Evolutionary Psychology

www.epjournal.net – 2007. 5(2): 363-382

Original Article

Competitive Status Signaling in Peer-to-Peer File-Sharing Networks

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Abstract: Internet peer-to-peer file sharing is a contemporary example of asymmetrical sharing in which "altruists" (file uploaders) share unconditionally with non-reciprocating "free riders" (file downloaders). Those who upload digital media files over the Internet risk prosecution for copyright infringement, and are more vulnerable to computer hackers and viruses. In an analysis of file-sharing behavior among university undergraduates (*N*=331), we found that significantly more males than females engaged in risky file uploading. Contrary to expectations, uploaders were not concerned about their reputation online and file sharers were not interested in identifying or chatting with uploaders while online. Among uploaders, males were more likely than females to be identified as uploaders by friends, to discuss uploading and to upload in the presence of peers. We interpret these results using costly-signaling theory, and argue that uploading is a costly signal in which males engage in avoidable risk taking as a means to compete for status among peers in social contexts other than the Internet.

Keywords: unconditional generosity, risk taking, costly signaling theory, sex differences

Introduction

Asymmetrical sharing between non-kin is widespread among humans, and thus creates a theoretical conundrum for those who study behavior from an evolutionary perspective. Since Darwin (1859) first pinpointed the altruism problem, evolutionary models based on conditional reciprocity, such as reciprocal altruism (Trivers, 1971), risk reduction (Cashdan, 1985), and tolerated theft (Blurton Jones, 1987), have provided valuable insight into the dynamics of cooperative behavior. However, many cases of human sharing, such as meat allocation by hunters in foraging societies, appear to come with no strings attached (Smith, Bliege Bird, and Bird, 2002; Sosis, 2000). With an increasing interest in incidents of unconditional sharing, new approaches for understanding non-kin human sharing have emerged. Costly signaling theory (CST) has proven a useful tool for explicating cases of conspicuous generosity (Gurven, Allen-

Arave, Hill, and Hurtado, 2000; Zahavi and Zahavi, 1997) and other forms of wasteful advertising (Neiman, 1998). Peer-to-peer (P2P) file-sharing networks are contemporary examples of large-scale generosity in which altruists (file uploaders) share digital data such as music with non-reciprocating free riders (file downloaders) via the Internet. This research addresses the altruism problem by testing evolutionary hypotheses about non-kin sharing within the novel milieu of P2P file-sharing networks.

P2P file-sharing networks such as *Limewire* allow free downloading of music and other digital media from the computers of anonymous uploaders. In this study, we define a *downloader* as a file sharer who strictly downloads files without contributing digital data to the network; we define an *uploader* as a file sharer who downloads files, but additionally contributes digital media to the file-sharing system. File sharing is convenient and virtually risk-free for downloaders, most of whom simply log on to an online file-sharing program, choose the desired media from a variety of uploaders, copy the file to a computer hard drive, and log off. Uploaders, on the other hand, allow other file sharers direct access to their computer's hard drive, which can increase susceptibility to computer viruses and hackers. Most significantly, uploaders are the target of well-publicized attempts by the Recording Industry Association of America (RIAA) to deter infringement of copyright laws, and can be fined up to $150,000 for sharing files online (Rainie and Madden, 2004). The zealous uploader further increases such risks by leaving his or her computer on overnight and while at work or school, which allows other file sharers to download large files such as movies or TV sitcoms. In light of the benefit downloaders enjoy with little cost, it comes as no surprise that the majority of file sharers are downloaders, whereas uploaders represent only a small proportion of file sharers. From this intriguing sharing system an evolutionary paradox emerges: why do uploaders risk prosecution and other tangible costs, to provide free digital data to a large number of non-reciprocating downloaders?

When modeling human altruism, a researcher may observe naturally-occurring phenomena (e.g., Smith et al., 2002), implement an experimental protocol (e.g., Henrich et al., 2005), or test theoretical sharing strategies using game theory (e.g., Axelrod and Hamilton, 1981), all of which are methodologies with intrinsic benefits and shortcomings. A current methodological focus on hypothetical scenarios of economic resource exchange (such as the Dictator and Ultimatum games) has contributed an abundance of data on non-kin sharing, but seldom do these experimental methods reflect real-life dynamics of human reciprocity (Sullivan and Lyle, 2005). In contrast to the artificial parameters of economic game theory, P2P file-sharing networks are observable, ubiquitous phenomena that involve repeated, real-life resource exchange between millions of distantly related strangers throughout the world. These dynamic sharing systems—which transcend language, social and geographic boundaries—provide a unique opportunity to test evolutionary hypotheses about unconditional sharing.

Zahavi (1975) proposed that the effectiveness of sexual selection lies in its ability to provide information to the selecting sex about the quality of the selected sex. Females are more often the selecting sex, since they endure disproportionate costs associated with reproduction (e.g. gestation, parental care). As a result, males in most mammalian species vie for access to mates by signaling an underlying quality directly to a female or by competing for status among other males. Zahavi's handicap principle (1975, 1977) contends that by exhibiting a costly display such as an elaborate physical character or an altruistic behavior, a signaler honestly reveals a hidden quality to potential mates. Costly signaling theory, derived from the handicap principle, has provided powerful insight into enduring anthropological puzzles, such as unconditional provisioning by hunters in foraging societies (Gurven et al., 2000; Smith et al.,

2002; Sosis, 2000) and risk taking by young men (Farthing, 2005; Nell, 2002; Wilke, Hutchinson, Todd, and Kruger, 2006). Although sexual selection models for handicap signaling focus on signal transmission from male to female, CST anticipates signals between members of the same sex (Bliege Bird and Smith, 2005; Zahavi and Zahavi, 1997).

A conflict of interest between the signaler and the audience may arise, so mechanisms must exist to reduce the chances that signalers cheat and to ensure that audience members pay attention. Signals can achieve evolutionary stability if (1) signalers differ in a quality that is otherwise not readily observable; (2) both the audience and signaler can potentially benefit from the transaction; (3) a link exists between the quality advertised and the cost of the signal; (4) a conflict of interest exists between signalers and the audience in that the signal can be "faked" by low-quality signalers; and (5) the signal provides honest information about the quality advertised insofar as high quality signalers pay lower signal costs or receive greater benefits (Bliege Bird and Smith, 2005; Grafen, 1990).

