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?Does god play dice?? Randomness vs. deterministic explanations of idea originality in crowdsourcing

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Abstract

Which factors are responsible for the success of crowdsourcing tournaments? Extant research appears to assume that there is a deterministic relationship between factors such as the organization of the tournament, characteristics of the participants attracted, and specific situational factors on the one hand and the quality of their contributions gained on the other. We introduce the alternative idea that in fact the originality of any participants? idea is largely random and thus the success of the tournament rests on the number of participants attracted. In order to compare the explanatory power of randomness and 22 deterministic factors derived from literature we conducted a huge experiment in which 1,089 participants developed ideas for apps. Our finding is crystal clear: randomness outperforms deterministic explanations by over 500%. It appears that at least in crowdsourcing, God does play dice.

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1. Introduction

Recently, many companies have introduced crowdsourcing tournaments to outsource creative tasks such as idea generation, product or logo design to an undefined solution base outside the firm to gather high quality solutions with high levels of originality and innovativeness (Afuah & Tucci, 2012; Bayus, 2012; Bullinger, Neyer, Rass, & Moeslein, 2010; Dahlander & Magnusson, 2008; Hutter, Hautz, Fuller, Mueller, & Matzler, 2011; Terwiesch & Xu, 2008). While a number of such crowdsourcing tournaments are reported to be tremendously successful (Boudreau & Lakhani, 2009; Huston & Sakkab, 2006) others failed to produce the desired outcome. This prompted many scholars to investigate the factors determining crowdsourcing success, both conceptually (e.g. Afuah & Tucci, 2012; Pisano & Verganti, 2008; Terwiesch & Xu, 2008) as empirically (e.g. Boudreau, Lacetera, & Lakhani, 2011; Jeppesen & Lakhani, 2010). The underlying (implicit) assumption of the vast majority of studies is that the creative output generated by crowdsourcing tournaments is (1) determined by specific activities set by the crowdsourcing organizers (such as the design of the tournament or the incentives given), the characteristics of the participants attracted, and specific situational factors, (2) which are sufficiently general and stable to describe them empirically, and (3) can at least to some degree be influenced by the firm employing the crowdsourcing ideation tournament. Regarding characteristics of participants, for example, Frey et al. (2011: 398) "concentrate on the roles of motivation and knowledge as determinants of the quality of such individual contributions" (emphasis by the authors). Yet findings are quite heterogeneous.

In this article, we suggest that this lack of a consensus may be due to the inherent limitations of the deterministic perspective. We investigate in to what degree the output quality of crowdsourcing tournaments is in fact random. As the physicist and Nobel laureate Max Born put it: "chance is a more fundamental conception than causality" (Born in Mlodinow, 2009: 195). There are many indicators that this also holds in the business context (Ayton & Fischer, 2004; Fisman, Khurana, & Rhodes-Kropf, 2005; Langer, 1975; Mlodinow, 2009; Tyszka, Zielonka, Dacey, & Sawicki, 2008). Managers and other decision makers often perceive patterns, order, and causality in randomness (Kahneman, 2011).

Explanations are given by the concept of the "illusion of control" (Langer, 1975; Langer & Roth, 1975) and by the "clustering illusion" (Gilovich, 1993). Humans are "sense-makers", they have an inherent aversion against randomness. They infer patterns, regularities, and causalities from single cases or from completely random distributions. CEOs, for example, intuitively construct causal stories such that their decisions make sense (Salancik & Meindl, 1984). And although a variety of experiments have shown the prevalence of luck in many sports, gambling and business situations, people consistently believe in the "hot hand" (Ayton & Fischer, 2004; Gilovich, Vallone, & Tversky, 1985; Tversky & Kahneman, 1971). This might also explain why research has not taken up this perspective in the numerous studies on crowdsourcing success. Only indirect evidence can be found: Bayus (2012) found that successful contributors in crowdsourcing tournaments are unlikely to repeat their early success, which allows the conclusion that maybe also the initial success was in fact a matter of luck rather than the result of specific reasons.

Our research question thus is how the explanatory power of randomness and deterministic causal factors compare in explaining the output quality of crowdsourcing tournaments. It is important to know which of the two explanations matter more as they have opposing managerial implications. If on the one hand the success of crowdsourcing is determined by specific factors, then it is important to carefully design tournaments in a way that it corresponds to these factors. If on the other hand success is random, all that matters was to get an as large crowd as possible, corresponding to the law of large numbers.

2. Explanations of crowdsourcing tournament success

Success of crowdsourcing in new product ideation is mostly conceived as originality of ideas, i.e. the degree how much they differ from existing paradigms and involve radically new functions, designs, and elements (Kristensson, Gustafsson, & Archer, 2004; Terwiesch & Xu, 2008). Numerous factors have been suggested as determining crowdsourcing success. In order to collect the most important variables for our empirical study, we use a framework that distinguishes between (1) the organization of the tournament, (2) characteristics of participants, and (3) and situational factors, as suggested by Bullinger et

al. (2010), Leimeister et al. (2009) Malone et al. (2010), and Zhao & Zhu (2012). We base our selection both on the general literature on creative problem solving and on the specific literature on success factors of crowdsourcing tournaments for new product ideation (e.g. Bayus, 2012; Leimeister et al., 2009; Poetz & Schreier, 2012). Inevitably, some of the constructs may overlap to a certain degree. However, our objective is not to develop a parsimonious and theoretically compelling explanation, but to collect ideally all relevant potential explanations for obtaining highly original ideas from crowdsourcing tournaments.

2.1. Organization of crowdsourcing tournaments

Incentives. It is a fundamental economic argument that people exhibit specific behavior or increase their effort if they expect to derive benefits from doing so (Acar & van den Ende, 2011; Frey & Jegen, 2001). Thus attractive incentives for participants set by the organizer are portrayed as a key variable to augment the quality of contributions and thus the success of crowdsourcing tournaments (Boudreau et al., 2011; Terwiesch & Xu, 2008). Evidence for this can be seen in the fact that basically all real-world crowdsourcing tournaments display some sort of incentive for high-quality contributions (Bullinger et al., 2010). These incentives vary in form (e.g. cash prizes vs. non-cash prizes, see Brabham, 2009; Piller & Walcher, 2006), value (e.g. rather symbolic prizes vs. incentives of considerable value, see Fueller, 2006), and award structure (e.g. fixed-price vs. multiple-prize award winner, see Boudreau et al., 2011; Terwiesch & Xu, 2008). The underlying hypothesis is that given that the incentives are effectively customized to the target group, they will increase the likelihood of obtaining original contributions (Afuah & Tucci, 2012; Boudreau et al., 2011). Some studies provide initial evidence for the importance of incentives in crowdsourcing tournaments (Frey et al., 2011; Lakani, Jeppesen, Lohse, & Panetta, 2007; Leimeister et al., 2009; Piller & Walcher, 2006).

Interaction between participants. Much literature regards the opportunity to interact and collaborate with other individuals while conducting creative tasks as a crucial variable (Bullinger et al., 2010; Hutter et al., 2011). The resources of any individual are inevitably quite limited, thus the advantages of complementing it with resources of peers appear obvious. Interacting with others and observing their ideas can serve as

source of inspiration and heuristics for the initial development of the idea or for its further refinement (Perry-Smith & Shalley, 2003). Feedback and critique from peers may help reducing thinking barriers and particular weaknesses or errors (Perry-Smith, 2006). Creative re-use is also supported if people have access to other than their own solutions (Swift, Matusik, & George, 2009). Finally, the presence of other participants can motivate and create a stimulating climate, at an extreme it may induce positive pressure to perform (Bullinger et al., 2010). Hence it does not come as a surprise that several scholars emphasize the importance of enabling interaction when companies organize crowdsourcing tournaments (e.g. Bullinger et al., 2010; Hutter et al., 2011). A problematic counterforce may undermine these potential advantages: If the setting is highly competitive, e.g. if the incentive is limited to a fixed number of few (or just one) winners it may be that crowdsourcing participants refrain from cooperating (Boudreau et al., 2011; Terwiesch & Xu, 2008).

