals that we would rely upon to correct poorly-chosen innovation or borrowing may be insufficient to move people dug in to one strategy or the other—as did even very large bonuses in our Experiments 1 and 2. Accordingly, innovation markets are unlikely to run smoothly in the absence of intervention. IP laws may have more to do than establishing rights and letting the system work its way out.

B. IP Doctrine, Optimism, and Tastes for Innovation

IP law solves market failures by molding people's behavior. By providing incentives for some activities and by making other activities more costly, IP doctrines attempt to affect how people act. But if it is going to accomplish its goal of optimizing creative production, IP law must accurately assess how people respond to the positive and negative incentives that it creates. This assessment should not only focus on the incentives IP law creates to innovate. It should also take into account how IP law affects incentives to license existing innovations, which we have referred to in this Article under the term "borrowing."

As we explained at the beginning of this Article, copyright and patent laws must balance the incentives of initial creators with those of subsequent creators. They mostly do this through sequential innovation doctrines like the derivative works right and the doctrine of equivalents. These doctrines affect the scope of rights that are given to initial creators and the scope of the innovation space that is preserved for subsequent creators. By affecting the objective characteristics of the scope of innovation spaces, IP doctrines attempt to alter the economic values associated with different courses of conduct and, thus, the conduct that people choose to engage in.

John Haltiwanger & Michael Waldman, *Limited Rationality and Strategic Complements: The Implications for Macroeconomics*, 104 Q.J. ECON. 463 (1989) (concerning market participants with different information processing capacities); John Haltiwanger & Michael Waldman, *Rational Expectations and the Limits of Rationality: An Analysis of Heterogeneity*, 75 AM. ECON. REV. 326 (1985) (same); Uri M. Possen & Mikko Puhakka, *Some Aggregate Effects of Heterogeneity in Information Processing*, 49 BULL. ECON. RES. 231 (1997) (same); Thomas Russell & Richard Thaler, *The Relevance of Quasi Rationality in Competitive Markets*, 75 AM. ECON. REV. 1071 (1985) (concerning market participants with different utility functions); Thomas Russell & Richard Thaler, *The Relevance of Quasi Rationality in Competitive Markets: Reply*, 77 AM. ECON. REV. 499 (1987) (same). For related experimental studies, see Colin F. Camerer, *Do Biases in Probability Judgment Matter in Markets? Experimental Evidence*, 77 AM. ECON. REV. 981 (1987); Colin F. Camerer & Ernst Fehr, *When Does "Economic Man" Dominate Social Behavior?*, 311 SCIENCE 47 (2006); Ernst Fehr & Jean-Robert Tyran, *Individual Irrationality and Aggregate Outcomes*, 19 J. ECON. PERSP. 43 (2005); Ernst Fehr & Jean-Robert Tyran, *Limited Rationality and Strategic Interaction: The Impact of the Strategic Environment on Nominal Inertia*, 76 ECONOMETRICA 353 (2008).

Our research suggests that people's decisions about whether to engage in innovating or borrowing are not motivated solely by objective factors about innovation environments. Rather, subjective factors including degrees of optimism play important roles in people's choices. In addition, specific features of an innovation environment can manipulate creators' behavior when creators rely on heuristics that are not well-suited to the task. Ultimately, these findings seriously complicate the law's ability to channel creators' conduct. By manipulating the costs and benefits of innovation behaviors, IP law attempts to encourage people to act in socially optimal ways. These experiments suggest that the law's carrots and sticks may have to be substantially larger than previously realized in order to marginally influence creators' behavior.

This insensitivity to incentives may be less of a problem if there will be opportunities for sorting, such that people with strong preferences either way will find appropriate creative opportunities consistent with their preferences. This may be possible, but whether it is depends on the structure of IP doctrines. IP law affects the extent to which switching between innovating and borrowing is feasible. In particular, while patent law establishes a relatively level playing field between initial creators and downstream creators, copyright law strongly favors initial creators in a way that curtails downstream creators' ability to borrow. As we described above,[168] patent law is generally more solicitous of borrowers than copyright law is. Patent law allows inventors who make novel and nonobvious contributions to existing inventions to obtain their own patents without obtaining a license, while copyright law's derivative works rule generally prohibits borrowers from engaging in sequential creativity without first obtaining a license.