From the CST perspective, meat sharing at public feasts creates a social arena in which hunters can competitively display their kill to a general audience, instead of specifically towards potential mates. Both the hunter and the audience benefit from the signal. The audience, by observing differential hunting success, receives adaptive information about the value of each hunter as a reciprocator, ally, competitor or mate. Using this information, the audience members can make educated decisions concerning how to interact with the signaler in the future (Hawkes and Bleige Bird, 2002). The successful hunter potentially receives benefits associated with increased relative status, such as securing coalitional ties and high-quality mates. Finally, the signal is quality-dependent, and thus honest. That is, low-quality hunters cannot systematically fake the signal because it is too costly and will not yield long term benefits. Therefore, only a skilled hunter can afford to incur the cost of sharing meat that would otherwise be consumed by himself and his family.

File-sharing networks are also social venues in which altruists provide a resource to a large number of non-reciprocators. Asymmetrical sharing by uploaders is different from other types of generosity in that the cost of the signal does not result from giving up a resource that can be individually consumed. Most of the digital data that is shared by uploaders was likely downloaded for free or is a copy of an original file that is retained by the uploader. The handicap that uploaders do endure is two-fold: file uploading is *risky* in that uploaders are more susceptible to litigation, viruses, and hackers; and uploading is also *costly* because it requires time, an expensive Internet connection speed and a high performance computer.

Risk taking and unconditional generosity by uploaders may be explicable within a costly signaling framework. First, uploaders differ in quality in terms of both willingness to take risks and in the quantity and variety of media that they provide, and these differences are highly observable both online and offline. Second, there are potential benefits for both signalers and recipients. Uploader username "tags" help downloaders recognize those file sharers who have the qualities that they prefer (e.g., similar music interests, willingness to upload for extended periods of time, and/or a fast connection speed), and peers who observe the display online or offline may obtain useful information about the signaler such as the their ability to incur costs, and/or their willingness to share. File uploaders may benefit by increasing social status among offline peers and/or by enhancing their reputations among the online audience via their username tags. Finally, the signal is honest because only high quality file sharers can systematically incur the cost and risk of the signal. In other words, it won't pay for low-quality file sharers to fake the

signal over the long run. Drawing upon current evolutionary signaling theory, we tested the following hypotheses:

1. More males than females upload

Important differences in signaling behavior regarding level of participation and motivation exist between the sexes, but these dimensions are virtually unexplored in the scientific literature. Indeed, Bliege Bird and Smith (2005) contend that extrapolating the sex-differences dynamic of signaling behavior is one of the "most significant arenas" for future studies using CST. It is clear that many signaling games, such as those that are subsistence-based, are sex-specific. Further, there appear to be sex-specific interests in those signaling venues where both sexes participate. A study by Farthing (2005), which assessed attitudinal differences between the sexes regarding risk-taking behavior, suggested that males are more likely to attend to a risky signal. Of the three non-heroic risk types—physical risk taking, risky drug use, and financial risk taking—incorporated in Farthing's study, females did not prefer any risk type as a quality in potential mates *or* friends. Males also did not prefer risk taking in potential mates; however, males did prefer physical and financial risk-takers as friends to risk-avoiders. Hawkes and Bliege Bird (2002) have pointed out that a signal is not worth performing if there is no audience. Farthing's results suggest that females are not motivated to participate in signaling games that involve risk because two important audiences—female friends and potential male mates—will not attend to the signal. On the other hand, risk-taking males have a signal-receiving audience – other males. Sex differences in attentiveness to risk-taking behavior is also supported by a wealth of data indicating that young males are more prone to take avoidable risks, particularly in the presence of other males (Wilson and Daly, 1985; Byrne, Miller, and Schafer, 1999; Daly and Wilson, 2001; Nell, 2002). As is the case with reckless driving, binge drinking, or extreme sports, uploading involves potential risks that are well known among peers. Furthermore, because most file sharers are between the ages of 18-29, P2P file-sharing networks are an ideal arena for competitive signaling among young, risk-taking males (Rainie and Madden, 2004). We predict that (a) P2P activity will be gendered with significantly more males uploading than females, while (b) downloading, which is much less risky than uploading, will be comparatively less gendered.

2. Uploaders are signaling to offline peers and online file sharers

In P2P file-sharing networks, there are two possible audiences to whom uploaders are directing their signal: offline peers and online file sharers. It is highly plausible that uploaders are competing for status among same-sex offline peers (i.e. friends from college). It is also possible that uploaders are attempting to increase their online prestige by way of an observable tag such as a username. We anticipate that uploaders will be concerned with (a) offline recognition as uploaders among friends and (b) online reputation as uploaders among other file sharers.

3. File sharers are self-interested vs. group oriented

File-sharing networks cannot function without individuals who upload, suggesting a group selection scenario, and we test for the presence of group motivated altruism. Henrich and colleagues have argued that prosocial cooperation can evolve in very large groups in which

"institutional" norms are maintained by the anonymous punishment of individual rule violators (Henrich et al. 2006). However, "open" P2P file-sharing systems—the focus of this study—are anarchic with few rules, and participants expect cheating to occur. Further, there are few "institutional" mechanisms for imposing costs on individual file sharers who do not reciprocate (exceptions are "closed" administered systems like Bit Torrent that will be discussed below). Although cooperative, P2P file-sharing networks are also highly unstable because non-reciprocators greatly outnumber reciprocators. Given the opportunities for anonymous self-interested acquisition of media in P2P networks, we anticipate decision making that optimizes selfish returns (Maynard Smith, 1989; Trivers, 1971), and predict that both uploaders and downloaders are acting in their own interests, rather than for the good of the file-sharing community.

Materials and Methods

This is the first study to apply evolutionary concepts to the dynamic of Internet file sharing, and the primary goal is an initial descriptive analysis of file sharing by university undergraduates based on attitudinal and factual questionnaire data. Institutional review board research approval was obtained from California State University, Sacramento (CSUS) and Sacramento City College (SCC). Focus group discussions were used to obtain information on file-sharing behavior and to identify pertinent research questions and item statements. Four separate focus group sessions were conducted, each containing three to five subjects. A questionnaire was developed and implemented in a pilot study of 52 SCC students (56% male and 44% female) to test focus group-derived items/item clusters and questionnaire structure for the principal research phase.