Task framing. Individuals' performance in creative tasks characterized by a broad solution space is largely influenced by the way it is framed (Afuah & Tucci, 2012; Leimeister et al., 2009). Small differences may have huge effects on the problem-solving behavior of individuals. This is so because usually the task description is immediately and without much cognitive effort translated into an internal representation of the task (Simon, 1971). Such automatic "system 1" processes (Kahneman, 2003) may lead to a lock-in within local searches and thus constrain the individuals' creativity by "functional fixedness" (Luethje, Herstatt, & von Hippel, 2005) – effects that have already been documented in crowdsourcing tournaments (Jeppesen & Lakhani, 2010; Lakani et al., 2007; Leimeister et al., 2009).

2.2. Participants' characteristics

Naturally, there is much literature that suggests that the outcome of crowdsourcing tournaments is determined by its main resource, namely the crowd and its characteristics. For structuring the various variables discussed in the literature, we use a framework that distinguishes between the individuals' expertise, their task-relevant skills, and their personality traits (Alba & Hutchinson, 1987; Allport, 1961; Ericsson & Lehmann, 1996; Jacoby, Troutman, Kuss, & Mazursky, 1986).

2.2.1 Expertise

Domain-specific expertise. One of the most distinctive features of crowdsourcing tournaments is the self-selection of participants who are equipped with expertise in the problem domain (Jeppesen & Lakhani, 2010; Piller & Walcher, 2006; Terwiesch & Xu, 2008). Knowledge about the underlying nature of a problem is an important precondition for successful problems (Volkema, 1983). The organizer's description of the problem may not compensate for an insufficient understanding of solution constraints, problematic side-effects, important contextual factors, solutions already existing and so forth (Nelson, 1982). Thus domain-specific expertise appears an important determinant of the outcome quality in crowdsourcing tournaments (Jeppesen & Lakhani, 2010).

Analogous domain expertise. Literature on creative problem solving maintains that not only domain-specific knowledge is important but also expertise in domains analogous to the target domain plays a major role (Dahl & Moreau, 2002; Franke, Poetz, & Schreier, 2013; Page, 2007). "Analogous" means that the domains they share relational predicates but no or only few object attributes, such as e.g. the traffic system in city and the human circulatory system (Gentner, 1983). Accordingly, a number of scholars describe it as a major advantage of the open calls typical for crowdsourcing tournaments that also individuals with expertise in analogous fields may participate (Huston & Sakkab, 2006; Jeppesen & Lakhani, 2010; Lakani et al., 2007; Terwiesch & Xu, 2008).

Ideation task experience. Basically all learning theories suggest that prior experience in a specific task increases the likelihood of obtaining high-quality solutions in this task (Lovett & Anderson, 1996; Stein, 1989). Individuals who already have undergone creative problem-solving in a similar task may have developed a problem understanding, solution scripts or strategies superior to individuals who engage in this task for the first time (Ajzen & Fishbein, 1980; Eagly & Chaiken, 1993; Fishbein & Ajzen, 1975). Thus several scholars assess experience in the very task of the crowdsourcing tournament ideation as beneficial (Jeppesen & Lakhani, 2010; Lakani et al., 2007).

Lead userness. A somehow related approach is lead user theory (von Hippel, 1986). A number of studies found that individuals with an urgent personal need for a solution to a problem and a position ahead of

important market trends usually come up with ideas superior to average users (Franke, von Hippel, & Schreier, 2006; Lilien, Morrison, Searls, Sonnack, & von Hippel, 2002; Morrison, Roberts, & von Hippel, 2000). Thus it seems plausible to expect that lead users are better problem solvers also in crowdsourcing tournaments and a recent study by Poetz & Schreier (2012) confirms this.

2.2.2 Skills

Business skills, technical skills, creative skills. Skills are learned individual abilities that can reach highest levels of performance by training, practice and development. Skills are not bound to a certain task or domain as opposed to expertise, and individuals form them based on their education and experience in work, hobbies etc. (Bunderson & Sutcliffe, 2002; Ericsson, 1996; Ericsson & Lehmann, 1996; Frey et al., 2011). Gardner's (1993, 1999) theory of multiple intelligences presents a framework of specific skills that represent an individual's potential for processing information such as business or technical skills. Prior research in crowdsourcing tournaments suggests that individuals with distinctive skills such as creative or technical (Fueller, 2006; Hutter et al., 2011; Leimeister et al., 2009) will be most capable of developing commercially attractive ideas.

Competence profile. Individuals can be specialists with skills and experience only in few domains or a generalist with a skill set dispersed over different domains. Research in creative-problem solving in general (Bunderson & Sutcliffe, 2002) and in crowdsourcing tournament in particular (Frey et al., 2011) suggests that a broader competence profile yields in a higher likelihood of valuable contributions than a narrow specialist.

Education level. There is consensus among scholars that the greater general cognitive capabilities typically associated with a higher level of education is beneficial in creative problem-solving (Bantel & Jackson, 1989). Also in crowdsourcing tournaments winners are often reported to be predominantly higher educated (Brabham, 2009; Frey et al., 2011; Lakani et al., 2007).

2.2.3. Traits and roles

Creativity. Participants' capability to create novel ideas is largely influenced by their general level of creativity which is assumed to be a relatively stable personality trait (Amabile, 1996; Sternberg & Lubart, 1999). Individuals capable of "divergent" or "lateral" thinking should thus also provide more original solutions in crowdsourcing tournament settings (Franke et al., 2013).

Information hub. Information hubs are individuals who are particularly well connected within the information network (van den Bulte & Wuyts, 2007). Due to their central position they receive more information and they receive new information particularly early (Goldenberg, Han, Lehmann, & Hong, 2009). This ability of brokering knowledge might be an advantage when it comes to developing a new idea (Hargadon, 2002). Such novel recombinations of others' ideas have been found to generate top ranking submissions in crowdsourcing competitions (Gulley & Lakhani, 2010).

Boundary spanner. A different group of people who might have an advantage over average people are boundary spanners, i.e. "individuals who are especially sensitive to and skilled in bridging interests, professions and organizations" (Webb, 1991: 231). Prior research identified boundary spanning individuals as great asset to firms because they use their contacts outside their own social group to gain access to new areas of ideas or knowledge (Hosking & Morley, 1991; Obstfeld, 2005). Bullinger et al. (2010) suggest that this construct may also be beneficial in understanding why some participants produce superior ideas in the context of crowdsourcing.

Outsiderness. If we describe an idea as being "original" we mean in essence that it differs (in a positive way) from existing ideas. The same may hold for their originators. Individuals who systematically differ from the mass may bring along fresh and unconventional ideas that are not bound to current thinking. Studies in the sociology of science literature support this view by arguing that (radical) inventions are typically made by outsiders that are not located in the mainstream and thus are less bound by professional customs and traditions (Ben-David, 1960; Law, 1973; Mullins, 1972). There is initial evidence that such effects also exist in crowdsourcing tournaments (Fernandes & Simon, 1999; Jeppesen & Lakhani, 2010).

Age and gender. There is ample research that the ability to generate creative ideas is negatively affected by the individuals' age (Ruth & Birren, 1985; Simonton, 1988). Also in crowdsourcing tournaments, the

most productive individuals are found to be being young in age and male (Brabham, 2009; Frey et al., 2011; Fueller, 2006).

2.3. Situational factors

Human behavior and its outcome are not determined solely by expertise, skills, and traits and roles, it is also heavily influenced by situational factors, i.e. factors that are present in the very situation of the crowdsourcing tournament (Vallerand, 1997).

External support. The web environment crowdsourcing tournaments are embedded in makes it relatively easy to gain support by other people, either by asking friends or peers for advice, or re-using existing information or ideas from others by searching in the internet. Lakhani et al. (2007) incorporated this factor into their analysis of determinants of crowdsourcing success and found that a vast majority of participants consulted others while trying to solve the problem. Frey et al. (2011) found a similar pattern.