If a guitar designer wants to design and craft a guitar in the shape of Prince's former unpronounceable (but copyrighted) symbol, he cannot do so unless he obtains a license beforehand, and he will be subject to a copyright infringement lawsuit if he makes such a guitar.[169] This is because copyright law, as interpreted currently by most courts, gives control of most tweaking innovations to the original innovator. This is the result in cases like *Pickett v. Prince*, in which Judge Posner ruled that a guitar that the defendant designed based on the unpronounceable symbol that Prince briefly took as his "name" was an infringement of copyright.[170] Judge Posner ruled, moreover, that the defendant owned no part of his derivative work—even those parts which were not taken from Prince's pre-existing work.[171] Had the same activity occurred under the patent regime, however, the designer might have been able to obtain a patent that he could use to negotiate with Prince. In contrast to patent law, which creates rights in improvements and assigns them to the improver, copyright creates no such improver's rights. All ownership of the right to make derivatives is concentrated in the pioneer.[172] This means that minor innovations are relatively more expensive in copyright fields than they are in patent fields.

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168. *See supra* notes 35–38 and accompanying text.

169. *See* Pickett v. Prince, 207 F.3d 402 (7th Cir. 2000).

170. *Id*. at 406.

171. *Id.* at 407.

172. Judge Posner's approach in *Pickett v. Prince* has become the usual rule in copyright. It is also based on a rather shallow doctrinal mistake. Section 103(a) of the Copyright Act provides that "protection for a work employing preexisting material in which copyright

By making minor innovations more expensive, copyright law, in theory, affects sequential innovation in ways that patent law does not. First, among more-or-less rational creators, copyright law encourages them to engage in innovating rather than borrowing. Because creators are unable to obtain their own rights in their derivate creations, they will have less incentive to borrow from existing works. As the costs of borrowing rise, rational people will switch to innovating. Thus, instead of creating adaptions of existing superheroes, for example, people will create new ones.

Our data suggest that some creators will not respond to this shift in incentives, because the additional incentives are inframarginal. For creators who are deeply committed to borrowing, the additional incentive will not be enough to overcome their aversion to innovating. Our experiments suggest that some creators have strong individual preferences for borrowing, either due to innovation heuristics or insufficient optimism about their own creative ability. In addition, they may receive intrinsic value from tweaking existing ideas that exceeds whatever the market value of the innovation may produce.[173] For example, someone may enjoy manipulating sound recordings but have no interest in producing new ones. Because copyright law casts this behavior as infringement (and thus potentially subject to substantial statutory damages) and because the market value of the new work will often be small, the would-be borrower will likely forego the exercise entirely.[174]

While patent law provides downstream creators with options for both innovating and borrowing, copyright law largely forecloses opportunities for borrowing, at least without a prior licensing arrangement. In so doing, copyright law further distorts creators' behavior in ways that are likely to produce inefficiencies. Although copyright law may encourage more innovating by discouraging borrowing, this is not necessarily valuable innovation. In many cases, it will be duplicative and wasteful. As we have noted, the cumulative value of borrowing may actually be much greater than that of innovating, but because the value of any individual tweak is small, borrowing will be especially sensitive to the additional transaction costs that copyright law's prelicensing requirement produces.

Whether this variation in the treatment of sequential innovation between patent and copyright is warranted is a question for IP theory and further empirical research. As we noted at the outset, the answer depends on one's assumptions about the costs and direction of investment in research and the desirability of few or many solutions to a given problem. On one hand, copyright law's push toward innovating may produce greater social welfare if we believe that the kinds of issues that artists face

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subsists does not extend to any part of the work in which such material has been used unlawfully." 17 U.S.C. § 103(a) (2012). That text straightforwardly implies that copyright protection can extend to parts of a derivative work that are original to the improver—even if the parts that are not are used without permission.