Consistent with the descriptive objectives of the study, the assessment instrument is not constructed as a unidimensional scale of "file sharing," rather a series of subscales, or item clusters, designed to explore discrete file-sharing dimensions assayed during the pilot interviews. The final questionnaire comprised 36 items in three sections related to file-sharing behavior: one section (18 items) was completed by all file sharers (both uploaders and downloaders) (Table 4), a second section (10 items) was completed only by uploaders (Table 5), and a final section (8 items) was completed by non-file sharers. For the first section of the questionnaire, file sharers responded to clusters of items assessing the costs of uploading, selfish motivation when file sharing, recognition of uploaders while online, appreciation of uploaders, differential uploader quality, and the altruistic "message" of uploading (Table 4). Two major risk categories, risk of exposure to viruses/hackers and risk of prosecution, were included among other general statements about the costs of uploading. Selfishness in file sharing was assessed using direct statements about the benefits of file sharing, including saving money and time spent shopping for movies and music. To evaluate online recognition of uploaders by other file sharers, the questionnaire included statements about whether file sharers looked for specific usernames when downloading or used instant messaging to chat with uploaders. Focus group discussions revealed two qualities that file sharers looked for when downloading: uploaders who leave their computers on for an extended period (overnight or while at school or work) and uploaders with a fast connection speed. These two traits were used to measure "signal quality" among uploaders.

The second section, completed by uploaders only, contained groups of items that surveyed attitudes about group motivation, concern with online reputation, and concern with recognition as an uploader among offline friends (Table 5). Group motivation was measured

using items that examined an uploader's willingness to contribute to the file-sharing community despite the costs at the individual level. Concern with online reputation was assessed by including a statement about reputation building via usernames. Offline recognition was determined using items that examined peer identification of file sharers as uploaders. Non-file sharers responded to items that assessed concern with the costs of file sharing, perception of file sharers, and associations with file sharers. The questionnaire employed a five-point Likert scale: (1) strongly agree, (2) agree, (3) undecided, (4) disagree, and (5) strongly disagree. The questionnaire also assayed demographic information: age, gender, and relationship status, and additional factors such as self-rated computer competence, undergraduate focus of study, and preferred file-sharing digital medium (music files, music videos, popular movies or pornography).

Descriptive statistics of item cluster distributions were generated using 95th-percentile confidence intervals. Relationships between ranked dependent variables and fixed factors were analyzed using Kruskal-Wallis one-way analysis of variance, with Bonferroni adjustment for multiple measurements. The Bonferroni adjustment is used to avoid false positives (type 1 error), but is a conservative method that also increases the risk of false negatives (type 2 error). With this in mind, uncorrected as well as corrected *p* values are shown to mitigate the risk of type 2 error in the presentation of results. The underlying structure of the assessment variables was explored using principal components analysis. Two-way demographic comparisons were assessed with the chi-square test. The predictive relationships between uploader/downloader status, computer skill, and gender were tested using logistic regression. All tests are two-tailed at the 0.05 level of significance. Statistical analyses were carried out in SPSS 13.

Results

Participants

Study participants were recruited from General Education courses in anthropology and biology at CSUS. The study population (N=331) was composed of 55% females (n=183) and 45% males (n=148). Fifty percent (n=165) described themselves as single, 44% (n=145) as dating, and 6% (n=21) of the subjects were married. Thirteen subjects returned incomplete questionnaires and were excluded. The average subject age was 20.8 (SD=3.61) years. File sharers (n=233) comprised 70% of the total study population, of whom 53% were male (n=123) and 47% female (n=110). The average age of file sharers was 20.8 years (SD=3.36). The majority of the subjects were undecided (27%) about their focus of study in college, while 18% majored in the social sciences, 18% in business, 14% in health and human services, 9% in arts and letters, 6% in engineering and computer science, 4% in the natural sciences, and 4% in education. Digital music files were the primary shared medium of 94% of file sharers; and there were no sex differences among uploaders (x^2=1.74, df=2, p=0.420) or among downloaders in this regard (x^2=1.32, df=3, p=0.724)**.**

Factorial structure of assessment variables

Principal components analyses (PCA) were conducted to explore the underlying structure of the questionnaire items. Variables comprising the questionnaire answered by both downloaders and uploaders (see Table 4) were included in a PCA. Varimax rotation produced

eight components with eigenvalues >1 which accounted for 64.8% of the total variance. The components comprising the majority of variance were representative of the main four-item questionnaire clusters, but the rotated structure was complex with multiple loadings across components by items from the two-item clusters. These results indicate that moving from descriptive to predictive analyses in subsequent research would require expansion of the two-item clusters to four-item constructs.

To obtain a clearer picture of the relationships among the main assessment variables, a second analysis was conducted including only the four-item subscales. Five components with eigenvalues >1 were retained, accounting for 61.8% of the total variance in this model (Table 1). The rotated components closely paralleled the questionnaire item clusters (see Table 4): the first component "online recognition of uploaders" accounted for 15.5% of the rotated variance. The second and third items accounted for 13.3 and 12.2% of the variance, respectively, and split the "selfish motivation" items into separate components, suggesting that these items can be usefully modified in subsequent analyses. The fourth component comprised most of the "concern with costs" items and accounted for 11.9% of the variance.

Table 1. Factor loadings of items answered by uploaders and downloaders *N*=233 (see Table 4)

	Varimax Rotated Component Loadings				
Items	1	2	3	4	5
Online Recognition 4	.841				
Online Recognition 3	.773				
Online Recognition 2	.541				
Online Recognition 1	.383	-.345			
Selfish Motivation 3		.814			
Selfish Motivation 1		.745			
Selfish Motivation 4			.829		
Selfish Motivation 2		.388	.514		.304
Costs 3				.733	
Costs 1				.726	
Costs 4			.417	.493	
Costs 2					.904
Eigenvalue	1.81	1.59	1.46	1.42	1.15
Variance	15.5	13.2	12.2	11.9	9.5

Loadings < .3 are not shown

The underlying structure of items answered exclusively by file uploaders (see Table 5) was also assessed using PCA. Varimax rotation of the three uploader item clusters yielded a four-factor model accounting for 69.1% of the total variance (Table 2). The rotated components were congruent with the uploader questionnaire sub-scales (see Table 5): the first component "offline recognition" accounted for 20.9% of the variance; the second component "online reputation" accounted for 17.3% of the variance, and component three composed mainly of "group good" items comprised 17.2% of the rotated variance. The number of uploaders is small for a PCA, but the analysis is validated by the high factor loadings for the majority of rotated items (>0.6: Mertler and Vannatta 2005). Beyond the descriptive objectives of the current study,

the orthogonal structure of the questionnaire sub-scale items shows potential for further development and refinement in subsequent research.

