An Experiment on Protecting Intellectual Property

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An Experiment on Protecting Intellectual Property[‡]

Joy A. Buchanan[*] and Bart J. Wilson[†]

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Abstract: We conduct a laboratory experiment to explore whether the protection of intellectual property (IP) incentivizes people to create non-rivalrous knowledge goods, foregoing the production of other rivalrous goods. In the contrasting treatment with no IP protection, participants are free to resell and remake non-rivalrous knowledge goods originally created by others. We find that creators reap substantial profits when IP is protected and that rampant pirating is common when there is no IP protection, but IP protection in and of itself is neither necessary nor sufficient for generating wealth from the discovery of knowledge goods. Rather, individual entrepreneurship is the key.

Key Words: intellectual property, experimental economics

JEL Classifications: C92, D89, K39

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I. Introduction

Intellectual property (IP) laws restrict the use of non-excludable ideas. Without IP protection, in theory, as soon as a creator brings a new product to the market a competitor would start copying and selling the good at marginal cost. The reason given for IP protection is that if markets do not reward creators for their costly effort then there is no incentive to innovate. The argument *against* IP protection is that creators can charge monopoly prices and restrict access to their products, thereby resulting in lost welfare (Stiglitz 2008). Also, IP laws may raise the cost of further innovations because many new ideas build upon old ones. The access versus incentive debate weighs the loss from restricted consumption and reduced incremental innovations against the gains from providing incentives for people to create more valuable knowledge goods (Landes and Posner 2003). There is evidence that IP protection fosters innovation under certain circumstances (Moser 2004), however some economists argue that innovation would happen without IP laws (Levine and Boldrin 2002, 2008; Benkler 2006; Mokyr 2009).

The IP question is usually stated as a static cost-benefit analysis. However, the benefit of IP protection is in the future while the cost of IP protection is backward-looking. The cost is the lost welfare that could have been realized on products already created and sold under monopoly conditions. This is problematic for research because IP advocates and critics are, in an important sense, talking past each other. A replicable laboratory experiment is an apt tool for investigating this dynamic puzzle because neither future discoveries nor alternative histories can be observed in the naturally occurring economy. Inventors and artists choose to pursue a Knightian uncertain career path and produce a new product that their community values. This paper presents an experimental environment that allows subjects to, likewise, choose a creative project at the expense of foregoing gains from a more routine production task and also to interact with consumers.

We aim with this paper, in the form of an experimental design and a new set of facts, to bring something concrete and common to those discussing this important economic, legal, and policy question. In a laboratory experiment with random assignment of participants to treatment conditions, proponents of IP laws can continue to look forward in expectation that IP protection will provide their alleged benefits, but they must concurrently look backward on the results to observe how the counterhypothesis fares. Similarly, opponents of IP protection can continue to look backward to the consequences of monopoly pricing, but they must simultaneously look forward to what happens when there is no IP protection. We expected to discover whether IP protection causes innovation and we assumed that wealth would follow from innovation. Instead we find that an entrepreneurial disposition is at least as important as the rules of IP protection for creating wealth through innovation.

Our experiment replicates several important facts relevant to both advocates and critics of IP protection. Critics will find that prices are indeed higher when IP is protected, that creators reap substantial profits with their protected monopoly positions, and that IP protection is not necessary to induce people to create non-rivalrous knowledge goods. Advocates will observe rampant piracy, a common term for intellectual property theft, when there is no IP protection and that the protected IP treatment is ultimately the most encouraging for creating non-rivalrous knowledge goods. But "ultimately" is the operative word, for none of these observations tie together the complete story of the *process* by which knowledge goods and associated wealth are created in our experiment. Our experiment reveals an unseen linchpin of IP that can be neither taken for granted, nor assumed away. Our results indicate that IP protection encourages innovative people to become entrepreneurs.

In what follows, we first present our experimental design and procedures in Section II followed by our benchmarks and hypotheses in Section III. Section IV reports the results of our experiment, and Section V takes stock of what we learned. Section VI presents a new explicating treatment, reports the results of it, and offers concluding remarks.

II. Experimental Design and Procedures[1]

A. Environment

Each session consists of 18 periods, called "days", during which 10 subjects earn cash by producing, trading, and consuming two types of goods: gray and color. Gray goods are rivalrous and color goods non-rivalrous. Each participant is identified by a letter *A* through *J* and endowed with a house which displays his or her letter. Participants can produce goods during the first 155 seconds of the day. (Figure 1 summarizes the structure of an experimental 230-second day.)

Figure 1. Summary Timeline of a "Day"

One of the central assumptions underlying the protection of intellectual property is that it incentivizes people to forego other productive pursuits, say of rivalrous non-knowledge goods, in favor of creating non-rivalrous knowledge goods. Thus, as an active and explicit opportunity cost for producing non-rivalrous color goods, the gray goods are an important

[1] We recommend reading the full experiment instructions in Appendix A before reading further. A demonstration of the software can be viewed here: http://www.youtube.com/watch?v=l47DBxVG99Y.

feature of our design. Half of the subjects are endowed with the ability to produce light gray goods and the other half dark gray goods. To produce a single light or dark gray unit, a subject simply clicks on the window of his or her house which appears lit (in yellow). Gray production takes 4 seconds during which time a loading bar fills up on their house. The loading bar is visible to all participants on this home screen. Light and dark gray goods are perfect complements: a subject earns 9 US cents for each pair of light and dark gray goods that he or she possesses at the end of the day. Trade is a necessary feature of the gray economy so that the decision to sell colors is not the only activity in the experiment that involves market transactions. In the next subsection we discuss the institutional trading rules for trading light and dark gray goods.

The production and trading of gray goods is the subjects' default way to earn money in the experiment. It is against this opportunity that subjects must weigh the (Knightian) uncertain choice of producing a non-rivalrous color good that they may be able to consume and sell for profit.[2] To produce a color good, a subject clicks the "Enter Studio" button on the home screen. The subject then leaves the home screen and is presented with a color creation palate. (The lone lit window on their house darkens while a subject is in the studio.) The subject's task in the studio is to create one of 125 different colors by combining 5 different levels of red, green, and blue.

Figure 2 displays the studio interface. Subjects can see the color they are creating in the preview bar. Once the subject clicks the "Produce Color Good" button inside the studio, it takes 8 seconds (twice as long as a gray) to produce the item. The green progress bar fills over 8 seconds as the good is made. The subject is then returned to home and the color appears in their inventory. They must click the "Convert" button to learn the value of the color. To produce another color the subject must return to the studio and repeat the process.

The 125 colors can be thought of as arranged in a 5x5x5 cube, each with a red, green, and blue component, which we will represent with the 3-tuple (r, g, b). For example, $(1, 2, 5)$ appears as gold. The value of a given color is a function of the simple vector distance d between a color (r, g, b) and the favorite color of the day (r^*, g^*, b^*), i.e., $d = \sqrt{(r - r^*)^2 + (g - g^*)^2 + (b - b^*)^2}$. Because there are fewer colors that surround a color on an edge of the cube, we use a different function depending upon whether the favorite color of

[2] Our task shares some similarities with the entry decision game by Camerer and Lovallo (1999) in which subjects simultaneously decide whether to take a sure payoff or enter a contest for a prize that decreases in expectation with the number of entrants. When the contest depends on skill, they find excessive entry that appears to be rational on the part of subjects who are overconfident about their own relative skill level. Like ours, their subjects in the trivia contests are not choosing between gambles with known outcome distributions. We do not tell subjects the probability of getting a valuable color in the Studio on a random draw, because the colors they create are not random draws. Finding valuable colors involves both risk and skill.

the day is on an edge or in the center of the cube.[3] Table 1 displays the mapping of the distance to values.

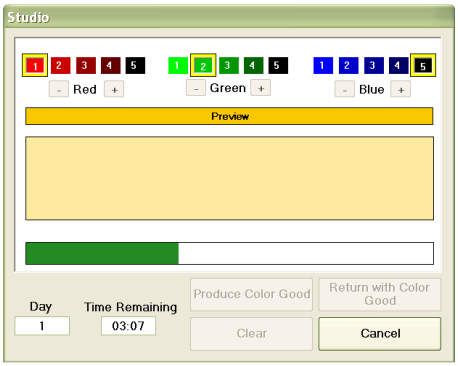


Figure 2. Studio Interface

Table 1. Color Values as a Function of Distance from Favorite

d	Center Favorite	Edge Favorite
0	40	40
1	30	30
$\sqrt{2}$	9	12
$\sqrt{3}$	5	9
2	0	5
> 2	0	0

The existing stock of knowledge is a commons that cannot be overfished but is always becoming outdated because the next generation has new tastes and new problems to solve. Thus, we inform the subjects that each day there is a new "favorite" color that is worth 40 cents to everyone. They are also informed that colors which are "close" to the favorite are worth less than 40 cents and that colors which are "far" away are worth nothing. Their creative challenge is to discover how to find valuable colors among the 125 options in the studio, which, in turn involves discovering the value function and a search strategy for zeroing in on the favorite color once a 5-, 9-, or 12-cent color is discovered.[4,5]

As subjects consume more color goods (they can only consume one unit of each color), they are charged a small, non-decreasing "usage fee" (decreasing marginal utility). The usage fee is small enough such that the favorite color and the six colors (five, in the case of an edge) 1 unit away from it are always profitable to consume, provided the price that the subject pays is

[3] An edge color is a color which has at most one component valued at 1 or 5.

[4] Anticipating that some of our subjects may be colorblind, we also display the 3 coordinates of the color. See Figures 3 and 4.

[5] Our creative task is theoretically similar to that of Ederer and Manso (2013) in that subjects search through a multi-dimensional space. Two important differences are that our search task is presented in the context of creating a new product rather than as a business management decision and that our subjects have an opportunity cost of innovating, so our subjects need to self-select into the innovative task.

sufficiently low. This feature introduces the potential for deadweight losses from monopoly pricing of a color good. It also makes the creation of additional color goods (slightly) more costly, particularly if its value turns out to be zero. Table 2 displays the usage fee function.

Table 2. Usage Fees for Consuming Color Goods

Number of Color Goods	Usage fee	Number of Color Goods	Usage fee
1	0	15	5
2	1	16	6
3	1	17	6
4	1	18	6
5	2	19	7
6	2	20	7
7	2	21	7
8	3	22	8
9	3	23	8
10	4	24	8
11	4	25	9
12	4	26	9
13	5	27	9
14	5	28	10

To reinforce the different nature of the rivalrous gray goods and non-rivalrous color goods, we inform the subjects that "[i]f you send a **gray** good to another person, you give up the item" and "[u]nlike **gray** goods, if you send a **color** item to other people it is not removed from your holdings."