Motivation. It is of course not enough to have the capabilities to perform in a given task, the individual must also be motivated to do so (Frey et al., 2011). The individuals' willingness to really give their best in creative problem solving may be a function of factors related to the crowdsourcing setting, such as incentives perceived or personal interest in the task. But it is naturally also impacted by factors such as current mood, fatigue, weather conditions etc. (Friedman, Forster, & Denzler, 2007; Gratwitch, Munz, & Kramer, 2003).

Time spent. It appears that the time spent on the task is related to the output in crowdsourcing. Jeppesen & Lakhani (2010) and Lakhani et al. (2007) found that winners spent significantly more time on solving the task than non-winners. There are several possible reasons for this finding. One is that time spent can be a proxy for the level of motivation, i.e. the level of effort the individual is willing to devote to the task or the desire to win the award money (Frey et al., 2011; Lakani et al., 2007). Another may be the absence of competing occupations or factors disturbing the individual (Lakani et al., 2007). Also, winning solvers are reported to be spending more time on recombining and transforming pre-existing knowledge (Lakani et al., 2007).

Timing of the tournament. It is clear that there are times when people are rushed and experience much more time pressure than usual. Examples of such situational factors are the days before Christmas or peaks in jobs (or studies). The timing of the tournament within such a period vs. in times where the individual is hungry for a new challenge may have effects on his or her willingness to engage and the level of concentration he or she shows (Brabham, 2009).

2.4. An alternative explanation: randomness

The notion that creative output of scientists or artists is a deterministic function of specific factors is seemingly supported by accounts of "geniuses", i.e. individuals of outstanding capabilities (Eysenck, 1995). It is easily overlooked that it has been shown, for example that those scientists who publish the most highly cited works also publish the most ignored works (Simonton, 1997). The "equal-odds rule" says that the number of significant contributions is dependent on the number of total contributions, which means, in essence, that creative success is luck (Davis, 1987; Simonton, 1997; White & White, 1978). Descriptions of the mental processes that led to e.g. scientific discoveries show that they often entail random combinatorial processes (Holton, 1971; Simonton, 2003). With the aim of finding original and useful solutions, scientists are creating relatively unconstrained recombination of a large but finite set of facts, concepts, techniques, heuristics, themes, questions, goals, and criteria that make up their domain (Campbell, 1960). An often cited example is given by the mathematician and physicist Henri Poincaré (1921) who reported that "ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination" (p. 387). Also lucky accidents may play a role as illustrated by the many examples of "serendipitous" inventions such as classical conditioning, X-rays, or penicillin (Austin, Devin, & Sullivan, 2012; Shapiro, 1986). Also the surprising frequency of "one-hit-wonders" in music, art and entertainment illustrate this component (Kozbelt, 2008). The controversy between those scholars who defend creativity as a guided capability and those who portray it as blind variation and selective retention and thus stress the factor of randomness is unresolved (Kronfeldner, 2010; Schooler & Dougal, 1999).

If the creative outcome provided by an individual problem-solver is inherently non-predictable, the consequence in crowdsourcing tournaments must be to include as many participants as possible (Boudreau et al., 2011; Terwiesch & Xu, 2008). Due to the law of large numbers the characteristic noise term can be mitigated this way (Diaconis & Mosteller, 1989; Sedlmeier & Gigerenzer, 1997; Tversky & Kahneman, 1971).

3. Method

In order to measure the relative explanatory power of randomness and causal factors we conducted an experimental crowdsourcing tournament with a typical ideation task. We manipulated the organization of the tournament and measured the participants' expertise, their skills, their personality traits, and situational factors. Our dependent variable is the novelty of the ideas generated. This setting allowed us to analyze data on two different levels. First, we could determine on the individual level in how far the numerous causal factors we measured actually explain the novelty of the individual participants' ideas. Randomness is the "invisible guest" in this analysis – it corresponds to the remaining unexplained variance (see the final section where we discuss the underlying assumptions). On the aggregate level, we could model randomness explicitly. In this second step, we used our data for a simulation of crowdsourcing tournaments. This corresponds to the perspective of a company that is rather interested in the outcome of the total crowdsourcing tournament than in the performance of each participant. For each crowdsourcing tournament simulated, we randomly drew participants from the overall sample. As we knew their ideas, we could measure what would have happened had we organized the tournament in this specific way and had been able to attract a crowd with these specific characteristics in these specific situational circumstances. The dependent variable was the novelty of the best ideas obtained in this specific tournament. The independent variables were the specific crowds' overall expertise, their skills, their personality traits, and situational factors. Randomness was captured by the size of the crowd, which we varied from 10 to 100 in the 36,400 tournaments we simulated. This is so because the law of large numbers basically says that the chance of getting a high number of spots is a function of the number of

dices rolled, given that die casts are actually random. Comparing the variances explained by the size of the crowd with the variance explained by all deterministic factors allows an answer to our guiding question in how far the success of crowdsourcing is determined by randomness.

3.1. Setting and participants of the crowdsourcing experiment

We conducted an ideation-based crowdsourcing tournament for smart phone apps in its natural web 2.0 environment. We had chosen the development of ideas for smart phone apps as the object of our study for two reasons. First, seeking for novel app ideas by means of crowdsourcing tournaments appears quite typical, which is visible by recent examples of Allianz, Deutsche Telekom, NYC, LG, Nokia, Samsung, or U.S. Treasury Department. Second, the ideation task can also be generalized to many other crowdsourcing tournaments as it has a broad, almost infinite solution space, and the quality of solutions is not arbitrary. Succeeding in such a tournament requires not only creativity and imagination but also skills (e.g. to describe the idea properly) and knowledge (particularly regarding already existing apps).

We invited participants to an idea competition regarding "mobile communication of the future", sponsored by the smart phone producer Apple Computer and the network provider Orange. As an incentive to participate, we announced prizes amounting to a total of € 50,000. We obscured the study intention in order to avoid problematic self-selection biases and the possibility to prepare an idea beforehand. People interested were informed that the contest would take place in two relatively narrow time slots (five hours in the evening time of two different days, a Thursday and a Saturday) we had defined in order to control the experiment (see below).

We broadly promoted the study and thus attracted a relatively large gross sample of n= 2,599 participants. We precluded double entries by controlling for IP addresses. However, we had to exclude 1,510 cases due to data lost (223), participants who did not fill out the questionnaire (1,169), a critical number of missing values (8), regular aborts (2), a task time of less than 100 seconds (40), inconsistent responses (28), multiple participation (24), minimum completing time of 20 seconds per form in all questionnaires (16). Thus, our net sample consists of 1,089 participants. Most participants were male

(68.7 %) students (87.9 %) with a mean age of 25.7 years (s.d. = 7.1), thus the sample largely corresponds to typical crowdsourcing tournament participants (Füller 2010). They came from Austria (69.5 %), followed by Germany (25.7 %) and Switzerland (2.7 %) or no indication regarding the home country (2.1 %).

3.2. Experimental design

We employed an online 2*2*2 between-subject experiment on a website we had programmed for this study. It consisted of seven phases. (1) When entering the website, participants logged in and received a short introductory text that described the procedure of the crowdsourcing tournament. Particularly, they were informed that they would get a specific task and had a maximum of 15 minutes to complete it. (2) Participants were then asked to self-assess their creativity (see operationalization). We measured this factor before the participants submitted their ideas in order to avoid a potential halo-effect. (3a) Then participants received the actual task of the tournament: they should develop an idea for a novel and innovative every-day-app that should be interesting to as many users as possible. They were randomly assigned to one of the two conditions of the task framing (narrow or broad) and (3b) to one of the two conditions regarding the incentive (incentive or none). (4) Then idea generation started. There was a blank field for a clear headline and a blank field that allowed for a text with a maximum of 1,000 characters. They were permanently informed about the remaining time. (5) After exactly 1 minute it was randomly determined whether they would keep on working alone or in the interaction condition. In the latter case, the participant was assigned to another participant of the study. This dyad was then enabled to assist each other. (6) After a maximum of fifteen minutes participants had to submit their idea, which they did on average after 9.73 minutes (s.d.=3.79). (7) After this, they were directed to an online questionnaire with the key variables. From the net sample, 622 participants were in the interaction condition and 467 worked alone. 540 participants received the broad task framing as opposed to 549 who received the narrow task framing. The number of participants in the incentive condition accounts for 527, whereas those who had not the opportunity to win the award counted 562 participants. Tests showed that there are

no significant differences regarding the distribution of independent variables between the eight treatment conditions which points to an effective randomization.