Table 2. Factor loadings of items answered by uploaders only *N*=64 (*see* Table 4)

	Varimax Rotated Component Loadings			
Items	1	2	3	4
Offline recognition 2	.798			
Offline recognition 3	.790			
Offline recognition 4	.634		.344	
Online reputation 1		.814	.374	
Offline recognition 1	.398	.792		
Group good 2			.795	
Group good 4			.713	
Group good 3	.387		.428	
Group good 1				.829
Online reputation 2		.481		.684
Eigenvalue	2.09	1.73	1.72	1.40
Variance	20.9	17.3	17.2	13.7

Loadings < .3 are not shown

Computer skill

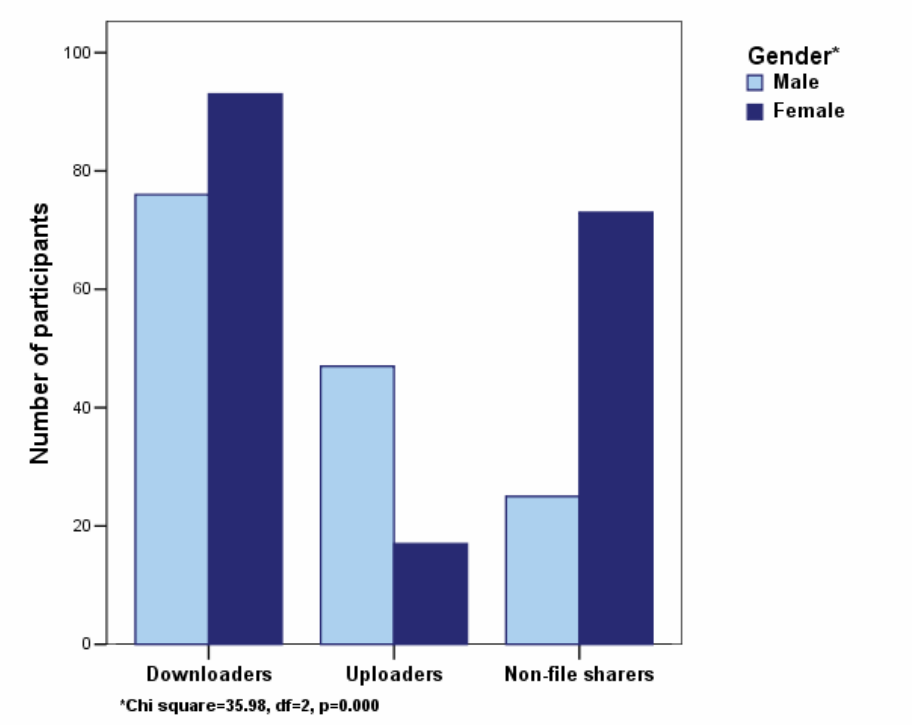
Subjects self-rated their computer competence by means of a five-point scale in order to assess correlations between computer competence and fixed factors, such as gender and P2P file-sharing activity. Only 5% of the study population reported novice computer competence ($x < 3$), 48% reported average skill ($x = 3$), and 47% rated expert computer competence ($x > 3$). The mean self-rated computer competence was 3.50 for all subjects. Males rated their computer competence significantly higher than females among all subjects (Kruskal-Wallis H test=30.2, df=1, p=0.000). There were similar sex-differences among downloaders (H=7.63, df=1, p=0.006) and non-file sharers (H=10.9, df=1, p=0.001); however, among uploaders there were no differences in self-rated computer competence between the sexes (H=0.56, df=1, p=0.46).

There were no within-sex differences between male uploaders and male downloaders in self-rated computer competence (H=0.87, df=1, p=0.351); in the same regard, there were no differences between female uploaders and female downloaders (H=2.46, df=1, p=0.116).

Gender differences in file sharing

As anticipated, there were significant gender differences in P2P file-sharing activity (x^2=35.98, df=2, p=0.000) (see Figure 1). Hypothesis 1(a) was supported in that significantly more males (72%) than females (28%) uploaded files (x^2=26.48, df=1, p=0.000). Hypothesis 1(b), that downloading would not be gendered, was also supported (45% male and 55% female, x^2=.009, df=1, p=0.92). Although not included as a study prediction, there were significantly more females (74%) than males (26%) among non-file sharers (x^2=20.77, df=1, p=0.000).

Figure 1. Gender differences in P2P file-sharing activity (*N*=331)



A possible confounding factor in our results is that males are more likely to upload as a function of gender differences in computer competence. The relationships between file-sharing activity, gender and computer skill were further tested using binomial logistic regression, with file-sharing activity as the dependent variable, and gender and computer competence as independent covariates. With non-file sharers excluded from the model, male gender significantly predicts file uploading, whereas computer skill had no significant effect on the model (Table 3). These results confirm that gender is predictive of file uploading, and that file uploaders as a group are not uniquely computer competent. Therefore, we conclude that the observed sex-differences in P2P activity are not the result of a gender divergence in computer competence.

Table 3. The relationships between file-sharing activity, gender and computer skill were tested using binomial logistic regression, with file-sharing activity as the dependent variable, and gender and computer competence as independent covariates.

	B	***Wald***	***df***	***p***	**Odds Ratio**
Gender	1.119	11.575	1	.001	3.060
Computer Skill	.343	2.300	1	.129	1.410
Constant	-2.892	11.766	1	.001	.055

Significant gender differences emerged in attitudes about the costs of file sharing ("concern with costs" item cluster, Table 4). While males were more cognizant about the risk of prosecution from uploading (H=6.45, df=1, p=0.01), females were more aware of possible exposure to viruses and hackers (H=3.75, df=1, p=0.05). Females were significantly more likely than males to contend that uploading is riskier than downloading (H=4.95, df=1, p=0.03).

Table 5 reports means for items answered specifically by uploaders and reveals differences in attitude between male and female uploaders. Items related to concern with offline recognition (Table 5, C8 and C9) show marked differences between the sexes. Males were significantly more likely to upload in the presence of friends and were more likely to be recognized as uploaders among friends. Regarding concern with group good, males—unlike females—felt strongly that the file-sharing system would collapse if not for their participation as uploaders (Table 5, Item A1).

Table 4. Items answered by uploaders and downloaders. Corrected mean rank scores (*SD*) and Kruskal-Wallis *H* statistics (*N*=233) (5=strongly agree, 4=agree, 3=uncertain, 2=disagree, 1=strongly disagree).