B. Institution

Subjects can exchange gray goods via a public bulletin board on which they can post goods for any price from 0 to 9 cents.[6] Figure 3 displays the gray bulletin board. Posters have the option of posting their offer anonymously or not and can edit their offer at any time. By clicking on the "Accept" button, the software automatically completes the exchange of x cents for a light or dark gray good. Alternatively, subjects can asynchronously use the "Send Items" button to send a gray good to any person, and another person can use the "Transfer Cents" button to send money directly to another person. This feature is useful for pairs of subjects who would like to directly exchange dark and light gray units with each other, with or without the exchange of money. It is worth noting that the subjects must rely on reputation via

[6] In an unreported pilot session, subjects were allowed to post any price they would like. Transaction prices quickly bubbled to as high as 45 cents/unit as subjects attempted to churn units at higher and higher prices. Since we are not interested in studying how price bubbles form for commodities with a known fixed value, we capped the posted prices at the public maximum of 9 cents.

repeated interactions to enforce any contracts agreed to in the chat room that involve using the "Transfer Cents" and "Send Items" buttons.[7]

Similarly, subjects can post color goods in a separate bulletin board, again either anonymously or by their letter name (see Figure 4). The value of color goods is included in the table to eliminate potential problems of asymmetric information. More details on the rules of the color good bulletin board will be discussed in the treatment subsection below. The color exchange mechanism was inspired by institutions for the sale of digital media over the internet such as iTunes.

A public chat area is open at all times on the right side of the screen, and under the chat box is a record of actions such as transfers that are relevant to the subject (see Figure 5 for a complete view of the screen). The summary section on the left side of the screen maintains a real time accounting of their inventories and earnings. At the beginning of each day, we give each subject a loan of 250 cents to use for trade, which is automatically subtracted from their earnings at the end of the day.

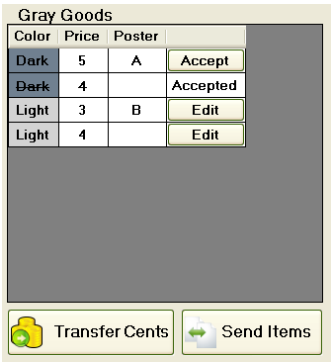


Figure 3. Gray Bulletin Board

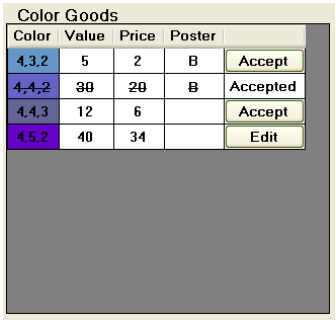


Figure 4. Color Bulletin Board

As mentioned above, subjects can produce goods only during the first 155 seconds of the day. The remaining 75 seconds of the day can only be used for trade and chat. The chat room and bulletin boards are open continuously for all 230 seconds of the day.

[7] Subjects' successfully establish verbal trade contracts. While there are accusations of reneging in the chat room, particularly in early days when the participants are exploring the interface, many of the accused contritely apologize for any confusion and some offer to make it up to the offended participant. Crockett, Smith, and Wilson (2009) similarly find that reputation and repeated interaction are sufficient for enforcing chat room agreements for the exchange of rivalrous goods.

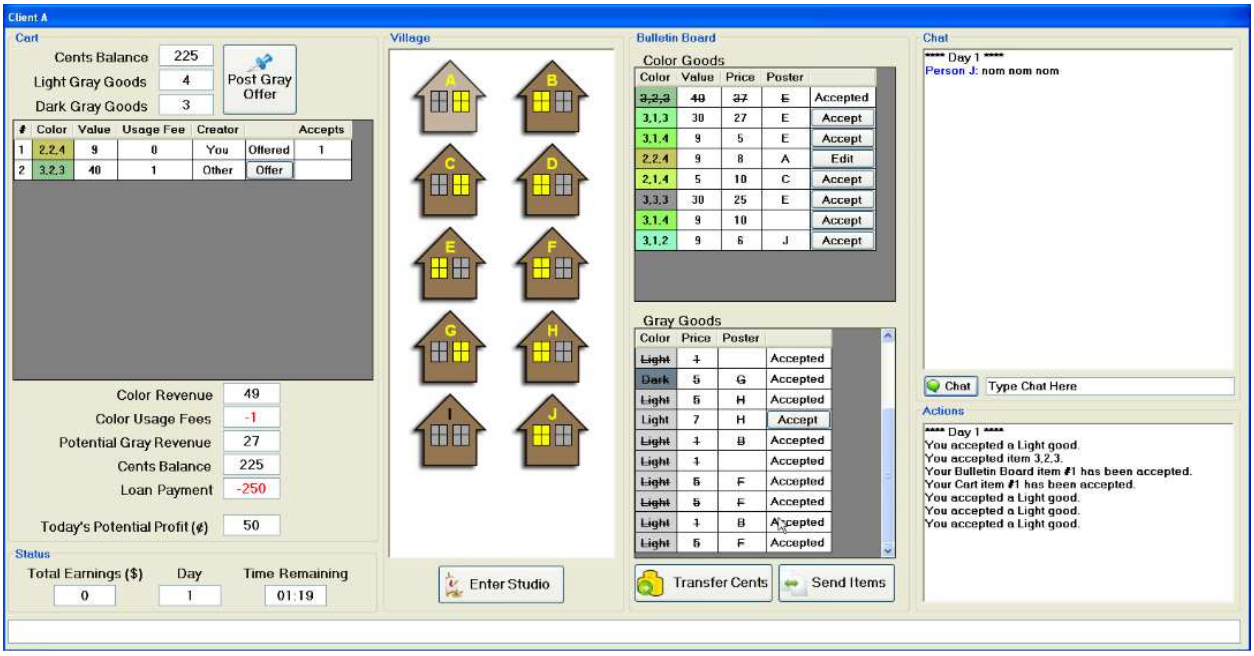


Figure 5. Full Screenshot of Subject Interface

C. Treatments

One of the benefits of a laboratory experiment is that we, the experimenters, can perfectly enforce intellectual property rights by setting the permissible actions of the participants through the software interface. Moreover, we can ask the counterfactual question of what happens when we remove the software enforcement *without any change in the instructions* to the participants that might nudge their decisions or alert them that the circumstances could be different.

In what we will call the *IP* treatment, once a subject creates a color in the studio, no other person can go into the studio and create it. Only the creator can sell or transfer a color good to another person. If a subject sells a color good to another person, the buyer cannot post it on the bulletin board, nor transfer it via the "Send Items" button. The option to do so is simply not presented to subjects in this treatment. Because items cannot be produced in the last 75 seconds of the day, a creator can wait until the last portion of the day to post which colors are valuable so as to search out for him- or herself as many valuable colors as possible without divulging the general location of the "favorite".

In the *No IP* treatment, any person can go to the studio during the production time and create a color that another has already created. Any person who purchases a color can also repost it on the bulletin board and sell it to others for any price. Subjects can use the "Send Items" button to secretly transfer colors to other people, bypassing creators in a way that file-sharing networks do online. The "Transfer Cents" button, available in both treatments, gives

people the option of compensating color good creators through other means if creators are not making a profit from selling them on the bulletin board.[8]

Because subjects trade the rivalrous gray goods via a multilateral bulletin board and/or the bilateral "Send Items" and "Transfer Cents" buttons, there is nothing different about how people can trade color goods. (That is why we incentivize trade in the gray economy via Leontief preferences.) Thus, if subjects do not engage in IP production and trade, we can rule out the explanation that they did not know how. The institutional format is the same; the question is what type of system and behaviors emerge for the non-rivalrous color goods when intellectual property is perfectly enforced and when it is not.

D. Procedures

We initially conducted six sessions in each treatment, for which we recruited a total of 120 undergraduates at Chapman University. Later in Section VI we will report on another treatment condition which we subsequently conducted with 87 more undergraduates. No subject participated twice, and many had participated in other economic experiments. Subjects were seated at visually-isolated computer terminals, read self-paced instructions, and were free to ask questions at any time. Each of the first 12 sessions consisted of 10 participants, 5 men and 5 women, contained 18 days of 230 seconds each, and lasted no longer than 90 minutes (approximately 10 minutes for instructions, 69 minutes for the session proper, and approximately 10 minutes for private payment). Each subject was paid $7 for showing up on time, plus what their decisions earned them in the session. Not including the show-up payment, mean earnings for all 207 subjects was $15.42, with a standard deviation of $9.24.

III. Benchmarks, Hypotheses, and Methodology

If a subject uses every second of the production phase, he or she can produce 38 light or dark gray units.[9] Assuming that a different subject spends the same amount of time producing the complementary gray good, a dark-light gray pair of traders can exchange 19 units to individually earn $1.71 per day, or $30.78 over 18 days. If all ten subjects only produce gray, total earnings per day for the group would be $17.10.

In contrast, the value from consuming all of the color goods with a value greater than 5 cents in a day generates earnings of $2.61 ($2.62) per day for a center (edge) favorite color, net of usage fees.[10] Half of the 18 favorite colors are in the center and half on an edge, and so over

[8] If there are reasons beyond monetary profit that motivate people to go to the studio, they are equally present in both treatments. No subject made a significant contribution to the color economy who was not earning money from sales of colors.

[9] To do this, a subject must forego any communication in the chat room and postpone all trading until the last 75 seconds of the day.

[10] The usage fee from consuming 18 (19) color goods is 6 (7) cents.

18 days there are potential earnings of $47.07/participant from consuming all the color goods (with a value greater than 5 cents). If all ten subjects spent the entire time producing colors, discovered all goods with a value greater than 5, and sold every one of these colors to every other participant, total earnings per day would be $26.15 (on average). However, if a proper subset of the 10 subjects is sufficient to discover and sell the valuable colors goods to everyone else, then pairs of light and dark gray participants can consume color goods *and* produce and consume gray goods. The result would be total earnings greater than $26.15 per day for all 10 subjects, specifically, $26.15 + $3.42*p*, where *p* is the number of pairs producing and consuming light and dark grays in addition to the color goods. The point is that a group that engages in color production has the potential to earn twice as much as a group that only makes and trades gray goods.[11]

Our hypotheses follow from the intuitive proposition that perfect and costless protection of non-rivalrous property incentivizes individuals to spend more time producing intellectual property by granting creators the exclusive right to sell it for financial gain. This is the assumed benefit of IP. Because intellectual property is non-rivalrous *ex hypothesis*, producing a greater volume of IP can benefit everyone, which in this experiment translates into higher earnings. Here are our primary hypotheses regarding our two treatments:

> **Hypothesis 1:** Participants in the *IP* treatment spend more time creating color goods than participants do in the *No IP* treatment.
>
> **Hypothesis 2**: The *IP* treatment generates more value from color goods than the *No IP* treatment.
>
> **Hypothesis 3**: Total earnings are higher in the *IP* treatment than in the *No IP* treatment.
>
> **Hypothesis 4:** The price of color goods (as a percent of value) is higher in the *IP* treatment than in the *No IP* treatment.
>
> **Hypothesis 5:** Sales revenue to color creators is higher in the *IP* treatment than in the *No IP* treatment.

Before we present results, we acknowledge that our design is more complex than many economic experiments. Our specific research question calls for offering subjects a complex continuum of choices and interactions. Innovators in society are faced with an array of options.