173. If some of our borrowers derive considerable intrinsic satisfaction from their activities, we might hope that this would result in higher willingness to pay to borrow. If that were the case, then there might be opportunities for licensing these sorts of sequential creativity. We doubt, however, that the intrinsic pleasure that these creators feel is regularly translated into economic value in the sense that they are willing to invest considerable sums in producing it. Moreover, the transaction costs of licensing these sorts of deals are large relative to the economic value of the individual works that get produced.

174. At best, the would-be borrower might switch to manipulating public domain works.

are best approached from a variety of different perspectives. Perhaps, by encouraging artists to innovate, copyright law is pushing them to view problems with fresh eyes and new insight.[175] On the other hand, we might think that when artistic creativity is involved, people do not value too much novelty, instead preferring reinterpretations of familiar themes.[176] This is in contrast to technological creativity where people value maximal novelty.[177] If this is the case, then copyright law is hindering exactly the kind of creative expression that people want most.

We are not in a position to justify or refute one of these normative assertions. We raise them to illustrate the potential practical importance of our findings and their relevance to IP policy. If copyright law's emphasis on innovating over borrowing is socially costly, there is a readily available alternative that is derived from patent law. The law could reject Judge Posner's interpretation and allow borrowers to obtain "blocking copyrights" in their new contributions.[178] This would level the playing field between initial creators and downstream creators and balance out the incentives that downstream creators face for innovating and borrowing.[179]

C. Addressing the Limitations of This Research

The laboratory experiments reported here allow us to test fundamental assumptions about people's behavior in novel ways. Random assignment of subjects to different conditions allows us to investigate causal relationships between factors that are not easily measured in other kinds of empirical studies.[180] As always, though, these advantages come with certain costs. Aspects of our experimental design produce unavoidable limitations in the strength and generalizability of our findings. We have discussed many of these at length in a previous paper and will only briefly mention them here.[181]

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175. For example, it has been suggested that the inability of the filmmakers of *Selma*, the biopic about Martin Luther King, Jr., to use his copyrighted speeches encouraged them to think creatively about the meaning of King's work rather than just its words. *See* Jonathan Band, *How Copyright Forced a Filmmaker To Rewrite Martin Luther King's Historic Words*, TECHDIRT (Dec. 30, 2014, 6:13 AM), https://www.techdirt.com/articles/20141229/13390429545/how-copyright-forced-filmmaker-to-rewrite-martin-luther-king.shtml [https://perma.cc/8L5Y-D5AK] ("Proponents of long copyright term might point to these reviews as proof of the copyright system working properly. Denied the ability to quote King directly, DuVernay was forced to create her own expression—paraphrases of King's speeches—and her own interpretation of King's life.").

176. *See* Fromer, *supra* note 72, at 1479.

177. *Id*. at 1484.

178. *See* Lemley, *supra* note 6, at 1075–76.

179. We are not committed to this as the optimal strategy. Creating a blocking copyrights regime would increase transaction costs associated with licensing derivative works. In theory, at least, this could cause some of the public goods problems that Kitch was concerned with. *See* Kitch, *supra* note 43, at 266.

180. ROBERT M. LAWLESS, JENNIFER K. ROBBENNOLT & THOMAS S. ULEN, EMPIRICAL METHODS IN LAW 101 (2010) ("[O]ne of the advantages of the experimental design is in its ability to isolate causal relationships.").

181. *See* Buccafusco et al., *supra* note 90, at 1973–75.