3.3. Operationalization

3.3.1. Stimuli: manipulation of the organization of the crowdsourcing tournament

The design of stimuli is based on the insights of two pilot studies. First, we had interviewed nine distinguished experts of crowdsourcing tournaments worldwide (platform founders, directors and managers from the crowdsourcing platforms Topcoder.com, Atizo.com, Hyve.de, Cambrianhouse.com, Ideabounty.com, Brainstore.com, Brainreactions.com, Trendwatching.com and a startup). Second, we had carried out an exploratory search in blogs, crowdsourcing tournaments, user groups, and discussion forums.

Incentives. Incentives are context-sensitive (Afuah & Tucci, 2012; Boudreau et al., 2011), thus we had conducted interviews with two decision makers from Apple and consulted users of the Apple community (n=54) regarding the most effective reward in our context. Based on this we decided to operationalize the incentive as the total of all revenues of the app. We informed participants in the incentive condition about the incentive before they started the idea development on a separate info page with a clear text that explained that all ideas with truly innovative potential would be programmed and commercialized by our sponsors Apple and Orange and no costs would arise for the idea generator while he or she would receive 100% of the revenues generated by his or her app (a number of apps were actually selected by our sponsors for development). In the "no incentive" condition we gave no such information.

Interaction between participants. We facilitated the interaction within the pairs of participants by a real time chat tool that looked and worked similar to an SMS conversation between iPhone holders. Both participants were kept anonymous but could permanently see each other's idea and idea development process. They could use a chat function to comment on each other's ideas, assist each other, etc. As there was no rivalry even in the incentive condition (we had explicitly indicated that all ideas with innovative potential would be commercialized) we expected participants to cooperate. Indeed, an ex post analysis of

the interaction protocols logged shows that participants in this condition made vast use of the interaction possibilities. On average, they exchanged 4 messages that primarily (95.12 %) focused on the ideas (and not on other topics).

Task framing. While the task wording as such was identical for both groups, we operationalized the task framing (broad vs. narrow) by the three examples of apps we gave participants in the two conditions for matters of illustration. Numerous studies on task framing show that solution examples fundamentally impact the individuals' problem solving activities and eventual answers given in rational choice (Tversky & Kahneman, 1971) and creative tasks (Friedman et al., 2007). In the broad condition, the examples were selected from three very different categories (a location-based service app, a music recognition app, and a photography app), in the narrow condition, we displayed three examples from the same category (photography). We took the app examples from Apple's App Store. All were ranked top 50 in the cost-free section during the data collection period and the total popularity of both conditions was identical (see Figure 1).

< Insert Figure 1 about here >

3.3.2. Measurement of participants' characteristics

Domain-specific expertise. We used the scale from Lakhani et al. (Lakani et al., 2007) and adapted the items to the app idea development context. We generally used 5-point rating scales with 1= strongly disagree and 5= strongly agree and averaged multi-item constructs to indices. Cronbach's alpha for this construct was .74.

Analogous domain expertise. We operationalized this construct on the basis of extant literature (Huston & Sakkab, 2006; Jeppesen & Lakhani, 2010) with a single item.

Ideation task experience. We again measured this construct on the basis of extant literature (Allen & Marquis, 1963; Cohen & Levinthal, 1990; Jeppesen & Lakhani, 2010; Lakani et al., 2007) with a single item we adapted to our context.

Lead userness. We measured the first lead userness dimension of expected benefit using three items of Franke et al. (2006) and three items of von Hippel's (2005) for the second dimension of trend position. We aggregated the scales to a lead userness measure. Cronbach's alpha for the trend position measure was .93, expected benefit.82.

Business skills, technical skills, creative skills. We measured the relevant skills of the participants with three items based on Gardner's theory of multiple intelligences (1999).

Competence profile (generalist vs. specialist). Analogous to Frey et al. (2011) we used the Herfindahl Hirschman index (Hirschman, 1964). We applied the normalized index H* of the concentration along the three skills items (business, technical, creative) that reflected different knowledge bases. The value of 1 indicates that an individual is an extreme specialist with a maximum value in one knowledge base and the minimum in all other bases. The minimum value 0.1 (H*=1/N with N being the total number of items) means that the individual is an extreme generalist with equal values across all knowledge bases.

Education level. We measured education level asking for the highest standard of education in the demographics section. Responses were recoded. The value of 1 indicates that an individual is a university graduate; the value of 0 indicates no university graduation.

Creativity. We measured this construct using the Buffalo Creative Problem Inventory (Puccio, 1999) analogous to Rickards & Moger (2006) or Isaksen & Geuens (2007), which we had reduced by means of a pilot study with n=50 students (n=50, Cronbach's alpha was .77) to three items. Cronbach's alpha for this measure was .65.

Information hub. We measured this construct based on King & Summers (1970), Lazarsfeld, Betrelson, & Gaudet (1944) and Katz & Lazarsfeld (1964). As recommended by King and Summers (1970) and Silk (1966) we relied on self-assessment and asked participants to assess their role in their social environment. Again, we provided the diagram and color-coded the role of an information hub (based on the two-cycle flow of communication model by Trodahl, 1966). The item reads "I am the hub in the social groups I belong to.".

Boundary spanning. We measured the degree in how far the individual acts as boundary spanner based on extant literature (Granovetter 1973, Rosenkopf and Almeida 2003). Self-assessment is recommended to be the preferred form of measurement (King and Summers 1970, Silk 1966). For matters of illustration we provided a diagram and color-coded the role of a boundary spanner between groups. The item reads "I am the connection link between social groups that would be apart otherwise.".

Outsiderness. We measured this construct with the cosine similarity function (Lewis, Ossowski, Hicks, Errami, & Garner, 2006; Salton & Buckely, 1988) which is the most widely reported measure of vector similarity. It is a standard measure for determining similarities between two vectors by calculating the cosine of the angle between them. We compared the profile of each participant's knowledge base with the profile of all other individuals in the sample and calculated outsiderness for each individual i as $1 - \sum_{j=1}^{n-1} cosine_{ij}$. An outsiderness close to 1 indicates that an individual is completely dissimilar to all other participants in the sample, a value close to 0 means that the individual has a profile highly similar to others.

External support. We asked participants to indicate whether they received helpful support from others while developing their idea. For this, we took the measure of Lakhani et al. (2007) and adapted the item to the study context.

Motivation. We measured the degree in how far participants felt motivated to perform at the task analogous to Frey et al. (2011), Lakhani et al. (2007), and Jeppesen & Lakhani (2010). The two items have a Cronbach's alpha of .59.

Time spent. Total time available was limited to 15 minutes. Jeppesen & Lakhani (2010) and Lakhani et al. (2007) actively asked for time investment (in hours) for the development of a scientific solution to an R&D broadcast search problem, while we analyzed the log files we tracked automatically.

Timing of the tournament. We conducted the experiment on two independent days. The dynamic market development of apps precluded a long interim time (as there are constantly new apps introduced (on average 745 apps have been admitted per day into the App store by Apple in 2011, Freierman, 2011), the measurement of the dependent variable – originality – would have been severely affected by this, causing

a methodological artifact). Therefore, we decided to launch the tournament with a minimum interim time of only two days in December, a Thursday and a Saturday evening from 5 to 10 p.m. each. The latter tournament day was on the second Christmas shopping weekend and we expected people to be more rushed on this day. Tournament day was tracked automatically.