[11] As the experiment designers, we could have specified a probability distribution for returning from the studio with a color good to our subjects in the instructions. We did not do that because a probability distribution is inconsonant with the decision problem of unknowable uncertainty that would-be IP discoverers face in the naturally occurring economy. Modeling a utility maximizing agent who has a small set of pre-defined choices and payoffs would require us to assume away the very problem that we wish to explore.

For example, someone can try to create a new product and then give up if the first design is not well-received. Our open-ended design allows us to learn what we consider to be the major contribution of our paper: the *process* by which knowledge goods and wealth are created.

While we recognize the benefits of simple designs and formal theoretical frameworks for studying choice behavior in the laboratory, we submit that binary choice designs do not teach experimenters about the process by which individuals make their decision. Thus, the findings from simple experiments complement the results of more complex environments and vice versa. A methodological insight from our experience is that open-ended designs allow experimentalists to study emergent institutions (see, e.g., Wilson et al. 2012). Knowing what people choose is important, but it is also crucial to learn how those choices, and not others, come to be available in a society.

IV. Results

A. Tests of Our Hypotheses

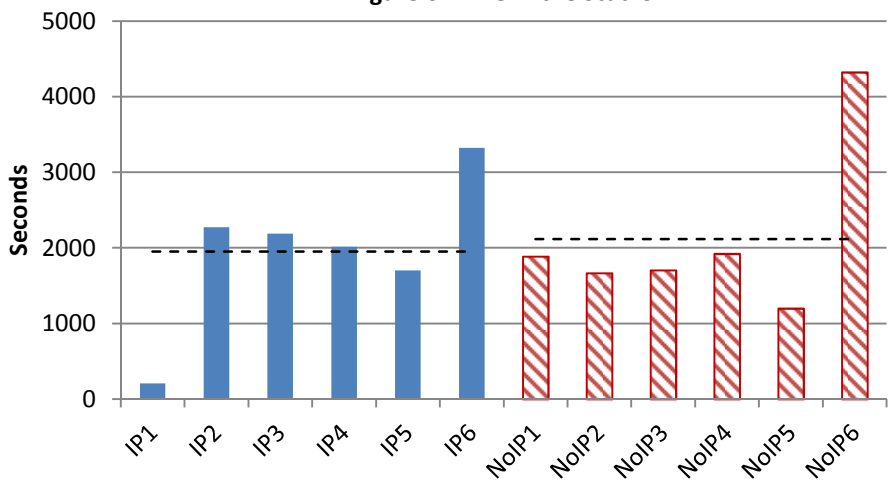
We present the results of our experiment as a series of five findings corresponding to our five hypotheses above. The data that we report is exclusively drawn from the second half of the experiment (the last 9 of 18 days) to mitigate the effects of different groups converging to their particular sets of behaviors and outcomes as they explore the confines of the environment and institution in this experiment. Unless otherwise noted, the conclusions of the treatment effects do not change for the data set comprised of observations from the first nine days, though the statistics themselves surely do. For example, every session earned more money in the second half of the experiment than the first. We begin by assessing the hypothesis on the amount of time spent discovering color goods in the studio.

> ***Finding 1:*** *Sessions in the* IP *treatment do <u>not</u> spend more time in the studio than sessions in the* No IP *treatment.*
>
> *Evidence*: Figure 6 reports total number of seconds spent in the studio by session. The average *IP* session spends 1,953 seconds in the studio, which is *less* than the average of 2,118 seconds for *No IP* sessions (see dashed lines in Figure 6). Using a Wilcoxon rank sum test, we fail to reject the null hypothesis of equal amounts of time ($U_{6,6}$ = 22, *p*-value = 0.71, one-sided test).

We do not observe more time spent in the studio in the *IP* treatment than in the *No IP* treatment. The session with the most time in the studio of all the sessions is in the *No IP* treatment, *No IP6*, and the session with the least amount of time in the studio is in the *IP* treatment, *IP1*. Although we present the subjects in the *IP* treatment with an opportunity to profit from sole ownership over the color goods they create, we cannot force those in *IP1* to take advantage of it by entering the studio to create them. This demonstrates that IP

protection is not sufficient to induce creative activity; an entrepreneurial mindset is necessary. Nor is IP protection necessary, as *No IP6* demonstrates. These are important points, which we will return to at the end of this section.

Figure 6. Time in the Studio



Spending time in the studio may be directly correlated with the total value of the color goods created in the studio, but it need not be the case. How people spend their time in the studio and the quality of the search processes can differ by the incentives of *IP* and *No IP* treatments. For example, most of the people in a *No IP* session could each spend a little amount of time in the studio with the hope of personally consuming a valuable discovery, but given the lack of incentive to profit from a single discovery or two, the subjects spend most of the production time making grays. Conversely, a select few participants in an *IP* session could spend most if not all of their time in the studio searching for colors with the incentive to profit from selling their discoveries. Hence, while subjects in a *No IP* session may collectively spend as much total time in the studio as subjects in an *IP* session, the subjects in the two treatments discover different amounts of total value depending upon the amount and quality of time spent in the studio.

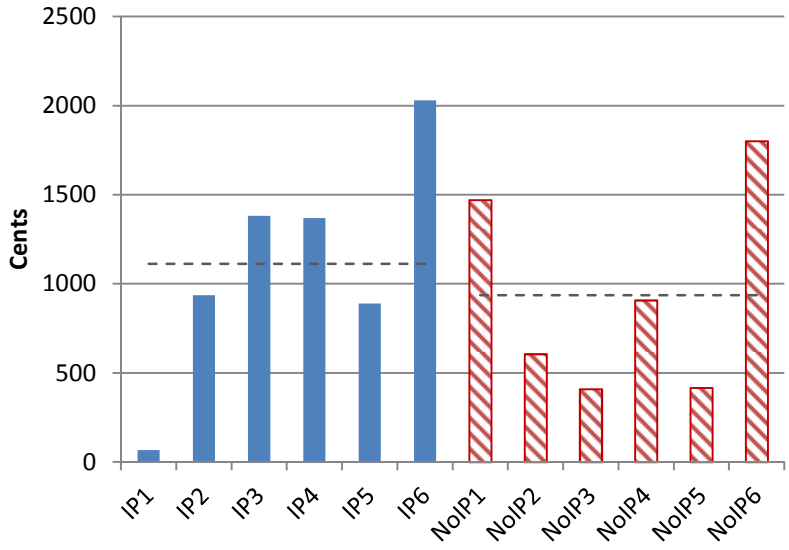
> ***Finding 2:*** IP *sessions on average do <u>not</u> produce more value in the color studio than* No IP *sessions.*
>
> *Evidence*: Figure 7 reports the total value of color goods discovered by session. The average total value discovered is $11.12 in *IP* sessions ($13.20 excluding *IP1* which does not search for colors) and $9.36 in *No IP* sessions. Using a Wilcoxon rank sum test, we fail to reject the null hypothesis of equal value generated across treatments, including and excluding *IP1* (respectively, $U_{6,6} = 21$, p-value = 0.35, one-sided test and $U_{6,5} = 21$, p-value = 0.16, one-sided test).

We do not observe more color value created in the *IP* treatment than in the *No IP* treatment. The second and third highest amounts of color value created are in the *No IP* treatment (*No IP1* and *No IP6*). The additional success of *No IP1* in creating color value makes it difficult to conclude that the success of the *No IP* treatment relative to the *IP* treatment is a fluke. Lastly, it is notable that even though *IP6* spends (exactly) 1,000 *fewer* seconds in the studio than *No IP6*, its participants discover *more* total value of color goods. We will discuss these observations more fully later in the section.

***Finding 3*:** IP *sessions on average do not earn more money than* No IP *sessions.*

Evidence: Figure 8 reports the total earnings by session broken down by gray and color consumption. *IP* and *No IP* sessions earn on average $120.50 and $111.14, respectively, over the last 9 days of the experiment. Using a Wilcoxon rank sum test, we fail to reject the null hypothesis of equal earnings ($U_{6,6} = 24$, p-value = 0.39, one-sided test).

Figure 7. Total Color Value Discovered

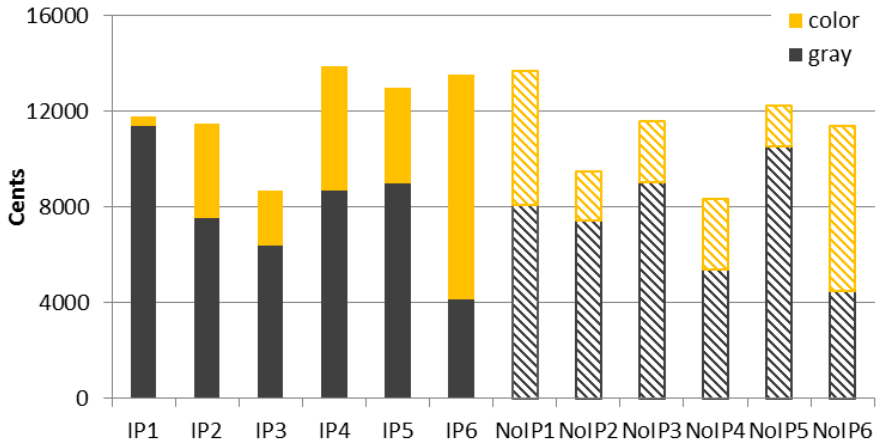


Given Finding 2 on the amount of color value discovered by treatment, Finding 3 is not surprising. But notice that there are sessions with tall (short) bars in Figure 7 and corresponding short (tall) total bars in Figure 8. Not only do participants not spend more time in the studio in the *IP* treatment, but more time in the studio does not necessarily result in discovering more color value, which in turn does not always lead to higher group earnings.

One explanation for the lack of treatment effect on total earnings is that IP protection only has a meaningful effect when a color market exists. Our experiment reveals two auxiliary assumptions that are often taken for granted, namely, that with IP protection participants will seek to discover color goods and that once valuable color is discovered, the creator will sell the

colors to others. Simply put, IP protection is not sufficient for generating high total earnings; our experiment reveals that something more is necessary: entrepreneurs who create a market where there currently is none. In *IP1* the participants largely ignore colors and in *IP3*, the lowest-earning *IP* session, subject C singlehandedly discovers an impressive amount of color value, but he offers none of it for sale. In this paper, we use the word creator or innovator to mean someone who goes to the Studio and makes a new color. The label "entrepreneur" identifies a subject who both innovates *and* generates economic surplus from colors. This distinguishes the color market makers from subjects like IP3-C who make colors but do not engage the market.

Figure 8. Total Earnings by Type of Good



Perfect IP protection is also not necessary for generating high total earnings because as the highest-earning *NoIP* session, *No IP1*, shows, participants may respect the IP of an entrepreneur without any exogenous enforcement. We will more fully discuss these and other observations on IP protection and the necessity of entrepreneurship following our next two findings on the prices and sales revenue of color goods.