Items	Downloaders *n*=169	Uploaders *n*=64	*H* statistic[a]	all female file sharers *n*=110	all male file sharers *n*=123	*H* statistic[b]
A. Concern with costs						
1. Uploading increases the chances a file sharer is prosecuted. (+)	3.49 (0.91)	3.44 (0.94)	0.15	3.34 (0.92)	3.59 (0.89)	6.45**†
2. Uploading does not increase susceptibility to viruses and hackers. (-)	2.08 (0.89)	2.20 (0.88)	0.82	1.98 (0.86)	2.24 (0.90)	3.75*
3. Uploading is riskier than downloading. (+)	3.18 (1.00)	3.00 (1.04)	1.71	3.31 (0.96)	2.98 (1.04)	5.00*
4. The potential costs of uploading are not significant. (-)	2.84 (0.70)	2.89 (0.80)	0.07	2.95 (0.63)	2.77 (0.80)	4.23*
B. Selfish motivation						
5. I file share in order to get free stuff. (+)	3.24 (1.41)	3.20 (1.27)	0.23	3.12 (1.39)	3.33 (1.35)	1.36
6. Downloading digital data does not save me money. (-)	2.20 (0.98)	2.00 (0.99)	2.67	2.21 (0.95)	2.09 (1.02)	1.61
7. The main reason I file share are for the personal benefits. (+)	3.77 (1.02)	3.95 (0.93)	2.28	3.83 (0.99)	3.81 (1.01)	0.00
8. It is easier getting digital data from the store than P2P networks. (-)	2.49 (1.01)	2.38 (1.15)	1.56	2.62 (1.06)	2.32 (1.02)	6.12**†
C. Appreciation of uploaders						
9. I respect the file sharers that I download from. (+)	3.65 (0.94)	3.75 (1.01)	1.04	3.68 (0.95)	3.67 (0.97)	0.00
10. Uploaders are suckers. (-)	2.25 (0.83)	2.02 (1.02)	9.72**†	2.32 (0.89)	2.07 (0.88)	4.11*
D. Online recognition of uploaders						
11. I don't care about knowing who I am downloading from. (-)	3.46 (1.15)	3.69 (1.14)	2.02	3.25 (1.18)	3.76 (1.07)	11.72***†
12. I never chat or send messages to uploaders. (-)	3.91 (1.19)	3.67 (1.25)	1.99	3.83 (1.18)	3.86 (1.24)	0.12
13. I look for specific usernames when I am downloading. (+)	2.27 (1.00)	2.36 (1.06)	0.45	2.35 (1.01)	2.24 (1.03)	0.89
14. While file sharing, I recognize certain uploaders. (+)	2.55 (1.03)	2.83 (1.19)	2.84	2.65 (1.09)	2.60 (1.08)	0.17
E. Signal quality						
15. A 'select' uploader does not need a fast computer speed. (-)	2.57 (0.88)	2.44 (0.91)	0.70	2.62 (0.75)	2.46 (0.99)	2.32
16. A 'choice' uploader leaves his or her computer on for large downloads. (+)	3.40 (0.79)	3.77 (0.83)	10.18***†	3.25 (0.75)	3.72 (0.81)	20.3***†
F. Signaling generosity						
17. Uploaders are more likely to share other things in their lives. (+)	2.99 (0.87)	3.17 (0.85)	1.58	2.96 (0.86)	3.11 (0.87)	1.5
18. Uploaders are not making a statement about their willingness to share. (-)	3.11 (0.80)	2.97 (0.84)	1.77	3.16 (0.74)	2.99 (0.86)	1.67

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] Differences between downloaders and uploaders

[a] Differences between female and male file sharers

† significant after Bonferroni adjustment

Table 5. Items answered by uploaders only: male *vs.* female (*N*=64). Corrected mean rank scores (*SD*) and Kruskal-Wallis *H* statistics (5=strongly agree, 4=agree, 3=uncertain, 2=disagree, 1=strongly disagree).

Items	all uploaders *n*=64	Female uploaders *n*=17	Male uploaders n=47	*H* statistic[a]
A. For the good of the group				
1. Without uploaders like me, the file-sharing system will collapse. (+)	3.27 (1.20)	2.76 (1.20)	3.45 (1.16)	4.09*
2. I do not upload for the good of the file-sharing community. (-)	2.81 (1.08)	3.00 (1.12)	2.74 (1.07)	0.65
3. The benefit to the file-sharing community is greater than the personal cost of uploading. (+)	3.27 (1.01)	3.06 (1.25)	3.34 (0.92)	0.65
4. I don't care about helping out other file sharers (-)	3.02 (1.20)	3.18 (1.38)	2.96 (1.14)	0.49
B. Concern with online reputation				
5. Uploading does not enhance my reputation among other file sharers while online. (-)	3.41 (0.97)	3.47 (0.72)	3.38 (1.05)	0.01
6. I like 'tags' such as usernames because they help increase my online reputation. (+)	2.47 (0.98)	2.12 (0.70)	2.60 (1.04)	3.25
C. Concern with offline recognition				
7. I don't talk about uploading with my friends from college. (-)	3.02 (1.13)	3.35 (1.06)	2.89 (1.15)	2.18
8. I have uploaded while hanging out with my friends from college. (+)	3.25 (1.18)	2.41 (1.23)	3.55 (1.02)	10.2*** †
9. Most of my college friends know that I upload. (+)	3.08 (1.13)	2.59 (1.18)	3.26 (1.07)	4.34*
10. I'd prefer that my friends did not know that I upload. (-)	2.19 (0.94)	2.06 (1.09)	2.23 (0.89)	0.82