A first set of limitations relates to our subject population. We recruited subjects from AMT rather than using real creators and innovators.[182] We did this primarily for purposes of ease and cost reduction. Running these experiments with similar numbers of real-life creators would have been enormously more expensive. Nonetheless, these samples could differ in important ways, including in terms of intrinsic motivation, skill, and demographic characteristics. Moreover, unlike our sample of individually acting subjects, many creators work as part of firms.[183] Perhaps aspects of firm relations alter the individual effects that we see here. While we look forward to running similar experiments with more realistic samples in the future, we also want to note the extent to which creativity and innovation are increasingly mass phenomena.[184]

A second set of limitations involves the creativity tasks that we employed. Although the wagon game involved aspects of creativity associated with algorithmic and heuristic thinking, it obviously differs in many ways from filming a movie or designing a smartphone. And while the Scrabble task may be closer to artistic creativity, it obviously still does not cover the entire creative process of a Picasso painting. Perhaps our results would have been different if we had used more open-ended creativity tasks or if the games had involved slower cognition. It is certainly possible, although it is difficult for us to predict how these changes would likely affect our results.

IV. CONCLUSION

Perhaps more than any other area of the law, IP is grounded in the idea that legal doctrines can affect people's behavior in socially beneficial ways. In order to succeed, however, the law needs an accurate account of human motivation. The four experiments reported in this Article shed new light on the central issue of IP law—how best to regulate sequential innovation. More research like this is essential if IP law is going to give up its reliance on untested assumptions and adopt a behaviorally realistic view of human motivation.

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182. We discuss debates about the validity and reliability of Mechanical Turk samples *supra* note 97.

183. Similarly, creative production frequently occurs in teams, which might also change the effects or salience of IP thresholds. *See, e.g.*, Anthony J. Casey & Andres Sawicki, *Copyright in Teams*, 80 U. CHI. L. REV. 1683 (2013).

184. Consider the rise of Web 2.0. *See* Edward Lee, *Warming Up to User-Generated Content*, 2008 U. ILL. L. REV. 1459; *see also* VON HIPPEL, *supra* note 148 at 1 ("When I say that innovation is being democratized, I mean that users of products and services—both firms and individual consumers—are increasingly able to innovate for themselves."); Stefan Bechtold, *Physicians as User Innovators*, *in* INTELLECTUAL PROPERTY AT THE EDGE: THE CONTESTED CONTOURS OF IP 343 (Rochelle Cooper Dreyfuss & Jane C. Ginsburg eds., 2014).

APPENDIX A: EXPERIMENT 1: WAGON BONUS

Logistic regression of innovation behavior. When the coefficient is greater than 1.0, this indicates a positive relationship between that variable and innovating. When it is less than 1.0, there is a negative relationship. Coefficients equal to 1.0 indicate no directional relationship. Numbers in parentheses indicate standard error.

Dependent Variable – Innovation/Borrow Dummy (1 = Innovate; 0 = Borrow)
$p < 0.01$ - ***
$p < 0.05$ - **
$p < 0.10$ - *

Variable	Reg. 1	Reg. 2	Reg. 3	Reg. 4	Reg. 5
Bonus condition	1.002 (0.004)	—	—	—	—
Ease of solving	—	0.589*** (0.151)	—	0.594*** (0.156)	0.566*** (0.163)
Ease of innovating	—	3.726*** (0.150)	—	3.866*** (0.156)	3.704*** (0.155)
Risk seeking	—	0.972 (0.076)	—	—	—
Openness	—	—	1.329** (0.119)	1.231 (0.136)	1.156 (0.138)
Extroversion	—	—	0.858 (0.108)	0.751** (0.127)	0.853 (0.110)
Conscientiousness	—	—	0.878 (0.141)	0.853 (0.160)	—
Agreeableness	—	—	1.130 (0.137)	1.262 (0.156)	—
Neuroticism	—	—	0.852 (0.122)	0.771* (0.141)	—
Age	—	—	1.018* (0.011)	—	1.014 (0.012)
Gender	—	—	0.993 (0.224)	—	0.992 (0.254)
Constant	1.993*** (0.160)	0.412 (0.564)	0.909 (1.320)	0.554 (1.477)	0.517 (1.110)
Did not understand instructions	—	—	—	—	0.604** (0.110)
Observations	432	432	432	432	432
R^2	0.00067	0.237	0.028	0.254	0.253

APPENDIX B: EXPERIMENT: WAGON SOURCES

Logistic regression of innovation behavior. The default condition is *Previous AMT Player*. When the coefficient is greater than 1.0, this indicates a positive relationship between that variable and innovating. When it is less than 1.0, there is a negative relationship. Coefficients equal to 1.0 indicate no directional relationship. Numbers in parentheses indicate standard error.