> ***Finding 4***: *Transactions prices are higher in the* IP *treatment for the highest value colors worth 12, 30, and 40¢.*
>
> *Evidence*: We analyze the 1,719 color transactions in the second half of the experiment using a linear mixed effects model for repeated measures.[12] Table 3 reports the results of the model with the transaction prices as a ratio of the price paid to the value of the color good as the dependent variable. The treatment effect, *IP*, and the value of the color good (*Value5*, *Value9*, *Value12*, *Value40*) are modeled as (zero-one) fixed effects. We also include a fixed effect, *Pirate*, for whether a sale in *No IP* treatment is made by someone who is not the original creator of the color, plus all two-term interactions

[12] See Longford (1993) for a description of this technique commonly employed in experimental sciences.

between *IP* and *Pirate* with the different values of the good. The 12 independent sessions are modeled as random effects, e_i. Specifically, we estimate the model

$$Price_{ij} = \mu + e_i + \beta_{IP}IP_i + \beta_5 Value5_j + \beta_9 Value9_j + \beta_{12} Value12_j + \beta_{40} Value40_j + \beta_{Pir} Pirate_j + \beta_{IP5} IP_i \times Value5_j + \beta_{IP9} IP_i \times Value9_j + \beta_{IP12} IP_i \times Value12_j + \beta_{IP40} IP_i \times Value40_j + \beta_{Pir5} Pirate_j \times Value5_j + \beta_{Pir9} Pirate_j \times Value9_j + \beta_{Pir12} Pirate_j \times Value12_j + \beta_{Pir40} Pirate_j \times Value40_j + \varepsilon_{ij}$$

where $Price_{ij}$ is the ratio of the price paid to the value of the good sold in day *j* of session *i*, with $e_i \sim N(0, \sigma_1^2)$ and $\varepsilon_{ij} \sim N(0, \sigma_{2,i}^2)$. We accommodate heteroskedastic errors by session when estimating the model via maximum likelihood. As the benchmark, μ measures the price of a 30¢ good sold by the original creator of the color in the *No IP* treatment. We hypothesize that $\beta_{IP} > 0$ and $\beta_{Pir} < 0$, i.e., *IP* monopolists charge higher prices than sellers without such protection and that pirates in the *No IP* treatment sell for prices lower than the original creators of the good. All other tests are two-sided.

Table 3. Estimates of the Linear Mixed-Effects Model for Transaction Prices

	Estimate	Std. Error	Degrees of Freedom	*p*-value
$\boldsymbol{\mu}$	0.483	0.048	1694	<0.0001
$\boldsymbol{IP}$	0.177	0.067	10	0.0119†
$\boldsymbol{Value5}$	0.017	0.036	1694	0.6419
$\boldsymbol{Value9}$	0.076	0.020	1694	0.0002
$\boldsymbol{Value12}$	-0.043	0.019	1694	0.0280
$\boldsymbol{Value40}$	0.064	0.018	1694	0.0004
$\boldsymbol{Pirate}$	-0.059	0.027	1694	0.0158†
$\boldsymbol{IP \times Value5}$	-0.390	0.038	1694	<0.0001
$\boldsymbol{IP \times Value9}$	-0.270	0.022	1694	<0.0001
$\boldsymbol{IP \times Value12}$	-0.052	0.021	1694	0.0153
$\boldsymbol{IP \times Value40}$	-0.009	0.020	1694	0.6546
$\boldsymbol{Pirate \times Value5}$	-0.054	0.065	1694	0.4005
$\boldsymbol{Pirate \times Value9}$	-0.049	0.045	1694	0.2675
$\boldsymbol{Pirate \times Value12}$	-0.036	0.073	1694	0.6201
$\boldsymbol{Pirate \times Value40}$	0.012	0.058	1694	0.8289
			1719 obs.	

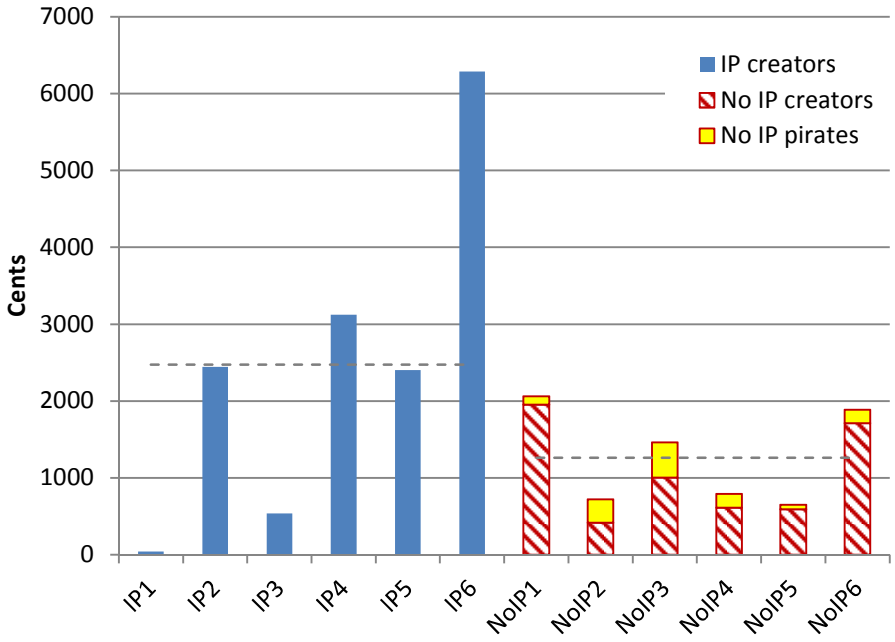
†One-sided test.

IP protection significantly raises the price of 30¢ and 40¢ colors by 18 percentage points and 12¢ by 12.5 [=100 × (.177 – .052)] percentage points (*p*-value = 0.0119). Surprisingly, the two lowest possible values of colors are cheaper in the *IP* treatment than in the *No IP* treatment. Consistent with conventional expectations, pirates in the *No IP* treatment sell for prices significantly lower than original creators of color goods (6 percentage points, *p*-value = 0.0158).

Finding 5**:** *Conditional on an active market for colors, sales revenue to creators of color goods is <u>higher</u> in the* IP *treatment than in the* No IP *treatment.*

Evidence: Figure 9 plots sales revenue of color goods by session. Excluding the antipreneurs of *IP1* and *IP3*, the average sales revenue from color goods in the *IP* treatment is a whopping $35.64 when compared to the average sales revenue of $10.49 in the *No IP* treatment.[13]

Figure 9. Sales Revenue of Color Goods



By virtue of their monopoly rights, color creators in *IP2*, *IP4*, *IP5*, and *IP6* turn the higher prices in Finding 5 into higher sales revenues in Finding 6. Sales revenues in the *IP* treatment dwarf those in the *No IP* treatment, even when including the revenue to pirates. These two findings importantly show that in the *IP* treatment there is considerable value to discovering color goods in the studio and selling them to the other participants, but these treatment effects and session-level measurements mask how the 10-person economies generate these outcomes. In the following subsection we drill down to the subject level for an explanation that ties all five of these findings together.

B. Subject Level Analyses

As we mention above, entrepreneurship is the key to understanding the results of our experiment. Six subjects conspicuously differentiate themselves from the other 114 in terms of their earnings and especially their color sales revenue. In the two panels of Figure 10, we respectively plot color sales revenue and total earnings against total time in the studio for each of the 120 subjects in the experiment. Some observations of particular interest are labeled

[13] That said, using a Wilcoxon rank sum test to compare all 6 sessions in the *IP* treatment to all six sessions in *No IP* treatment, we fail to reject the null hypothesis ($U_{6,6} = 24$, p-value = 0.20, one-sided test).

with the session name and subject ID. For example, "NoIP1–C" labels subject C in the first session of the *No IP* treatment. *Notice that the same six individuals appear in the top right corner of both panels.* The six highest earners in the experiment all spend considerable amount of time in the studio and successfully market the color goods they make. We will refer to these individuals as "entrepreneurs", all of whom earned at least $24.00 in the second half of the experiment.

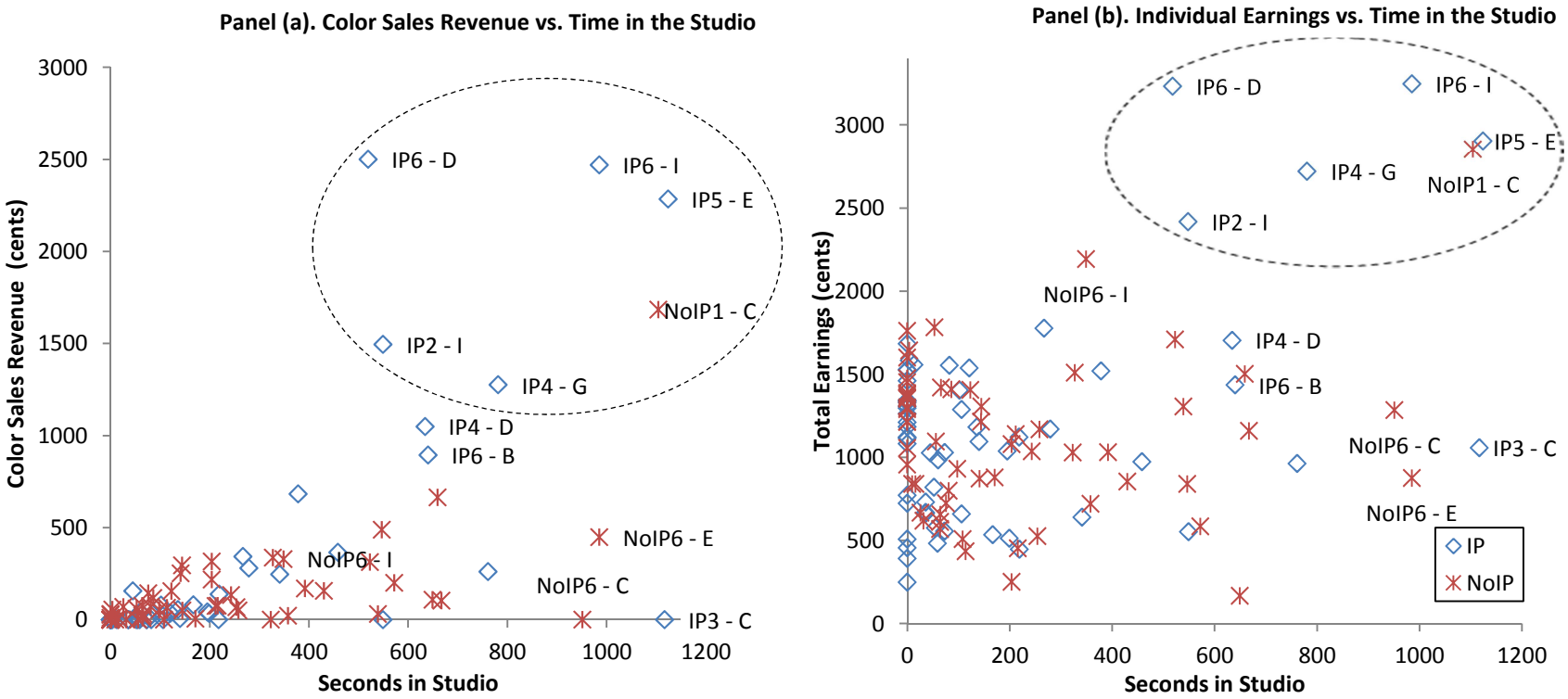
Some individuals appear like entrepreneurs on only one dimension. NoIP6–I is the seventh highest earner but his earnings are mostly generated from producing and consuming grays; he is not an entrepreneur because he does not commit to the studio. IP3–C spends time in the studio and finds many color goods, but he sells none.[14] NoIP6–C expresses the same antipreneurial attitude.[15] We define innovation in this experiment as spending time in the Studio and producing valuable colors. Subject IP3-C is an "innovator," but his choice is an example of the evidence that led us to conclude that invention is only half of the necessary formula for creating wealth via innovation. NoIP6–E spends enough time in the studio to appear like an entrepreneur, but his sales revenue from color goods is only 447¢. NoIP6–E does not succeed because subjects in *No IP6* pirate his goods. NoIP1-C succeeds as an entrepreneur because subjects in No *IP1* pirate very little relative to the amount of color activity in that session.