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

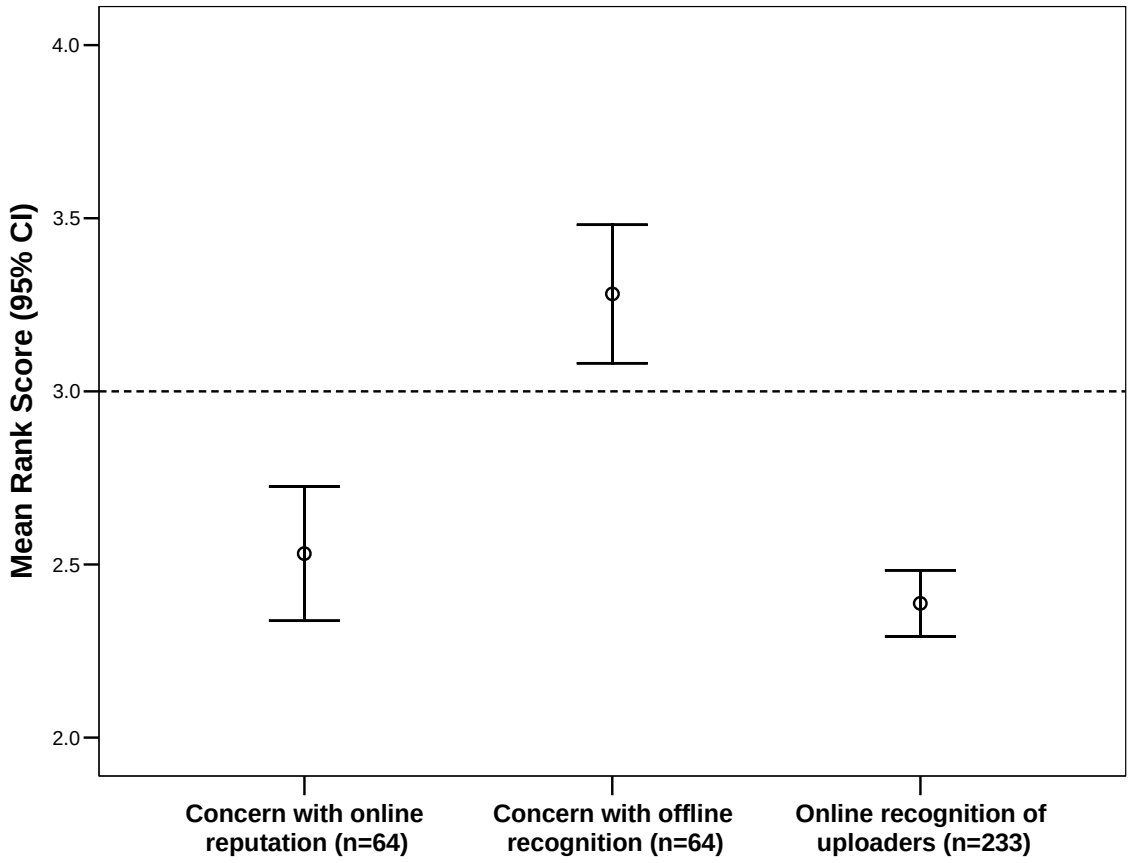
[a]Differences between female and male uploaders.

† significant after Bonferroni adjustment

Motivations for file sharing

We expected that uploaders would be concerned with increasing online reputation via an observable tag, such as a username. Contrary to this prediction, uploaders were not concerned with online reputation (item cluster mean 2.53, 95% CI 2.3-2.7, *n*=64). Furthermore, for an online signal to be effective there must be an audience attending to the signal, but file sharers were not interested in identifying or chatting with uploaders while online (item cluster mean 2.39, 95% CI 2.3-2.5, *n*=233) (Figure 2). Downloaders also were not impressed with items related to "signal quality," indicating ambivalence to a key observable dimension of online performance by uploaders (Table 4, Item E16). Thus, the results do not indicate signal transmission from uploaders to other file sharers they associate with while online.

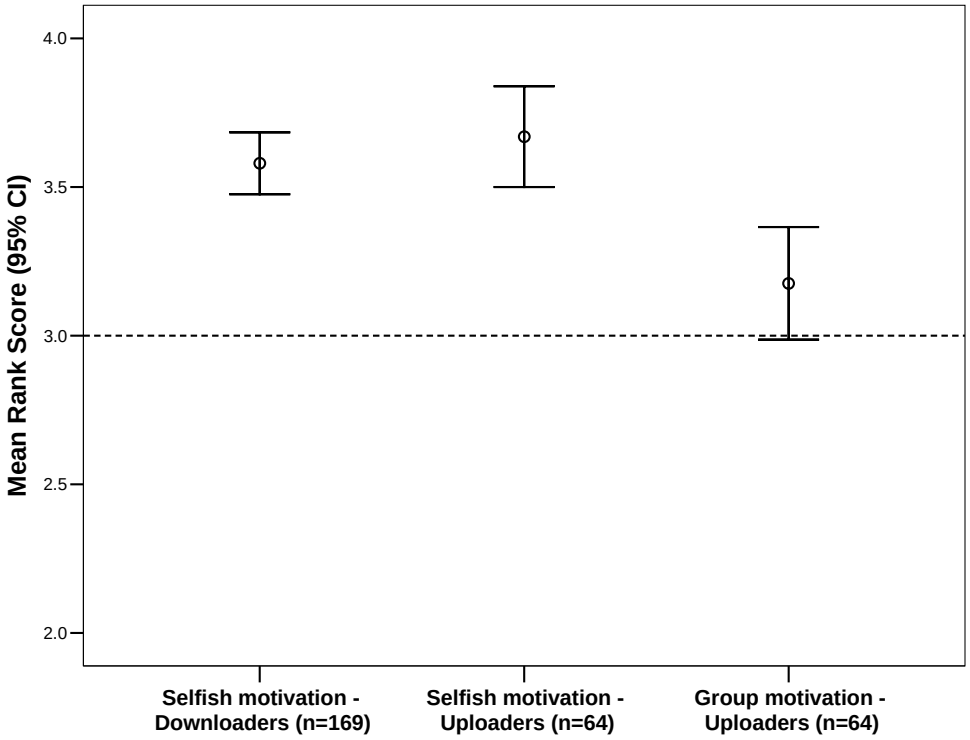
Figure 2. Offline vs. online recognition of uploaders (*N*=233). Item cluster means and 95% confidence intervals derived from a corrected 5-point Likert scale (*5=strongly agree, 4=agree, 3=uncertain, 2=disagree, 1=strongly disagree*).



We predicted that those file sharers that upload would be concerned with recognition as uploaders among offline friends at college. The results support this hypothesis, and it appears that uploaders, particularly males (Table 5, Items C7, C8, C9), are engaging in signaling offline in social contexts other than the Internet (item cluster mean=3.28, 95% CI 3.1-3.5, *n*=64) (Figure 2).

The final prediction was that file sharers were motivated by selfish rather than group interests. All file sharers (item cluster mean 3.61, *SD*=0.68), including both uploaders (item cluster mean 3.70, S.D. 0.65) and downloaders (item cluster mean 3.58, *SD*=0.69), stressed selfishness as a primary reason for file sharing, and the differences between them were not significant in this regard (H=1.57, df=1, p=0.211). Because uploaders can receive the same benefits (free digital data) as downloaders without incurring the risks, we also must consider whether uploaders were behaving in this manner for the good of the file-sharing community. Whereas uploaders acknowledged selfish motivation as the primary reason for file sharing, they also claimed that they were uploading for the good of the file-sharing community, albeit to a significantly reduced degree (Figure 3). Our results indicate, therefore, that both downloaders and uploaders are primarily self-interested, but that they also acknowledge greater than expected group-directed motivation.