Dependent Variable – Innovation/Borrow Dummy (1 = Innovate; 0 = Borrow)
$p < 0.01$ - ***
$p < 0.05$ - **
$p < 0.10$ - *

Variable	Reg. 1	Reg. 2	Reg. 3	Reg. 4
MIT Student	1.542	1.643	1.389	1.349
	(0.355)	(0.347)	(0.400)	(0.411)
Computer Generated	0.922	0.938	0.834	0.837
	(0.340)	(0.347)	(0.376)	(0.390)
Age	—	1.025	—	1.047**
		(0.017)		(0.020)
Gender	—	1.646	—	1.636
		(0.314)		(0.351)
Risk seeking	—	0.963	—	—
		(0.094)		
Perceived quality of solution	—	—	0.976**	0.973**
			(0.011)	(0.012)
Ease of solving	—	—	0.481***	0.486***
			(0.202)	(0.206)
Ease of innovating	—	—	2.447***	2.651***
			(0.188)	(0.197)
Did not understand instructions	—	—	0.524**	0.471***
			(0.273)	(0.283)
Constant	1.483	0.415	24.856***	3.810
	(0.240)	(0.742)	(1.208)	(1.425)
Observations	212	212	212	212
R^2	0.011	0.037	0.189	0.225

APPENDIX C: EXPERIMENT 2: SCRABBLE BONUS

Logistic regression of innovation behavior. When the coefficient is greater than 1.0, this indicates a positive relationship between that variable and innovating. When it is less than 1.0, there is a negative relationship. Coefficients equal to 1.0 indicate no directional relationship. Numbers in parentheses indicate standard error.

Dependent Variable – Innovation/Borrow Dummy (1 = Innovate; 0 = Borrow)
$p < 0.01$ - ***
$p < 0.05$ - **
$p < 0.10$ - *

Variable	Reg. 1	Reg. 2	Reg. 3	Reg. 4	Reg. 5
Bonus variable	1.012***	—	1.013***	1.013***	1.012***
	(0.004)		(0.004)	(0.004)	(0.004)
Ease of solving	0.504***	—	0.508***	0.519***	0.515***
	(0.138)		(0.138)	(0.135)	(0.135)
Ease of innovating	3.910***	—	3.903***	3.882***	3.889***
	(0.135)		(0.135)	(0.133)	(0.133)
Openness	—	1.002	0.996	0.997	—
		(0.010)	(0.012)	(0.012)	
Extraversion	—	1.009	1.000	1.000	—
		(0.008)	(0.011)	(0.010)	
Conscientiousness	—	1.004	0.998	0.997	—
		(0.010)	(0.012)	(0.012)	
Agreeableness	—	1.015	1.016	1.014	—
		(0.012)	(0.015)	(0.014)	
Neuroticism	—	1.003	0.993	0.996	—
		(0.009)	(0.011)	(0.010)	
Age	0.991	—	0.989	—	—
	(0.011)		(0.011)		
Education	1.020	—	1.025	—	—
	(0.077)		(0.078)		
Gender	0.851	—	0.840	—	—
	(0.217)		(0.227)		
Risk seeking	1.056	—	1.052	—	—
	(0.075)		(0.082)		
Confidence in verbal/language ability	1.037	—	1.029	—	—
	(0.147)		(0.151)		
How often do you play Scrabble	1.109	—	1.114	—	—
	(0.099)		(0.099)		
Motivation to score well	0.926	—	0.894	—	—
	(0.161)		(0.166)		
How well did you understand instructions	1.261	—	1.323	—	—
	(0.243)		(0.250)		
Constant	0.144**	0.177*	0.124	0.138	0.194***
	(0.964)	(0.969)	(1.605)	(1.236)	(0.387)
Observations	541	541	541	541	541
R^2	0.293	0.008	0.296	0.290	0.288