We define piracy in our experiment as remaking a color that has been posted by a creator or reselling a color good created by another. The comparison between *No IP6* and *No IP1* is clear in Table 4 and Figure 11. Table 4 reports that pirates in *No IP6* remake 39 color goods that the original creator of the color had already posted to the bulletin board. Figure 11 plots the sum of the amounts by which pirates post prices *less* than the original creator posts for the same good. This statistic captures the amount by which pirates undercut original creators of valuable color goods. *No IP6* again tops the sessions, and *No IP1* is near the bottom. As an entrepreneur, NoIP1–C spends 1,104 seconds in the studio discovering 1,292¢ of color value (79% of the total value for the session) and his fellow subjects respect his ownership of those colors paying him 1,683¢ for those goods. (His sales revenue is low relative to the *IP* entrepreneurs due to the low prices he charges for the colors.) NoIP6–E spends 948 seconds in the studio discovering 857¢ of color value, but can only sell that value for 447¢ to his fellow

[14] When asked privately while being paid, "What was your strategy in this experiment?", IP3-C replied, "Colors baby!". The experimenter followed up by asking, "Why do you think other people were selling the colors they found?" He laughed and replied, "That's silly." He found pricing gray to be equally useless. Overall, IP3-C appeared confident that he had made the most of his participation in the experiment.

[15] In day 15, NoIP6-C brags in the chat room that he found the 40¢ color, but that he "just didnt wanna sell it." NoIP6-G reprimands him with the single word reply of "post". NoIP6-C never does.

Figure 10. Entrepreneurs

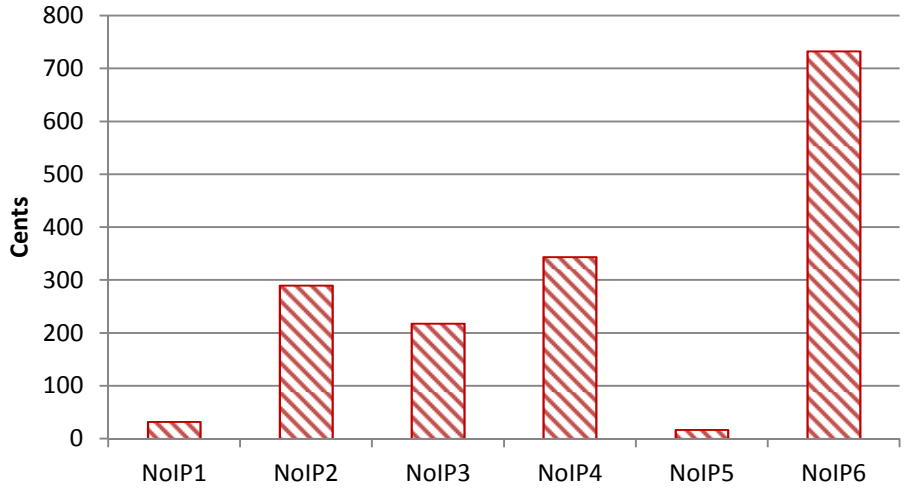


participants. His fellow *No IP6*ers would rather remake the good themselves than pay him for it, and they resell the good for less.

Table 4. Remakes of Color Goods

Session	Number
No IP1	1
No IP2	2
No IP3	1
No IP4	27
No IP5	3
No IP6	39

Figure 11. Sum of Price Undercutting by Pirates



The chat room discussion in *No IP3* illuminates a problem that might explain why this session did not see many gains from color goods. On day 11 Person *H* says, "someone should make a really red color and someone else shoul[d] make a really blue color […] for 0 price". *H* recognizes the value of *someone* making a trip to the studio, but, not surprisingly, no one responds to his suggestion. Other subjects in *No IP3* also recognize the potential value of colors and even offer suggestions in the chat for finding the good colors. Collectively they spend almost as much time in the studio as the most successful groups, but no individual commits to the search process nor do the group members provide incentive for *someone* to do so.

The upshot is that entrepreneurs are necessary for generating wealthy economies in our experiment, and while IP protection is neither necessary nor sufficient for generating wealth by discovering color goods, entrepreneurs only express themselves in the *IP* treatment, or in the *No IP* session where most subjects behave as if they are in the *IP* treatment.

C. An Analog to Internet and Media Piracy

There is an evolving conflict and IP policy dispute between internet "pirates" and firms that create digital goods such as music or software tools. Our design is inspired by the low transaction costs of internet exchange institutions, such as iTunes, and websites that facilitate piracy (which constitutes theft by some IP standards). In the *No IP* treatment, non-creators can give non-rivalrous copies of color goods away via the same tools by which they could transfer rivalrous gray goods. That is, non-creators could privately and directly give away a color good to any other participant. How often did this occur? Never once. Without suggestion or discouragement, *No IP* pirates could also "file-share" by anonymously posting colors on the bulletin board for a zero price. This occurred only 6 times out of 704 transactions in the last half of the experiment (four in *No IP3* and two in *No IP4*), and not one of those transactions, we might add, was for a 30¢ or 40¢ good. It appears that our subjects in both treatments consider posting colors to be a for-profit activity.[16]

By design, the instructions in both treatments are exactly the same. Subjects in our *No IP* treatment seem to take it as given that the "offer" button appeared next to every color in their inventory (see Figure 5). Similarly, subjects in the *IP* treatment never once comment that they did not have the option of distributing colors they had not created. Though we observe activity in the *No IP* treatment that could be labeled as IP theft, never once in a *No IP* chat room is an action labeled as such. Out of 4,980 words, *No IP* creators never once complain about pirating; never once describe reposting or remaking a color good as "theft" or "stealing"; and no one ever suggests that they somehow compensate the people who invest time in producing color goods through a cents transfer or an intentional effort to buy the good from them. This stands in stark contrast to previous research in which undergraduates are rather vocal in calling out certain actions as "stealing" and "theft" although they were never prompted to consider the goods as property. In computerized experiments with virtual goods, Kimbrough, Smith, and Wilson (2010) and Jaworski and Wilson (2013) report that these words are some of the first and most frequently posted sentiments in the chat room when people remove rivalrous blue and red chits from one another's possession without consent.[17] In that environment, the moral outrage indicates that subjects believe that rivalrous goods in their designated houses are theirs and to remove them is a violation of a property right. In designing our experiment we were curious whether we would observe the same moral outrage evoked by IP piracy, and we find that it is not, or it is at least never expressed as such. This is perhaps evidence that

[16] The elements that lead to the free file-sharing culture that we observe on the internet today are not present in this environment. It would be an interesting extension to explore this further, possibly by incorporating the pervasive "us vs. them" mentality of internet pirates toward media companies.

[17] Likewise, in the less related experiment of Wilson et al. (2012).

property rights for non-rivalrous IP goods are perceived quite differently than they are for rivalrous goods.[18]

V. Summary of the First Experiment

This experiment demonstrates that entrepreneurship plays a critical role in creating wealth when intellectual property protection is either exogenously enforced or endogenously and voluntarily respected. The precise generative mechanism by which entrepreneurship does this has not yet been specified here or, to our knowledge, elsewhere. What we observe (and what we and most honest readers did not foresee) is that IP protection interacts to express the indispensably important element of individual entrepreneurship—an "alertness to previously unnoticed changes in circumstances which may make it possible to get far more in exchange for whatever they have to offer than was previously possible" (Kirzner 1973, p. 16). The first contribution of this paper is to establish the importance of these facts of entrepreneurship with respect to intellectual property protection, which future theories must address if intellectual property protection is to be used as an economic tool.

Our paper is not the first empirical project to fail at finding clear benefits of intellectual property protection. Bessen and Meurer (2008), Lerner (2009), and Mokyr (2009) all similarly conclude that patents have little impact on innovation from empirical data.[19] Individual entrepreneurship plausibly played an important role in the economies they studied but perhaps their data was not sufficiently disaggregated to reveal it. The difference in this study is that we are able identify, person by person, each instance of an entrepreneur in a way that no field study on IP protection and innovation has. Our next step is to explore *within-subject* the effect of IP protection on the individuals we have identified as entrepreneurs. With more sessions, we can also ask whether our sighting of an antipreneur (those who make colors but don't sell them) was an improbable fluke. Our next and final section lays out such a treatment condition, our procedures, and the results from this second experiment.

The theoretical and empirical literature on entrepreneurship classifies unique individuals who create wealth the same way we do. Shane and Venkataraman (2000) define entrepreneurship as a process by which "opportunities to create future goods and services are

[18] A movie trailer distributed by the Motion Picture Association of America demonstrates that there is indeed widespread disagreement over the morality of violating intellectual property law. The logic they present, in this order, is:

1. You [the viewer] would not steal a physical object.
2. Pirating movies is "Stealing".
3. Piracy is prohibited by statutory law.

The trailer concludes with the pronouncement that media piracy is "A Crime". Understanding the psychological foundations of IP pirating is an interesting avenue to pursue in future research.

[19] Galasso and Schankerman (2013) use judges' decisions and patent citations to determine the effect of patent rights on cumulative innovation. They find that patent rights block innovation only when the patent holders are large firms and the policy implication is ambiguous.

discovered, evaluated, and exploited." Entrepreneurship combines inventing with business and marketing acumen. Shane, Locke and Collins (2003) study entrepreneurial motivation with the assumption that people intrinsically vary in their inclination and ability to pursue entrepreneurial opportunities. Entrepreneurs are sometimes classified in the literature by their tolerance for ambiguity. Risk tolerance may also be important, although entrepreneurs often do not have sufficient information to construct a precise useful probability distribution of outcomes, as is the case in our experiment. Using a survey, Palich and Bagby (1995) determine that entrepreneurs do not necessarily have a higher risk tolerance, but they are more likely to try new things because they are more optimistic (like the overconfident subjects in experiments by Camerer and Lovallo (1999)). Cardon et. al (2009) outline a theoretical framework of "entrepreneurial passion" and review empirical studies on that topic. Combining our methodology with techniques for identifying entrepreneurs in the population would be a productive path for future research.