Figure 3. Selfishness vs. group good in P2P file-sharing networks (*N*= 233.) Item cluster means and 95% confidence intervals derive from a corrected 5-point Likert scale *(5=strongly agree, 4=agree, 3=uncertain, 2=disagree, 1=strongly disagree).*



Discussion

Gender differences in signaling behavior

The observed gender differences in file-sharing activities raise important theoretical questions about CST. Cultural restrictions on inter-sex participation can explain many examples of sex-biased signaling (Bliege Bird and Smith, 2005), but in many signaling venues, such as P2P file sharing, males and females have equal opportunities to participate. Of the file sharers in this study, there were negligible differences between the sexes concerning participation (53% male, 47% females). In fact, more females (55%) than males (45%) exclusively downloaded files. It is not that females are excluded from or voluntarily do not engage in the file-sharing culture, it is that they choose to participate in the less risky, more immediately profitable behavior – downloading.

Risk taking has always been closely linked to males, but the mechanisms that favor such behavior have yet to be fully explicated within a costly-signaling framework (Wilke, Hutchinson, Todd, and Kruger, 2006). Our findings indicate that the level of risk a signal incurs can be a powerful predictor when extrapolating sex differences in costly signaling behavior. Compared with males, female file sharers felt that uploading was “riskier” than downloading (Table 4, Item

A3). Interestingly, male and female perceptions of the risks associated with uploading differed significantly. Females were more concerned about exposure to viruses and hackers, whereas males were more concerned with the potential of prosecution (Table 4, Items 1 and 2), implying that females and males interpret the costs and thus the information derived from the signal differently.

Exposure to hackers and viruses are real threats to file sharers, but the greatest risk is recording industry litigation, which can cost an uploader many thousands of dollars. A recent survey conducted by *Pew Internet and American Life*, a non-profit organization, reports that the percentage of file sharers was reduced by one-half after the RIAA pursued lawsuits against uploaders in 2003 (Rainie and Madden, 2004). Females stopped file sharing more than any other demographic group with a 58% decline in the number of users (Rainie and Madden, 2004). In our study, males were more cognizant of the risk of prosecution than females, yet males were significantly more likely than females to engage in risky uploading behavior – an outcome consistent with a CST dynamic in which risky file-uploading behavior by males constitutes the costly signal.

The efficacy of a signal is dependent upon the attentiveness of the audience, so in order for an offline signal to be effective, those who upload files must be recognized as uploaders among peers. Female uploaders were not identified as such among friends from college, did not talk about uploading with offline peers, and were much less likely to upload in the presence of peers when compared with males (Table 5, Item C9, C7, C8). Since few females upload, and it is seldom discussed among those who do, there are few, if any, potential benefits for a female signaler. Males, on the other hand, were more likely than females to upload, to talk about uploading, to upload in the presence of peers, and to be identified as uploaders among friends (Table 5, Items 7-9). The results also indicated that differences in signal quality are recognized more by males (Table 4, Items E15-E16). Sex differences in P2P participation and motivation strongly suggest that risky uploading behavior is an intrasex signal between males.

File sharing is a selfish endeavor

We considered two possible evolutionary explanations for uploading behavior: that group-beneficial uploading by file sharers is a self-interested costly-signaling dynamic, and a group-selection scenario in which uploaders are sharing for the good of the file-sharing community, despite the individual costs. Our hypothesis that uploaders would endorse self interest over group motivation was supported, but uploaders also tended to agree with items describing group-directed motivation (Figure 3). This is an interesting result and suggests that further research is required to parse these apparently conflicting responses from file sharers. However, there are several factors which anticipate the finding that self-interest is the primary motivation in P2P file sharing.

First, as discussed above, “open” P2P networks are anarchic: accessible to anyone who wants to participate, based on an expectation that participants will not necessarily reciprocate, and without administration or rules. This is in stark contrast to contemporary group selection models predicting that cooperation can be maintained in groups if institutional mechanisms exist for reducing within-group phenotypic variation and to limit within-group competition (Gintis, Bowles, Boyd and Fehr, 2003). Further, P2P file-sharing networks employ tools that *create* a competitive social environment by displaying phenotypic differences in uploader quality, an issue we explore below.

Second, non-reciprocators (or "leechers" in the P2P lingo) greatly outnumber reciprocators. In our study, only 27% of file sharers uploaded, which—from a group selectionist perspective—makes P2P file-sharing networks highly unstable cooperative systems. Boyd and colleagues (2003) have demonstrated that group-benefiting behavior that is individually costly can emerge if non-cooperators are punished. Interestingly, the level of leaching in open P2P networks has led many file sharers to choose to participate in "closed" networks like Bit Torrent. Such networks are the opposite of the more common "anarchic" systems: participants are registered members of the network, uploading is required and file sharing is regulated by system administrators. Therefore, Torrent networks have rules that reduce cheating, effectively exclude leechers and punish those that do not contribute enough files. Torrent systems are cooperative networks that may be explicable from the cultural group selection perspective, and we strongly recommend subsequent research of file sharing in these networks to test contemporary theories of costly punishment of non-cooperative norm violators (Boyd et al. 2003; Gintis et al. 2003; Henrich et al. 2005, 2006).

Signaling strategies: generosity

Our study results indicate that uploaders are concerned with recognition among their friends offline rather than online. We investigated two possible offline signaling strategies incorporated by uploaders. First, uploaders are signaling a willingness to share; and second, that uploaders are engaging in competitive status signaling in a risky social environment.

As a highly social species, humans often make important decisions about how to interact with one another based on imperfect and sometimes misleading information. Signaling provides an honest arena for individuals to communicate about aspects of human social life, for instance, with whom to develop a long term, mutually beneficial, reciprocal relationship. By reliably signaling a willingness to share, reciprocators can assort in a manner that excludes non-reciprocators. Furthermore, signaling a willingness and capacity to share can reassure current sharing relationships and increase the likelihood of reciprocation in times of need (Roberts, 1998; Gurven et al., 2000; Zahavi and Zahavi, 1997).

We investigated the possibility that uploaders are signaling a willingness to share. Although uploaders were more likely than downloaders to recognize uploading as a signal of generosity, the degree of endorsement among uploaders was not significant (Table 4, Items F17, F18). We also considered that male uploaders were signaling a willingness to share to potential mates. Females did care more about who they were downloading from than did males (Table 4, Item D11), but female uploaders and downloaders did not appear to recognize the altruistic message associated with uploading (Table 4, Items F17, F18). Consequently, the data suggest that uploading is not an intersex signal from males to females designed to broadcast a propensity for generous behavior. Male uploaders, however, were more likely than females to recognize the altruistic message of uploading, and the possibility of intrasex generosity signaling may constitute a useful direction for further research.