< Insert Table 1 about here >

Table 1 lists all constructs and items along with the results of the confirmatory factor analysis. Results (fit indices, Cronbach's Alphas, AVEs, C.R., and results of χ^2-difference tests) indicate that our measurement instruments are sufficiently reliable and valid.

3.3.3. Measurement of the dependent variable

We measured the originality of the 1,089 ideas generated by again asking a publicly invited crowd of n = 121 people using a specifically developed web-based evaluation tool (we ensured that no participant of the ideation contest could evaluate his or her own idea). Such a distributed evaluation approach is highly recommended by recent literature as it is not only more efficient, but can also lead to a more valid evaluation than traditional expert or in-house idea evaluation (Galbraith, DeNoble, Ehrlich, & J., 2010; Moeslein, Haller, & Bullinger, 2010; Toubia & Flores, 2007). As incentive for participation, we announced that crowd evaluators would take part in a raffle for prizes amounting to € 1,000.

Each evaluator rated a randomly selected set of 100 app ideas in randomized order. We asked "How new, uncommon, and unusual is this idea?" and employed a 5-point rating scale with 1 = very low originality and 5 = very high originality. Each idea was rated by at least 6 evaluators and we gathered a total of 12,162 originality scores. Generally, agreement was very high with 77.41 % of the ideas showing a variance of less than 1.5 in the ratings it received. (As any idea was evaluated by a different set of raters, we could not compute measures such as Krippendorff's alpha.)

In the case of 61 ideas where ratings lacked consensus (variance of 2.0 or higher), these were re-assessed in a moderated assessment workshop with 9 experts. Three were experts from Apple and Orange (NPD and market research departments). Three were lead users from the original evaluation where we asked all raters to fill out the leaduserness scale and indicate their willingness to take part in a potential re-assessment workshop. The jury was complemented by three product related experts with long-term experience and competence in the mobile communication industry, e.g. the product manager for iPhones at a mobile network company or a serial entrepreneur for apps. We trained the experts before they evaluated the quality of the ideas individually (Hayes & Krippendorff, 2007). After evaluating, the experts discussed differences in their assessments and could change their individual ratings if they wanted based on their joint discussion. The experts showed satisfactory consistency in evaluating the ideas with an interrater reliability accounting for .50, given the difficulty of the specific task (Krippendorff, 2004). The difference between mean originality after re-assessment (3.31) and the mean of the original evaluations (3.40) was not significant ($T=-1.03$, $df=58$, $p=.31$).

< Insert Table 2 about here >

3.4. Pilot study on validity of the experimental setting

In the experiment, we had decided to limit the ideation time for every participant to a maximum of 15 minutes, which is a typical time in experimental studies involving creative tasks (e.g. Althuizen, Reichel, & Wierenga, 2012). The reason was that we wanted to keep conditions standardized and controlled. A longer time slot would have allowed e.g. excessive internet browsing or seeking other forms of assistance.

Does a time limit of 15 minutes constitute a problematic restriction for individuals seeking for ideas for new apps? Related literature does not suggest that this is the case as previous research on crowdsourcing has found that the majority problem solvers instantly knew in which way to work for developing a solution (Jeppesen & Lakhani, 2010; Lakani et al., 2007). Similarly, Lakhani & von Hippel (2003) report that in crowdsourcing of support solutions in open source software communities members

typically spent only a few minutes for answering even tricky questions. While these findings are based on crowdsourcing of technical problems, research on intuitive decision making in marketing suggest that for ideation tasks, similarly, individuals only need very little time to develop a solution (Dijksterhuis, Bos, Nordgren, & van Baaren, 2006; Wierenga, 2011).

Although these findings collectively suggest that the time constraint in our experimental setup is unlikely to prevent participants from developing good solutions, we conducted a pilot study to ensure that the constraint task time does distort the quality of the ideas relative to the potential quality if participants had unlimited time. This test is important because theoretically, it may be that ideas brought up under time pressure are not representative for the idea quality an individual would provide with unlimited time. If this was the case, a methodological artifact would be the true reason why causal factors hardly explain idea originality of crowdsourcing participants – and not the reign of randomness.

We asked a convenience sample of students with a business, technical or creative background (n=39) to generate original ideas for apps. The ideation was conducted electronically, and we used the same task description as in the main experiment and also gave a blank field allowing for a text with a maximum of 1,000 characters and a clear headline. We set an incentive of an iTunes voucher amounting to € 100 for the best app idea. As in the main experiment, we announced that the task time would be limited to 15 minutes. After participants had finished, we explained them that there was a second and completely independent tournament where again the best app idea would be awarded with an iTunes voucher of 100 €. The only difference would be that this time there was no time limit at all. Participants were free to submit their original ideas, further refine them, or develop new ideas completely from scratch. The randomized ideas were rated by an expert (decision maker in market leading app development company in the creative industry) blind to the objective of the study and the source of the ideas using the same scale as in the main experiment (Hayes & Krippendorff, 2007; Krippendorff, 2004). Findings were comforting. First, the majority (99 %) of participants did not fully use the 15 minutes granted (mean 9.73 minutes, s.d. 3.79 minutes), suggesting that indeed they came up with an idea quite instantly. Second, and more importantly, the originality of the first and the second idea by the individual participants correlated

with r=0.847 (p=.000) which means that the possibility to further refine the idea has hardly a measurable effect on its originality as evaluated by independent experts. In sum, this clearly supports our assumption that the time limit in our experimental setup is not distorting the idea quality participants would be able to achieve without constraint. Consistent with this, only 8.0 % of the participants in our main experiment submitted their ideas within the last 30 seconds of the maximum time limit.

3.5. Simulation of crowdsourcing tournaments

3.5.1 Permutation procedure

We simulated crowdsourcing tournaments that differed in crowd size ranging from 10 to 100. The lower bound we derived from our dependent variable (mean originality of top 10 ideas, see below), the upper bound was imposed by the minimum of participants in any of the 8 (2*2*2) combinations of our experimental groups. This range appears to be more or less in line with real-world crowdsourcing tournaments. A pilot study we conducted on nine international crowdsourcing tournament platforms (eYeka, Solvster, Edge Amsterdam, Atizo, 12Designer, Brainrack, Innovation Framework, Jovoto, and Innovation Exchange) had revealed that the mean number of participants crowdsourcing tournaments is 104.

To simulate different crowdsourcing tournaments, we enumerated the possible configurations of the 8 treatment groups at 91 different sizes (ranging from 10 to 100 with an increment of 1), resulting in 728 different configurations. For each configuration, we then enumerated the combination of n (group size) from k (total treatment group) participants that are theoretically possible. As it would be computationally inefficient to include all $n!/k!(n-k)!$ possibilities of each combination, and results can be expected to be asymptotically correct, we randomly selected 50 simulated crowds from each combination. Overall, a total of 36,400 crowdsourcing tournaments were simulated (8*91*50). Note that this approach involves a resampling procedure, which makes it impossible to draw inferences from our simulated crowds to the population of crowdsourcing tournaments (which is not our objective anyway).

However, our approach enables us to make inferences to all potentially possible crowds of varying size that could be generated based on the 1,089 participants of our study.

3.5.2 Measurement

Independent variables. In order to measure the characteristics of the crowd simulated for the permutation we aggregated the individual participants' characteristics (see above) by averaging them.

Dependent variable. We measured the performance of each simulated crowdsourcing tournament as the mean originality of its top ten ideas. We decided for this selection for two reasons. First, there is clear evidence that the majority of ideas generated in crowdsourcing tournaments is of low quality (Leimeister et al., 2009; Poetz & Schreier, 2012; Toubia & Flores, 2007). Second, our exploratory research revealed that a short list of 10 ideas is an intuitive figure for managers seeking for creative ideas. (Note that our findings are robust to variations to the number.)

< Insert Table 3 about here >

4. Findings

4.1. Determinants of idea originality on the individual level

We tested the causal explanators as described in the research framework with OLS regression analyses. Overall, results allow the conclusion that randomness indeed plays a major role in determining the originality of an idea submitted. The total model (Model 1) shows that although we include 22 independent variables and thus basically all causal factors discussed in the literature, 93.6 per cent of the variance of the dependent variable is left unexplained (adj. R^2=.064, $p<.001$). Even if we take measurement error into account this suggests that the invisible guest of randomness has major prominence in our crowdsourcing tournament.