Shane, Locke, and Collins (2003) state the problem that previous empirical work cannot fully disentangle the intrinsic differences that inspire entrepreneurship from the differences in opportunity that individuals encounter. An advantage of a laboratory experiment is that it can control for the variation in opportunity. Every individual enters our economy with the same knowledge and equal opportunity to spend time in the studio and post to the color bulletin board, so their unique characteristics must account for their behavioral differences. The other source of variation is the different institutional environment that *IP* and *No IP* are randomly assigned to face study. We are unaware of any previous study that examines how the entrepreneurial drive interacts with the institutional framework of IP. Since we did not design the first experiment with entrepreneurs in mind, there is a lot of remaining work to be done to expand on our preliminary conclusion in the lab and the field. More targeted experiments would be able to tell us more about what kind of people are entrepreneurial types and what motivates them. What follows is a next step in the inquiry that will reveal more about how entrepreneurs in our experiments and the markets they serve behave under different IP institutions.

VI. An Explicating Treatment to Study Entrepreneurs

A. Procedures and Hypotheses

To recap, our working postdiction is that entrepreneurs are as important as the exogenous imposition of IP protection for the production and sale of nonrivalrous color goods. To learn more we conduct a mixed *IP-No IP* design over the course of two days.[20] On the first

[20] The reason for this mixed design is that we do not know the entrepreneurial potential of a randomly recruited group of new participants. If a *No IP* group does not produce an entrepreneur, it could be because they are like *IP1*, which had no underlying entrepreneurial potential. A pure within-group *IP-NoIP* design in which we change

day, 10 subjects participated in the *IP* treatment as described above. If we observed an entrepreneur in the session, that entrepreneur would then participate in the *No IP* treatment on the second (24-hour) day with 9 brand new subjects. The research plan called for 6 new *IP-No IP* pairings of sessions (12 sessions total) but that the second day would be canceled if we observed no entrepreneurs on the first day. We recruited the subjects to participate in a two (24-hour)-day experiment, but informed them that they would be told privately during payment on the first day whether or not they would be needed on the second day. To incentivize the entrepreneur to return on the second day, all subjects were informed at recruitment that the experiment earnings for both days would be paid at the conclusion of the second day, but that on first day they would receive the $7 for showing up on time. The only other design change was to allow subjects to sell gray goods in multi-unit bundles on the bulletin board because we observed that trading gray goods one at a time appeared to take time away from chatting and other opportunities, such as purchasing color goods.

We modify our five hypotheses from Section III to focus on the entrepreneurs in the paired *IP-NoIP* sessions:

Hypothesis 6a: Entrepreneurs spend more time creating color goods in the *IP* sessions than they do in their paired *No IP* sessions.

Hypothesis 6b: Entrepreneurs in the *IP* sessions generate more value from color goods than in their paired *No IP* sessions.

Hypothesis 6c: Total earnings are higher in the *IP* sessions than in their paired *No IP* sessions.

Hypothesis 6d: The price of color goods (as a percent of value) set by entrepreneurs is higher in the *IP* sessions than in their paired *No IP* sessions.

Hypothesis 6e: Sales revenue to entrepreneurs is higher in the *IP* sessions than in their paired *No IP* sessions.

B. Results

While there is much data that we could present that replicates our observations from the previous experiment, in the interest of brevity we only present data specifically relevant to Hypothesis 6.

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the treatment conditions from *IP* to *NoIP* on the same set of subjects is risky in that conditioning a set of color consumers to respect IP could result in the hysteresis effect of further respect after IP protection is removed (yielding more *NoIP1*-looking sessions). Likewise, a within-group *NoIP-IP* design could snuff out the entrepreneurial flame of a subject before IP protection is imposed.

The first three sessions, *IP7-IP9*, conducted at the beginning of fall of 2012 did not yield an entrepreneur (like *IP1* and *IP3*). Speculating that laboratory experience might make participants more comfortable in exploring and taking advantage of the studio,[21] we started only inviting subjects who had had prior lab experience in at least 7 different experiments. The next three *IP* sessions, *IP10-IP12*, each contained one entrepreneur identifiable by the criteria in Figure 10. We also found four more antipreneurs in *IP7* and *IP10-12*, which makes the persistence of the entrepreneurs in the last three *IP* sessions that much more impressive. Antipreneurs find colors without sharing them leaving less value for the entrepreneur to discover and sell. The data we present is from only the last nine days of a treatment condition.

Finding 6a**:** *Inconsistent with the hypothesis, two of the three entrepreneurs increase the amount of time spent in the studio with* No IP *relative to the prior* IP *condition.*

Evidence: See Figure 12.

Finding 6b**:** *Inconsistent with the hypothesis, two of the three entrepreneurs generate more value from color goods in the* No IP *condition as compared to the paired* IP *condition.*

Evidence: See Figure 13.

Finding 6c**:** *Inconsistent with the hypothesis, total earnings are higher in two sessions with the* No IP *condition as compared to their paired* IP *session.*

Evidence: See Figure 14.

Finding 6d**:** *Consistent with the hypothesis, the price color goods (as a percent of value) for entrepreneurs is higher in all three* IP *sessions than in their paired* No IP *sessions.*

Evidence: See Figure 15.

Finding 6e**:** *Consistent with the hypothesis, sales revenue to entrepreneurs is higher in all three* IP *sessions than in their paired* No IP *session.*

Evidence: See Figure 16.

[21] We conducted the previous 12 sessions at the end of the 2011 school year meaning that a large majority of the subjects had previously been in at least one, if not multiple, (unrelated) economic experiment. The previous 6 entrepreneurs prior to our experiment had had experience in 4, 5, 7, 9, 14, and 41 other experiments.

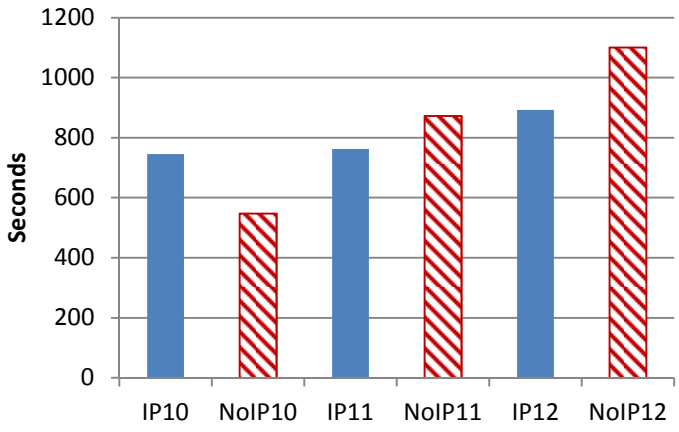

Figure 12. Time in the Studio by Entrepreneur

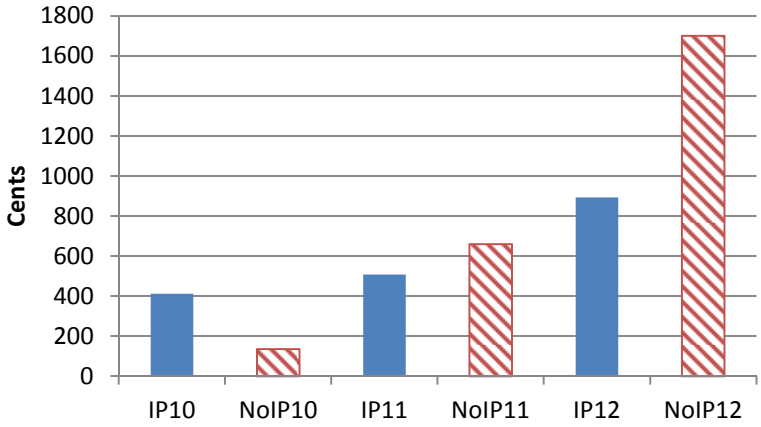

Figure 13. Color Value Discovered by Entrepreneur

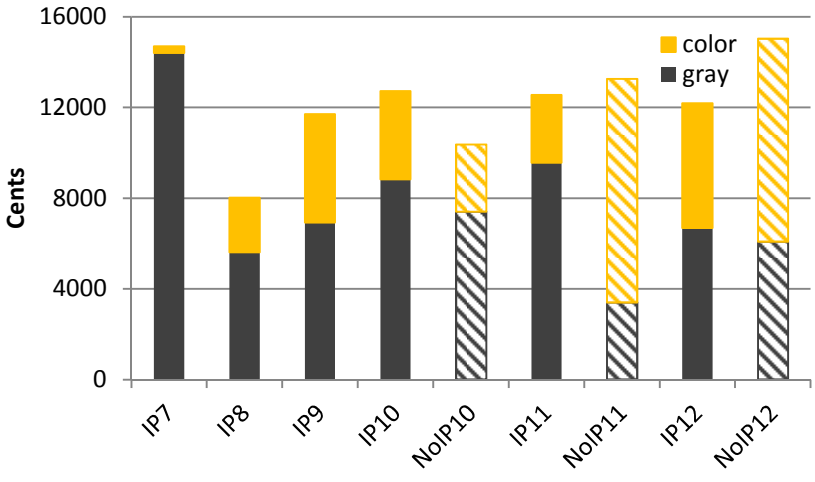

Figure 14. Total Earnings by Type of Good (Experiment 2)