Signaling strategies: Status competition

Veblen (1899) explained how conspicuously consuming material items can be a form of social competition that reliably signals economic status. Conspicuous consumption is a signal strategy involving uneconomical behavior that is observable among peers, including leisurely

spending and disinterest in financial profits. Veblen posited that this type of behavior honestly advertises economic status in social environments where status information is unreliable. This same logic has been applied by Mauss (1924) and is mentioned more recently by Zahavi and Zahavi (1997) when considering examples of conspicuous generosity such as public donations. According to the latter, charity donors are concerned with how they are perceived by peers, competitors, and potential mates, rather than with increasing reputations among charity recipients (Zahavi and Zahavi, 1997). Our results indicate that uploaders, like donors at charity events, are using their file-sharing activities to impress and compete with their "flesh and blood" social peers offline, and are relatively unconcerned about how they are perceived by those online file downloaders that receive their gift.

In order for a signaling game to be competitive, there must be variations in the cost and/or risk of the signal that logically relate to differential quality among signalers. Based on clues from the study data, and the accounts of informants obtained during the pilot interviews, it appears that all uploaders are not equal. In addition to a general willingness to risk litigation, there are other variable qualities that relate to the cost and the risk of uploading: (1) the degree of financial investment in technology used in file sharing (a high performance computer and fast internet connection), and (2) the degree of computer competence that a file sharer may use to mitigate online exposure to risk. These observable differences in quality can be competitively displayed in a manner that signals status among offline peers while file sharing.

All file-sharing programs allow downloaders who are searching for digital media to choose among available uploaders by connection speed (T3 or higher, T1, cable/DSL, or 65K modem). It has become such an important quality in uploaders that many file-sharing programs allow downloaders to filter-out low quality uploaders when searching for digital data. Moreover, some P2P file-sharing networks have icons that display an uploader's connection speed on his or her computer screen, and this signal of quality is highly observable when an uploader is file sharing in the presence of friends. The prestige element of connection speed is further evident in the uploader vernacular. When uploaders converse they will commonly ask, "What is your pipe size?" referring to one's connection speed. The size of one's "pipe" is positively correlated with the amount of data that can be transferred between file sharers. For example, the authors downloaded a 6-minute song from an uploader with a T4 connection speed (high-speed network) in one-tenth of the time it took to download the same song from an uploader with a 64K (dial-up) connection speed. Enhancing signal quality using technology is financially expensive—in the vernacular of file sharing, a high quality or "choice" uploader must be equipped with a computer with a fast processor, a "fat" hard drive that is capable of holding large quantities of downloadable data, and a "big pipe" for quickly transferring digital data.

In addition to greater financial investment, some uploaders also take comparatively greater risks. Differences in the level of risk incurred may logically relate to differences in computer competence among uploaders. Some uploaders leave their computers on all day and over night in order to allow long downloads from their computers, whereas others only upload while downloading files. The former increases the amount of time an uploader is vulnerable to hackers and viruses, while also increasing the chances an uploader is caught for infringing copyright laws. The aforementioned study conducted by *Pew Internet and American Life*, illustrates how "time spent uploading" increases risk. Among those surveyed that continued to file share after the 2003 wave of subpoenas, 20% claimed to spend considerably less time file sharing due to fear of paying the potential $150,000 fine (Rainie and Madden, 2004). This important signal of quality—time spent uploading—is recognized significantly more by

uploaders than downloaders, and to a greater degree by males when compared to females (Table 4, Item E16).

As discussed, many risky signals such as reckless driving are more likely to be performed by males (Nell, 2002). Turning to pop culture for an example, Richard Linklater's 1993 film entitled *Dazed and Confused* is rich with examples of competitive status signaling, ritual, and initiation among young adults. In one scene, a young man named Wooderson stands over his 1970 Chevrolet Chevelle SS, named "Melba Toast." Wooderson, with the hood "popped," confidently describes various qualities of his car to a male peer: "I'll tell you what Melba Toast is packing here. I've got a 411 positrac out back, 750 double pumper, Edelbrock intake, bored over 30, 11 to 1 pop-up pistons, turbo-jet, 390 horsepower. We're talking some [expletive] muscle." Later on, the reliability of this verbal display was demonstrated on the highway as Wooderson recklessly races a peer with both cars packed with teenage males. It was not difficult to recognize a parallel in behavior between the pop-icon car enthusiast and the uploader who muttered to another uploader as they sat down and "popped" open their laptops prior to a focus group discussion: "What do you have there… an Apple G4 Powerbook with a 450MHz G3 processor? My XPS M170 runs an Intel Pentium 2.26 GHz processor with 2 gigs of dual channel SDRAM. I've got 6 USB connectors and an 80GB, high speed, 7200 RPM hard drive." It appears that P2P file-sharing networks, like the highways where young men race their cars, provide a risky environment for uploaders to show-off their "skills" and "machinery."

In closing, Internet uploading behavior meets the criteria for a costly signal. File uploading is an avoidable and risky behavior that is highly observable among peers, and displays variation between uploaders in the costs/risks incurred that logically relate to differences in signaler quality. Both parties potentially benefit from the signal transaction: signalers can compete for enhanced peer-group status, and the audience (which is likely composed of other uploaders) gains important information about the differences in quality between members of their peer group.

Future research

Peer-to-peer file sharing constitutes an observable natural experiment in human reciprocity and is highly amenable to subsequent research. Future goals include development of methods to parse factors affecting the quality of the communicated signal, such as technology investment and computer competence, and to further understand the motivations for off-line competition among male uploaders. Second, in contrast to males, the nature and target of the signal being sent by female uploaders is unclear. As a group, female uploaders were not concerned with either their reputation online or recognition while offline, and were ambivalent about uploading for the good of the file-sharing community. Further research is required to clarify the motivations for risky uploading among female file sharers. Third, research of "closed" administered file-sharing systems such as Bit Torrent is recommended to test contemporary group selection theory of costly punishment of norm violators in cooperative groups.

Acknowledgements

We would like to thank Ed Hagen, Lisa Dunlap, and several anonymous reviewers for helpful suggestions. Elements of this study were presented at the 2005 Human Behavior and

Evolution conference (HBES) conference in Austin, TX, and the 2006 HBES conference in Philadelphia, PA.

Received 1 May 2007; Revision submitted 11 June 2007; Accepted 12 June 2007

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