APPENDIX D: EXPERIMENT 3: WAGON QUALITY

Logistic regression of innovation behavior. The default condition is *60% Strength*. When the coefficient is greater than 1.0, this indicates a positive relationship between that variable and innovating. When it is less than 1.0, there is a negative relationship. Coefficients equal to 1.0 indicate no directional relationship. Numbers in parentheses indicate standard error.

Dependent Variable – Innovation/Borrow Dummy (1 = Innovate; 0 = Borrow)
$p < 0.01$ - ***
$p < 0.05$ - **
$p < 0.10$ - *

Variable	Reg. 1	Reg. 2	Reg. 3	Reg. 4
80% condition	0.574 (0.376)	0.608 (0.379)	0.484* (0.412)	0.516 (0.416)
100% condition	0.396*** (0.356)	0.399** (0.360)	0.581 (0.398)	0.600 (0.399)
Age	—	0.999 (0.014)	—	—
Gender	—	0.643 (0.304)	—	0.735 (0.330)
Risk preference	—	1.015 (0.093)	—	—
Ease of solving	—	—	0.528*** (0.210)	0.534*** (0.212)
Ease of innovating	—	—	2.826*** (0.182)	2.801*** (0.182)
Constant	3.937*** (0.280)	4.842** (0.747)	1.793 (0.632)	2.064 (0.651)
Observations	241	241	241	241
R^2	0.029	0.040	0.192	0.195

APPENDIX E: EXPERIMENT 4: SCRABBLE QUALITY

Logistic regression of innovation behavior. The default condition is *60% Strength*. When the coefficient is greater than 1.0, this indicates a positive relationship between that variable and innovating. When it is less than 1.0, there is a negative relationship. Coefficients equal to 1.0 indicate no directional relationship. Numbers in parentheses indicate standard error.

Dependent Variable – Innovation/Borrow Dummy (1 = Innovate; 0 = Borrow)
$p < 0.01$ - ***, $p < 0.05$ - **, $p < 0.10$ - *

Variable	Reg. 1	Reg. 2	Reg. 3	Reg. 4	Reg. 5
80% group	0.961	—	—	0.982	—
	(0.355)			(0.344)	
100% group	3.957***	—	4.158***	4.000***	3.858***
	(0.421)		(0.380)	(0.410)	(0.377)
Ease of solving	0.711*	—	0.715**	0.693**	0.683**
	(0.167)		(0.170)	(0.168)	(0.312)
Ease of innovating	2.784***	—	2.790***	2.756***	2.751***
	(0.167)		(0.165)	(0.164)	(0.164)
Openness	—	1.027**	—	—	1.025
		(0.013)			(0.015)
Extraversion	—	1.003	—	—	—
		(0.012)			
Conscientiousness	—	0.993	—	—	—
		(0.017)			
Agreeableness	—	1.021	—	—	—
		(0.017)			
Neuroticism	—	1.000	—	—	—
		(0.013)			
Age	1.013	—	1.014	—	—
	(0.014)		(0.014)		
Education	1.060	—	—	—	—
	(0.119)				
Gender	0.574	—	0.608	—	0.623
	(0.347)		(0.332)		(0.169)
Risk Seeking	0.935	—	—	—	—
	(0.106)				
Confidence in verbal/language ability	1.052	—	—	—	—
	(0.226)				
How often do you play Scrabble	0.865	—	0.888	—	—
	(0.147)		(0.142)		
Motivation to score well	1.121	—	—	—	—
	(0.244)				
How well did you understand instructions	1.100	—	—	—	—
	(0.339)				
Constant	0.147	0.132	0.232*	0.306**	0.082
	(1.424)	(1.429)	(0.816)	(0.547)	(0.979)
Observations	273	273	273	273	273
R^2	0.333	0.033	0.331	0.326	0.332