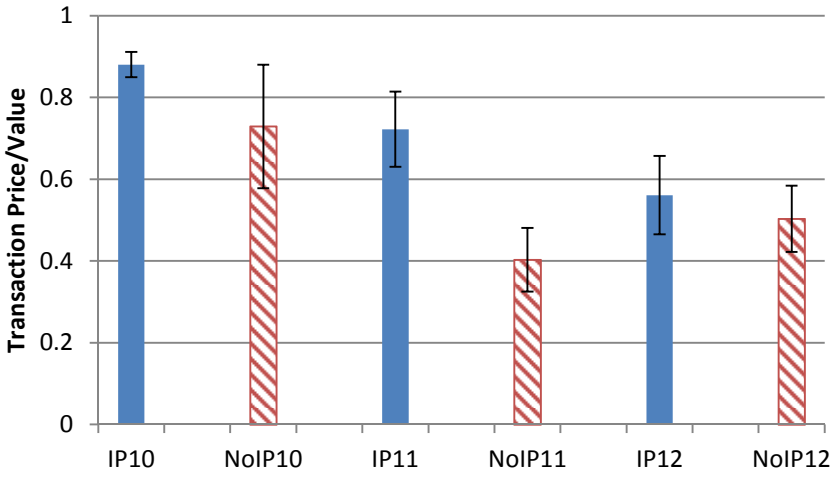

Figure 15. Ratio of Price/Value for 30¢ and 40¢ Colors Sold by Entrepreneurs

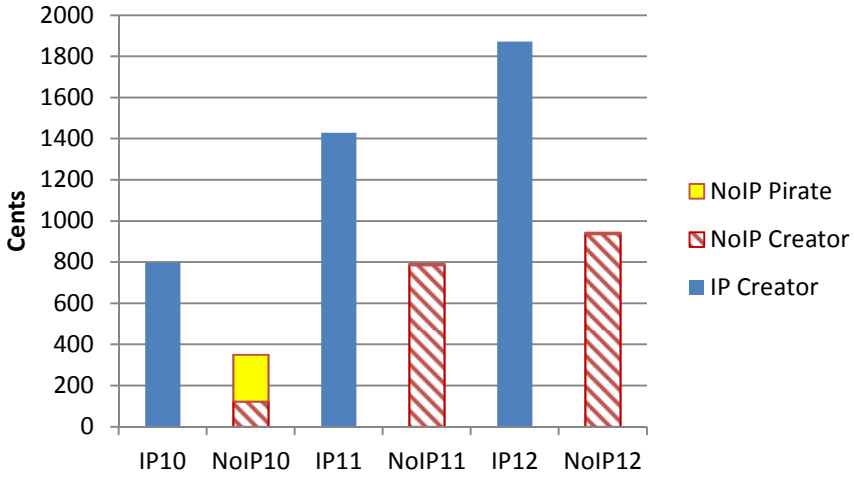

Figure 16. Sales Revenue of Color Goods to Entrepreneurs

Consistent with our first experiment, no new entrepreneurs emerge in the paired *No IP* sessions. Piracy, defined as undercutting the prices of creators and the intentional remakes of their posted colors, is common in all three paired *No IP* sessions. We find, as proponents of IP protection argue, direct evidence that entrepreneurs of nonrivalrous goods charge *lower* prices, sell *fewer* units (not reported above), and hence receive approximately 50% *less* sales revenue when their creations are *not* protected from piracy. The entrepreneur in *NoIP12* complained in the chatroom, "why do you sell my colors? stop re-selling my colors or ill stop making and no1 will have". This is the only explicit objection to piracy in our experiments. Experiencing protection in the *IP* treatment led him to demand that his intellectual property be respected in the *No IP* treatment. He uses economic reasoning to justify his perceived right similar to that of Article 1 of the U.S. Constitution.

The story of pecuniary incentives for IP protection is replicated in the laboratory. But as skeptics of IP protection contend, we also find that "it is not obvious that such forced scarcity is the most effective way to stimulate the human creative process" (Hayek 1988, p. 36). Two of the three entrepreneurs in our second experiment spend *more* time creating colors and discover more color value when their creations are freely reproducible by others. Moreover, Figure 14 indicates that the entire economies of these two entrepreneurs are wealthier even though the entrepreneurs themselves are not, under *NoIP*. This is an informative result for the debate on IP policy.

C. Conclusion

Our conclusion is that IP policy makers and researchers must specifically address entrepreneurs in their discussion of how IP laws encourage economic growth. Innovation by inventors is not an engine of wealth creation unless that invention is introduced and embraced by the market. We observed that IP protection does not inspire entrepreneurship automatically where its latent tendency is not already present in a group of ten. Societies of millions do not lack entrepreneurial individuals; however those individuals are sensitive to institutions and specifically to IP laws. We found that IP protection encourages entrepreneurs to emerge by allowing them to profit from their innovations in the market.

We do not claim that our design captures all the complexities of intellectual property protection or entrepreneurship. Future research could investigate other ways to reward people for their ideas through prizes or licensing and other ways to improve distribution and mitigate efficiency losses such as academic fair use.[22] Our method would be useful for exploring the effect of IP polices beyond the binary treatments we implemented and for including options such as teamwork. As suggested by Gilbert and Shapiro (2009) and others, there might be an optimal degree of intellectual property protection between full and none that would reward entrepreneurs but also protect against some of the losses that result from monopoly power. Other types of costs, such as large sunk costs, would also be interesting avenues to pursue, as well as finding ways to prevent piracy in a *No IP* world. We have implemented an environment most favorable for intellectual property protection with costless, perfect enforcement. It is an open question as to whether or not relaxing this assumption would choke off entrepreneurship in the *IP* treatment. In future research our findings on entrepreneurs could also be generalized to include firms that engage entrepreneurial individuals.

[22] See Gans et al. (2002) for an empirical study of how inventors commercialize ideas. Stronger IP protection increases the bargaining power of an innovator and makes it more likely that the innovator will end up cooperating with an existing firm via licensing or acquisition. Start-up innovators with less IP protection appear more likely to start their own enterprise.

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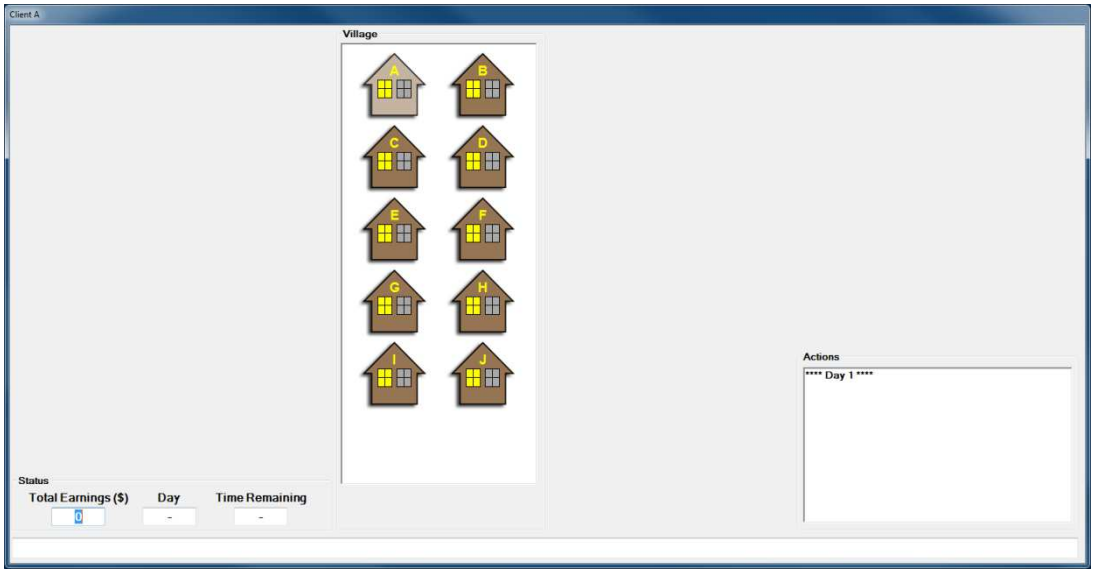
Appendix A. Experiment Instructions for Person A

<page 1>

Welcome

This is an experiment in the economics of decision making. The instructions are simple, and if you follow them carefully and make good decisions you can earn a considerable amount of money which will be paid to you in CASH at the end of the experiment.

In this experiment, you are **Person A**. You can see your house in the *Village* portion of the screen. This experiment consists of many days during which you and the 9 other people in the experiment can each produce two types of goods: gray and color. You can earn money by consuming and selling these items.



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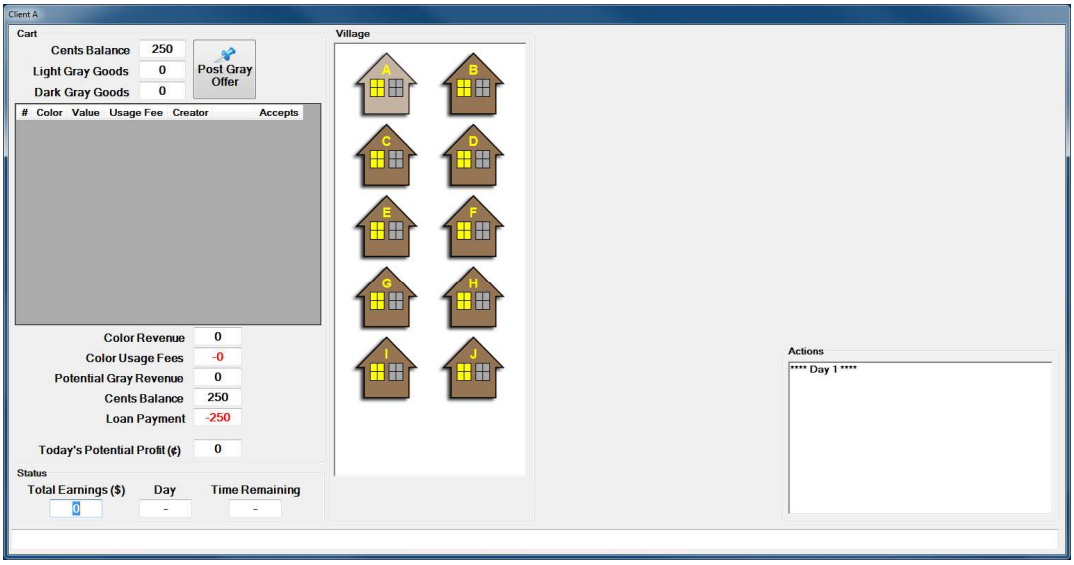
Gray Goods

One of the windows in your house is yellow. By clicking on that window, you can produce a dark gray good. You can practice this now. The number of gray goods you currently have is recorded in the top of the *Cart* portion of the screen. Half of the people in this experiment can make light gray goods and the other half dark gray goods.

A light or dark gray good is not valuable by itself. You must consume gray goods in light/dark pairs. For example, if you have 4 light grays and 2 dark gray items, then you have a total of two gray pairs and 2 extra light grays. Each pair of grays is worth 9 cents. The **Potential Gray Revenue** field in the *Cart* side of the screen reports how much your gray pairs are currently worth.



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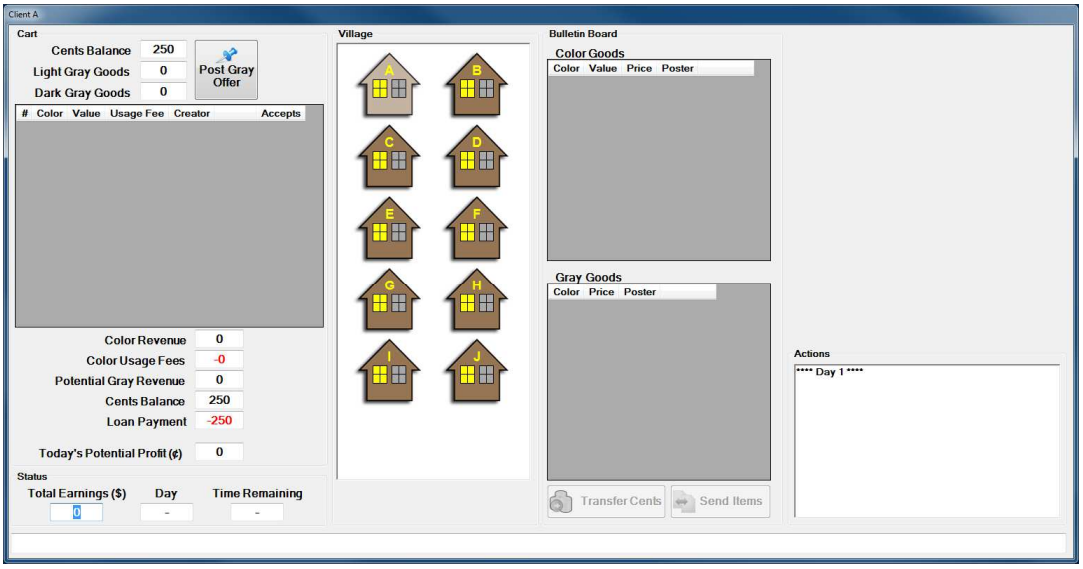
Bulletin Board

To exchange goods with other people you can post your items on the *Bulletin Board*. To post one of your gray goods, click on the Post Gray Offer button. Practice making a grey item and posting it to the bulletin board now.