Among the variables discussed in the literature, ten of the variables turned out to be significant predictors as suggested by the literature (four of them only marginal). The sign of the coefficients is in the

expected direction – with one exception: if we announced an incentive for delivering a good idea, this had a negative impact on the originality of the idea submitted (b=-.039, p<.1). A possible explanation are crowding out effects that have been reported in crowdsourcing before (Bayus, 2012; Frey et al., 2011).

The strongest influence has the group of situational variables with an adj. R^2 of .044 (p<.001). Variance explained by the organization of the tournament (Model 2), participants' expertise (Model 3), skills (Model 4), and personality traits (Model 5) is surprisingly low (see Table 4).

< Insert Table 4 about here >

4.2. Determinants of idea originality on the aggregate level

Again we use OLS regressions for analyses. Overall, the aggregation and particularly the inclusion of the crowds' size resulted in a high level of variance explained (Model 1, adj. R^2=.725)[1]. Obviously, crowd size explained by far most variance, 5.32 times as much as the other 22 independent variables collectively (Model 2 and 3). The second strongest effect comes from the incentive – again as a crowding out effect (see Table 5).

< Insert Table 5 about here >

5. Discussion

Our finding is crystal clear: randomness rules in our crowdsourcing tournament. The originality of the contributions is explained only to a very limited degree by the 22 deterministic factors we derived from the general literature on creative problem-solving and the more specific literature on crowdsourcing tournaments and hence had incorporated in our measurement. Our simulation shows that randomness

[1] Additionally, we tested for random effects with a mixed effects model and estimated fixed effects. The random intercept between groups was not significant (Wald Z=1.412, p=.158). The findings on the group level turned out to be robust.

outperforms all deterministic factors collectively by 532 %. It appears that in crowdsourcing tournaments, God indeed plays dices.

5.1. Contributions and avenues for further research

We contribute to the quickly evolving literature that investigates the factors explaining the success of crowdsourcing tournaments (Boudreau et al., 2011; Jeppesen & Lakhani, 2010; Leimeister et al., 2009; Poetz & Schreier, 2012; Terwiesch & Xu, 2008). The factor we add to this line of research is systematically from extant factors as it involves a different weltanschauung, namely a non-deterministic perspective. In a way this resembles the discussion in quantum mechanics in how far the world is deterministic or governed by pure chance (Bell, 2004). Randomness is also systematically different from extant factors from another perspective: its effect size is much greater. The obvious conclusion for managers who consider starting a crowdsourcing tournament for their new product ideation processes is that they are well advised to recruit as many participants as possible. The degree in how far this is achieved is far more important than the exact organization and the composition of the crowd attracted. Certainly, there will be minimum qualifications for participants and also we must not forget that an unprofessional, unattractive, or unfair design of the tournament will inevitably result in recruitment problems. However, the clear focus must be to increase the number of participants. This leads to a number of follow up questions that constitute opportunities for further research. The first question is in how far our findings can be generalized. The task we employed was typical for crowdsourcing tournaments in the area of new product ideation. It does not require specific technical knowledge as in expertise-based crowdsourcing projects such as scientific problem solving tournaments (e.g. Boudreau et al., 2011; Jeppesen & Lakhani, 2010) where randomness might play a less prominent role. It would be tempting to repeat our study design in fields systematically different from the one we studied. Second, the question arises how large numbers of participants can be attracted. As we can expect many more firms to launch crowdsourcing initiatives in the near future (Cook, 2008; Harhoff & Mayrhofer, 2010; O'Hern & Rindfleisch, 2009), this means that there will be fierce competition for participants. The question by

which communicative means and which incentives individuals can be motivated to participate will gain much importance. This research could also analyze how the contradiction can be managed that for organizers the number must be increased – but for potential participants a higher number means a lower chance of winning. Third, and related to this, it would be interesting to investigate saturation effects and the exact relationship between the crowd's size and the monetary value resulting from their ideas. Assuming that attracting more participants involves higher costs and there is a given (yet to be determined) relationship between recruitment effort and the resulting crowdsourcing tournament size, it is possible to calculate the optimal recruitment effort ex ante. Finally, if crowdsourcing tournaments become larger, the question of how to filter out the best ideas effectively becomes more important than ever.

Beyond our contribution to the area of crowdsourcing we also contribute to the more general literature on creativity and the factors determining it. Our findings support the position of advocates of the "equal-odds rule" (Simonton, 1997) who portray creativity as a process of blind variation and selective retention. In our huge sample we found relatively weak evidence that creativity is guided by systematic factors as is purported by their opponents (Kronfeldner, 2010; Schooler & Dougal, 1999).

5.2. Limitations

Our finding and the conclusions we draw from it rests on four assumptions. First, we assume that the experimental setting allowed participants to exploit their full potential for ideation. If this was not the case the low level of variance explained by the 22 factors would not be surprising. We thus had invested much effort to make the study realistic. The only major factor where our setting differs from "real" crowdsourcing tournaments is that we had limited the time for finding and describing an idea to 15 minutes. However, theoretical considerations and prior findings suggested that this is no problematic constraint (Althuizen et al., 2012; Gladwell, 2005; Lakani et al., 2007; Lakhani & von Hippel, 2003; Payne, Bettman, & Johnson, 1988). A pilot study we had conducted confirms this and also the time participants actually used in the experiment (mean 9.73 minutes, s.d. 3.79 minutes) suggests that we had

not violated this first assumption. Second, we assume that our measurement of the independent ("deterministic") variables is free of error. If this is not the case, it may not be that it is not the factors per se that have limited explanatory power, but their numeric representations in the form of our measurement. Particularly latent psychological constructs are vulnerable in this respect (Fornell & Larcker, 1981). We thus took great care for measurement and used established scales whenever this was possible. Reliability and validity analyses provide positive results. However, some measurement error is inevitable and certainly affects our findings, too. Third, we assume that we had incorporated all deterministic factors. Our line of argumentation is that what is not explained by them is randomness. However, it may be that we just missed to incorporate the "true" deterministic variables. For example, we were naturally limited in capturing situation variables such as mood or weather. Despite this, we note that we had invested great effort in collecting variables considered to be the most important by the literature. Fourth, we assume that we measured the dependent variable of idea originality correctly. If this was not the case, again the (almost) non-finding with regard to the deterministic factors would be an artifact. Evaluating idea originality of course is a difficult issue, and perfection is hardly achievable. We proceeded with great care in a way similar to most crowdsourcing tournaments actually conducted, namely by letting the crowd assess the idea (Adamczyk, Bullinger, & Moeslein, 2011; Afuah & Tucci, 2012; Preece, 2001). We followed the procedures as suggested by the literature (Hayes & Krippendorff, 2007; Krippendorff, 2004) and had a minimum of 6 independent raters randomly assigned and blind for the originator of every idea. Analyses showed a relatively high convergence in the ratings. The few controversially evaluated ideas were re-analyzed by experts. When we validated the idea ratings with alternative measures, we found high agreement. In sum it is fair to say that these assumptions constitute the vulnerable point of our article. Despite all effort real conditions will have met them only approximately at best. However, the sheer difference in effect size gives us confidence that our main conclusion, namely that randomness plays an important role in explaining the success crowdsourcing tournaments holds.