APPENDIX F: AN EXPERIMENT 1 FOLLOW-UP EXPERIMENT

One possibility is that the results of our first experiment are merely an artifact of the experimental design based on the subject's perception of the *source* of the provided submission on which the subject is attempting to improve. In the real world, follow-on innovators receive more information about existing ideas than in our first experiment. They may know, for example, whether the original innovator was a very talented and bright individual. In such case, follow-on innovators may consider it harder to "invent around" an existing idea and therefore decide to borrow rather than innovate. We ran another experiment to test whether subjects' decisions to innovate or borrow are influenced by the perceived quality of the original innovator.

We used the same wagon-creativity task and experimental software program as the previous experiment. After going through the practice game, subjects were given the same instructions about the nature of the game and the distribution of points as in Experiment 1. Subjects were also told that they would receive an additional sixteen points if their submission did not use three or more of the items from the existing submission. In three conditions to which subjects were randomly assigned, subjects were given different information about who had created the existing submission. In the baseline condition, subjects were told that the existing submission was randomly generated by a computer. In the second condition, subjects were informed that the submission was entered by a participant in a previous version of this study run on AMT. In the third condition, subjects were told that the submission was entered by a participant in a previous version of this study that was run at the Massachusetts Institute of Technology (MIT). For each condition, the provided submission was the same one that had been used in Experiment 1. Subjects then played the game, replied to comprehension questions, and answered a series of follow-up and demographic questions similar to those used in the previous experiment.

We recruited 303 subjects via AMT to participate in this follow-up experiment. As in Experiment 1, subjects were paid $0.50 for participating and $0.03 for each point they scored in the game. We excluded 73 subjects from the final data analysis for missing one or both of the comprehension questions or for missing an attention question. We also removed 18 subjects who went over the weight limit. This left us with 212 subjects. They remained equally distributed across the three conditions, had a mean age of 30.75, and 62.74% of them were male.

Our results do not confirm expectations that a higher perceived quality of the original innovator should prompt subjects to innovate less and borrow more. A superficial look at the descriptive data seems to suggest otherwise: the percentage of subjects choosing to innovate increases rather than decreases when moving from a computer-generated original submission, to a submission generated by another subject, to a submission created by an MIT student. However, a comparison of the three samples reveals that they cannot be said to be statistically different with a sufficient level of confidence.

Table 10. Percentage innovating per condition

	Computer-generated condition	Other AMT subject condition	MIT student condition
Percentage (%) innovating	57.75 (a)(b)	59.72 (a)(c)	69.57 (b)(c)

(a) Computer-generated versus other subject: two-tail t-test, $p = 0.81$.
(b) Computer-generated versus MIT student: two-tail t-test, $p = 0.15$.
(c) Other subject versus MIT student: two-tail t-test, $p = 0.22$.

Again, subjects' answers to follow-up questions reveal that the strongest predictor of their behavior was their perception of how easy it would be to innovate. The easier they thought it would be to innovate, the more likely they were to do so. *See supra* Appendix B, Regression 4. In addition, as subjects' perception of the given solution's increased, they increasingly decided to borrow. *See supra* Appendix B, Regression 4. This conforms to rational expectations, as well, because the better they believe the given solution to be, the harder it will be to innovate.

Finally, despite the very different identities of those who supposedly provided the solutions, our subjects did not differ in how strong they thought the given solution was between conditions. Whether they were told that the solution was randomly generated or submitted by an MIT student, subjects thought the solution was about the same quality. (The mean [standard deviation] of subjects' perceived quality of the solution were as follows: Previous Participant: 72.28 [16.93]; MIT Student: 75.96 [15.28]; Computer Generated: 75.92 [16.35]. Interestingly, these estimates are lower than the actual quality of the solution [90%], which could explain why subjects chose to innovate at such high rates. All differences are nonsignificant.)