If you want to list a price for your item, enter the number of cents you want to charge. Also choose whether you want your identification to be listed with your offer. When you click Post Offer, your item will appear on the public *Bulletin Board*. Your own posts on the bulletin board will have an Edit button so that you can change or delete it until someone accepts your offer.

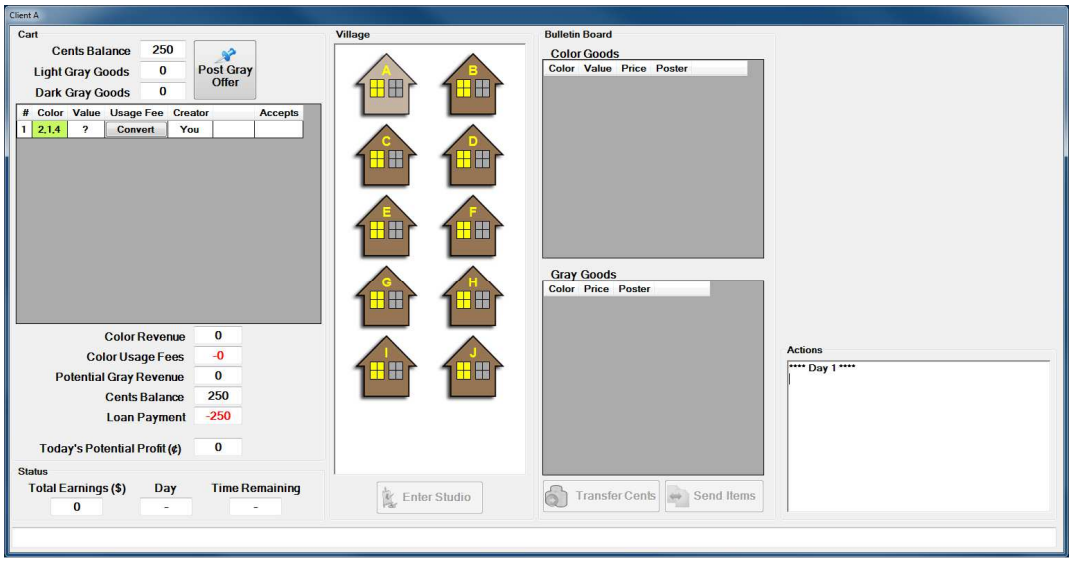
During the experiment, you can accept an item on the bulletin board by clicking Accept. When a price is listed for an item on the bulletin board, the person who accepts the item will automatically receive the item and pay the price in cents to the person who listed the item.



<page 4>

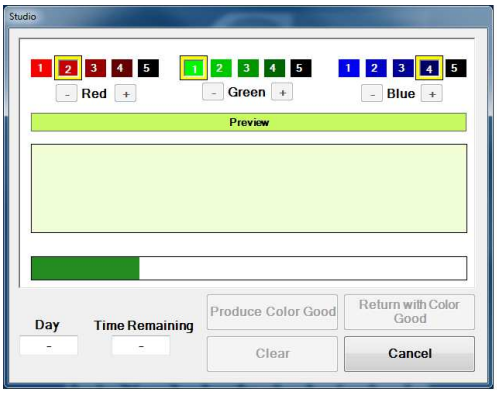
Color Goods

You can create color goods in the *Studio*. Click Enter Studio to see the Studio now. (The light in your house will turn off while you are in the studio.)



During the experiment you can construct a color by adding and subtracting Red, Green, and Blue components of a color. Your color will appear in the preview bar. To make a color item, click Produce Color Good. After you have produced a color item you can return to the *Village* with it by clicking Return with Color Good. You may also start a new color by clicking Clear.

Color goods can be much more valuable than a light/dark gray pair. There is a single "favorite color" of the day which is worth 40 cents, and colors that are close to the favorite color are worth less than this amount. Colors that are far away from the favorite are worth nothing.
Practice making the color (2,1,4) now by setting Red to 2, Green to 1, and Blue to 4 using the + and - buttons. Click Produce Color Good and then Return with Color Good. When you return to the *Village* with a color item it will appear in your *Cart* frame.



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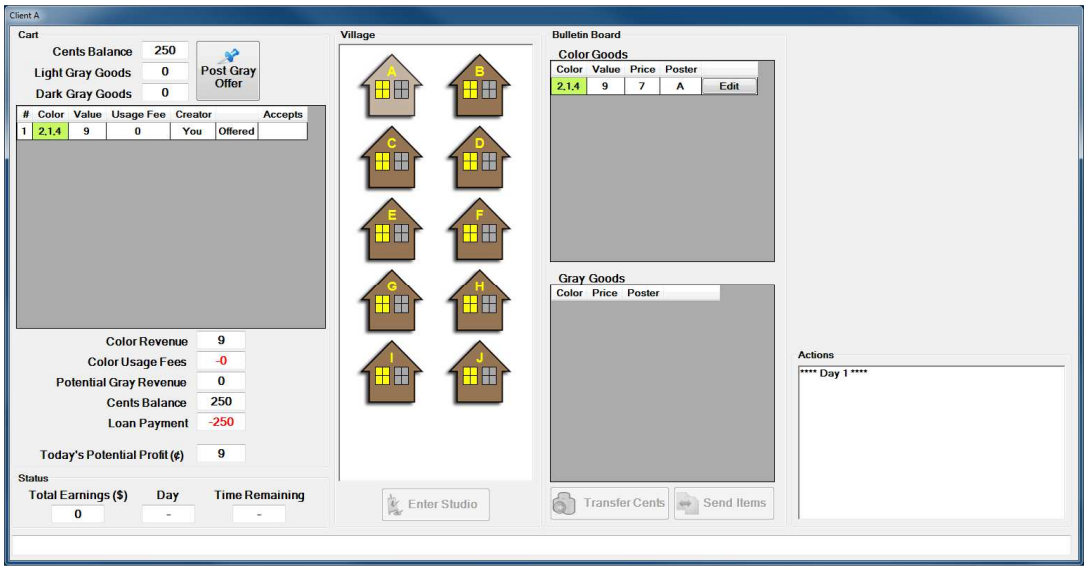
As you begin to consume color goods, you will be charged a small **usage fee**. The fee gradually increases with each color good you consume.

To learn the value and consume the color good yourself, click Convert.[23] After converting, you can post a color good on the bulletin board by clicking Offer. Practice this now.

As with gray goods, when a person accepts a color item that is listed with a price, that number of cents are immediately paid to the person who posted the color item.

- If you send a gray good to another person, you give up the item.
- Unlike gray goods, if you send a color item to other people it is not removed from your holdings.



[23] After a color is acquired, the Convert button appears in the Usage Fee column and a question mark is displayed in the Value column (see left side of Figure 4). After Convert is clicked, the value of the color good appears in the Value column and the Offer button appears in the column between the Creator and Accepts columns (unless the person is not the creator in the IP treatment).

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Transfers

You may transfer items and cash directly to other people with these buttons. You will see a record of your own transfers in your Chat window, but you will not see information on the transfers of other people.

Cash

You begin each day with a loan of 250 cents. You can use the loan to pay other people, but you will have to repay it in full at the end of each day. The cents that you spend will be deducted from your earnings for the day. The cents that you receive from others will be added to your total earnings.

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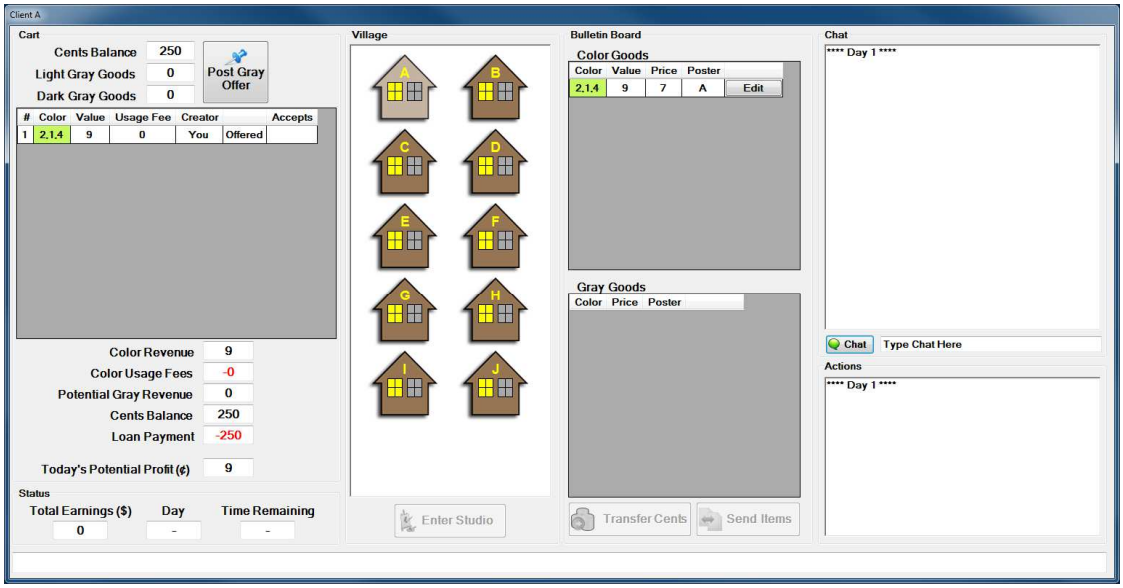
Chat

Every person in the experiment may chat on the right side of the screen. Type your messages in the top of the chat area, and then press ENTER or click the Chat button.

You are free to discuss any and all aspects of the experiment, with the following exceptions: you may not reveal your name, discuss side payments outside the laboratory, or engage in inappropriate language (including such shorthand as 'WTF'). If you do, you will be excused and you will not be paid.



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Review

The *Status* frame in the bottom left corner displays your earnings for the entire experiment, the current day, and how much time is remaining. A day lasts **230** seconds. You can produce items

during the first **155** seconds. You may trade and chat during the remainder of the day.

Important points:

1. You can produce a **gray** good by clicking on the **yellow** window of your house.
2. To earn money, you must consume **gray** goods in light/dark *pairs*.
3. If you send a **gray** good to another player, you give up the item.
4. **Color** goods are produced in the studio.
5. To earn money from consuming a **color** good in your cart, you must click the Convert button.
6. Unlike **gray** goods, if you send a **color** item to other people it is *not* removed from your holdings.

This is the end of the instructions. If you have any questions please raise your hand and a monitor will come by to answer them. If you are finished with the instructions please press Start. The instructions will remain on your screen until everyone is ready and the experiment starts.