Tables

Table 1: Measures

Constructs and items (1=low agreement, 5=high agreement)	SMC	Alpha	AVE	Factor loadings	C.R.	χ^2 diff. test	χ^2 p-values
Domain-specific expertise		.74	.52			>112.59	<0.001
I have had work experience with the development of ideas for apps.	.49			.70	-		
I have had experience with the development of ideas for apps during studies, education.	.59			.77	21.73***		
I have had experience with the development of ideas for apps in my leisure time.	.65			.81	22.37***		
I have already developed apps for non-mobile solutions.	.35			.59	17.22***		
Lead userness: expected benefit		.81	.61			>3.17	<0.075
In terms of apps I have needs that are not covered by existing solutions.	.51			.71	-		
I frequently get annoyed by poor apps.	.73			.86	24.33***		
I think most apps have room for improvement.	.59			.77	22.70***		
Lead userness: trend position		.93	.82			>3.17	<0.075
Usually I discover new apps earlier than others.	.87			.93	-		
I am always up to date with respect to trends in the field of apps.	.85			.92	51.33***		
I have already had benefits from the early usage of new apps.	.75			.86	43.56***		
Creativity		.65	.40			>321.94	<0.001
I like spending time on trying to look "under the surface" of problems.	.55			.74	-		
I am fond of seeing things in a broader context.	.38			.62	11.29***		
I like working on novel problems.	.27			.52	11.02***		
Motivation		.59	.52			>248.34	<0.001
I was really keen to generate a good idea.	.75			.86	-		
I enjoyed participating in the iChallenge.	.28			.53	16.54***		
Analogous domain expertise							
I have applied expertise from similar or related domains as I developed my idea (e.g. internet, social networks etc.).							
Ideation task experience							
I regularly download apps to my mobile phone.							
Skills and outsiderness							
My background (by profession, qualification and leisure) is business.							
My background (by profession, qualification and leisure) is technical.							
My background (by profession, qualification and leisure) is creative.							
My background (by profession, qualification and leisure) is scientific.							
My background (by profession, qualification and leisure) is humanistic.							
My background (by profession, qualification and leisure) is legal.							
My background (by profession, qualification and leisure) is craftsman-like.							
My background (by profession, qualification and leisure) is socio-cultural.							
My background (by profession, qualification and leisure) is athletic.							
My background (by profession, qualification and leisure) is entertainment-oriented.							
Information hub and boundary spanning							
I am the hub in the social groups I belong to (information hub).							
I am the connection link between social groups that would be apart otherwise (boundary spanner).							
External support							
I received valuable support from others when developing my idea.							
Originality of ideas; dependent variable							
How new, uncommon or unusual is this idea?							

n=1,089; global fit indices: CMIN = 199.502; df= 81; CMIN /df= 2.463; GFI= .976; AGFI= .965; IFI= .983; CFI= .983; RMSEA= .037

SMC = squared multiple correlations; Alpha = Cronbach's alpha; AVE = Average variance explained; C.R. = critical ration; *** = $p < 0.01$

Table 2: Summary statistics of key measures on individual level

	Variables	Mean	S.D	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
1	Incentives (yes)	48 4 %	50	-																					
2	Interaction (yes)	57 1 %	50	01	-																				
3	Task framing (narrow)	50 4%	50	- 01	03	-																			
4	Domain-specific expertise [a]	1 49	82	03	- 03	-	-																		
5	Analogous domain expertise [a]	2 86	82	02	03	04	20***	-																	
6	Ideation task experience (yes)	48 9 %	50	04	- 01	- 01	04	04	-																
7	Lead userness [a]	2 52	1 11	01	01	01	49**	22**	- 01	-															
8	Business skills [a]	3 67	1 30	- 01	02	-	- 10***	08**	04	- 07*	-														
9	Technical skills [a]	3 16	1 41	- 01	-	03	42***	12***	- 01	39***	- 16***	-													
10	Creative skills [a]	3 17	1 21	01	05	-	16***	13***	05	13***	- 14***	08**	-												
11	Competence profile [c]	45	14	01	- 02	- 04	- 19***	- 13***	- 02	- 21***	- 15***	- 44***	- 41***	-											
12	Education level	32 9 %	47	- 06*	03	01	13***	07*	01	01	- 01	09**	,062*	- 05	-										
13	Creativity [a]	4 14	65	- 04	-	01	13***	11**	03	16**	07*	16**	12***	- 14***	08**	-									
14	Information hub [a]	3 29	99	- 07*	-	02	08**	05	- 05	12***	19***	- 01	06*	- 11***	01	13***	-								
15	Boundary spanner [a]	3 75	1 03	- 01	-	02	1***	15***	03	16***	14***	07*	13***	- 19***	03	23***	10**	-							
16	Outsiderness [b]	14	03	-	- 02	- 02	- 09*	- 12***	01	- 08*	- 36***	- 13***	- 28***	53***	05	- 10**	- 14***	- 18***	-						
17	Age (years)	25 68	7 05	01	09**	-	01	02	- 01	- 06	- 04	03	- 03	03	36***	08**	- 04	02	09**	-					
18	Gender (male)	69 %	46	- 05	- 06	- 01	- 23***	- 15***	03	- 34***	06	- 41***	08**	13***	01	- 11**	01	- 01	01	- 03	-				
19	External support [a]	1 53	1	04	01	- 02	17**	11**	04	11**	-	06	06	- 06*	-	- 01	03	04	- 06	- 01	-	-			
20	Motivation [a]	4 125	79	- 02	07*	- 06	03	09**	04	13***	11***	- 01	17***	- 11***	- 08**	19***	14***	11***	- 14***	- 07*	02	02	-		
21	Time spent (seconds)	583 93	227 50	06	19***	- 01	- 08*	02	- 02	- 06*	-	- 05	1**	- 01	- 01	02	02	05	- 07*	- 05	- 04	- 04	20***	-	
22	Timing of tournament	40	49	01	-,214***	-	08**	- 08**	04	05	- 16***	05	- 02	05	- 05	- 08**	- 01	03	09**	- 05	- 06	06	- 03	- 08**	-

[a] 5-point index from 1="low" to 5="high"; two-tailed test of significance, * = p< 05, **
[b] cosine similarity vector from -1= dissimilarity, 0=independent, 1=similarity
[C] Herfindahl Hirschman index from 0=generalist, 1=specialist

Table 3: Summary statistics of key measures on tournament level

	Variables	Mean	S.D.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.
1	Crowd size	55	26 27	1																						
2	Incentives (yes)	50 %	50	-	1																					
3	Interaction (yes)	50 %	50	-	-	1																				
4	Task framing (narrow)	50 %	50	-	-	-	1																			
5	Domain-specific expertise [a]	1 49	12	01*	16***	- 16***	- 03***	1																		
6	Analogous domain expertise [a]	2 85	29	,001	08***	19***	25***	25***	1																	
7	Ideation task experience (yes)	49 %	08	01	26***	- 08***	- 02***	- 08***	- 07***	1																
8	Lead userness [a]	2 52	17	01	01*	05***	- 01*	55***	31***	- 06***	1															
9	Business skills [a]	3 66	19	-	- 06***	14***	-	- 09***	22***	-	- 06***	1														
10	Technical skills [a]	3 16	21	-	10***	37***	- 04***	06***	12***	05***	10***	- 10***	1													
11	Creative skills [a]	3 16	18	01	- 07***	-	14***	45***	30***	- 14***	49***	- 08***	02***	1												
12	Competence profile [c]	45	02	-	04***	- 12***	- 27***	- 06***	- 07***	- 05***	- 11***	- 11***	- 39***	- 32***	1											
13	Education level	32	07	- 01	- 40***	17***	04***	06***	-	- 05***	08***	- 05***	09***	12***	- 09***	1										
14	Creativity [a]	4 14	11	-	- 23***	- 01	,000	04***	-	- 20***	18***	- 06***	09***	22***	- 11***	18***	1									
15	Information hub [a]	3 29	11	- 01	- 45***	03***	13***	02***	07***	- 15***	12***	18***	,000	07***	- 13***	22***	17***	1								
16	Boundary spanner [a]	3 75	16	-	- 09***	- 03***	05***	07***	- 05***	- 01	17***	- 04***	11***	05***	- 20***	16***	34***	12***	1							
17	Outsiderness [b]	14	01	- 01	- 04***	- 12***	- 16***	02***	- 29***	12***	-	-42**	- 24***	- 16***	42***	19***	- 03***	- 09***	04***	1						
18	Age (years)	25 54	1 14	- 01*	05***	53***	- 07***	- 03***	15***	- 07***	04***	02***	19***	09***	- 01	34***	10***	- 02***	-	02***	1					
19	Gender (female)	31	07	- 01	- 30***	35***	- 04***	- 23***	- 18***	- 02***	- 34***	05***	- 09***	- 32***	15***	03***	- 08***	12***	- 03***	01	- 21***	1				
20	External support [a]	1 53	15	-	28***	10***	- 11***	22***	20***	08***	14***	07***	11***	08***	,000	- 13***	- 12***	- 11***	- 09***	- 13***	07***	- 11***	1			
21	Motivation [a]	4 11	15	-	- 15**+	39***	- 35***	05***	08***	- 12**	26***	11***	22***	09***	01*	09***	25***	11***	13***	- 03***	19***	- 14***	08***	1		
22	Time spent (seconds)	580 51	55 46	-	23***	76***	- 03***	- 15***	11***	- 01*	- 02*	10***	34***	- 09***	- 10***	- 10	- 05***	- 10***	- 01	- 14***	34***	- 37***	11***	39***	1	
23	Timing of tournament	41	,13	-	03***	- 08***	01*	26***	- 08***	03***	10***	- 17***	- 32***	13***	17***	- 16***	-	- 03***	05***	12***	- 43***	22***	- 01***	- 22***	- 63***	1

[a] 5-point index from 1="low" to 5="high" two-
[b] cosine similarity vector from -1= dissimilarity,
[C] Herfindahl Hirschman index from 0=generalist,

Table 4: Individual level analysis

	DV=originality of submitted idea					
	Model 1: All variables	**Model 2: Organization**	**Model 3: Participants' expertise**	**Model 4: Participants' skills**	**Model 5: Participants' traits & roles**	**Model 6: Situation**
Organization						
Incentives	-.039†	-.033				
Interaction	.053*	.117***				
Task framing	.000	-.008				
Participants' expertise						
Domain-specific expertise	.048†		.070*			
Analogous domain expertise	-.024		.014			
Ideation task experience	.007		.003			
Lead userness	-.030		-.010			
Participants' skills						
Business skills	-.042			-.028		
Technical skills	.025			.052†		
Creative skills	.041			.067*		
Competence profile	-.012			.009		
Education level	.069*			.095**		
Participants' traits and roles						
Creativity	.039				.072*	
Information hub	-.037				-.033	
Boundary spanner	.033				.031	
Outsiderness	.053†				.019	
Age	.038				.066*	
Gender	-.049†				-.051*	
Situation						
External support	.063*					.066*
Motivation	.057*					.048†
Time spent	.121***					.129***
Timing of the tournament	-.141***					-.141***
Adj. R^2	**.064*** **	**.012*** **	**.001**	**.015*** **	**.011** **	**.044*** **
R^2	.083***	.015***	.005	.020***	.017**	.047***
F	4.367	5.353	1.249	4.316	3.033	13.453
N	1,089	1,089	1,089	1,089	1,089	1,089

† = p < 0.1, * = p < 0.05, ** = p < 0.01, *** = p < 0.001 (one-sided)
Standardized coefficients are shown.

Table 5: Tournament level analysis

	DV= mean originality of the top ten ideas		
	Model 1: All variables	**Model 2: All deterministic factors**	**Model 3: Crowd size**
Crowd size	.782		.782
Organization			
Incentives	-.214	-.218	
Interaction	.091	.102	
Task framing	.012	.014	
Crowds' expertise			
Domain-specific expertise	.019	.025	
Analogous domain expertise	.042	.038	
Ideation task experience	-.029	-.018	
Lead userness	.005	.004	
Crowds' skills			
Business skills	-.012	-.017	
Technical skills	.089	.093	
Creative skills	.006	.004	
Competence profile	.081	.088	
Education level	.017	.015	
Crowds' traits and roles			
Creativity	.036	.038	
Information hub	-.015	-.020	
Boundary spanner	.008	.007	
Outsiderness	-.035	-.048	
Age	.037	.024	
Gender	.017	.008	
Situation			
External support	.012	.013	
Motivation	.085	.092	
Time spent	.003	-.012	
Timing of the tournament	-.016	-.022	
Adj.. R^2	**.725**	**.115**	**.612**
R^2	.725	.115	.612
F	4180.553	215,168	57448.48
N	36,400	36,400	36,400

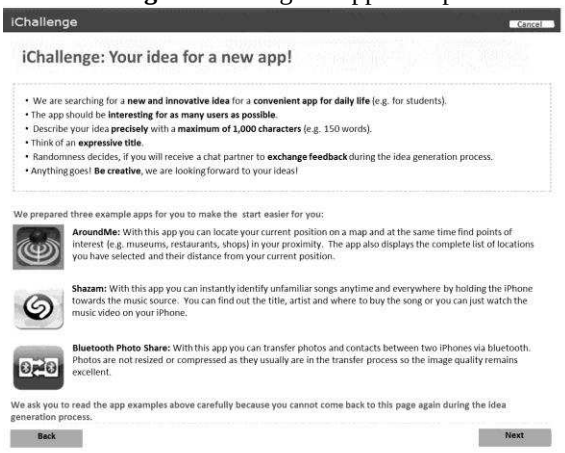
Standardized coefficients are shown.

Note that we do not indicate significance levels (due to the permutation design with an artificial sample size of 36,400 all coefficients are significant).

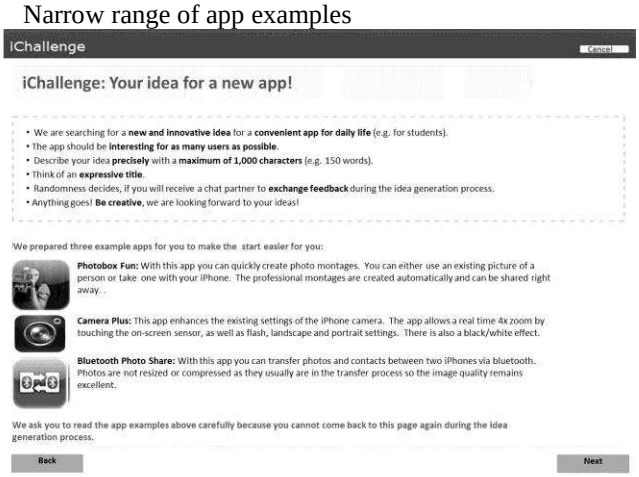
Figures

Figure 1: Experimental stimuli

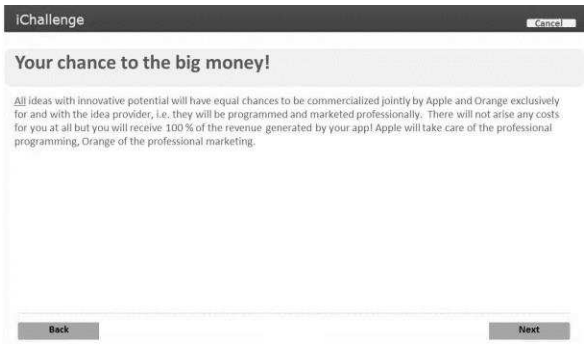
Task framing: Broad range of app examples



Narrow range of app examples

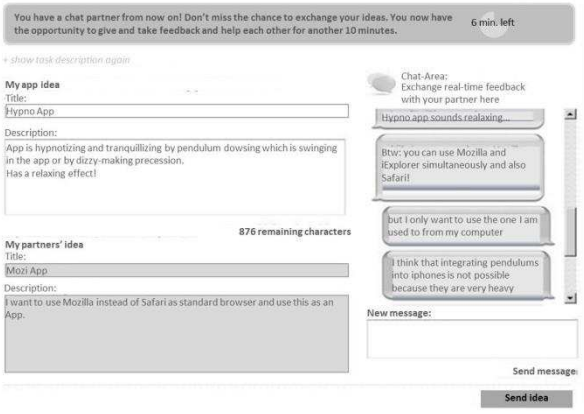


Incentive: Incentive announced



None

Interaction: Interaction



None

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