Worker’s Cognitive Abilities and Personality Traits as Predictors of Effective Task Performance in Crowdsourcing Tasks

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Abstract
The increased popularity of crowdsourcing platforms raises today interesting questions with respect to the better definition, initiation, management and quality of work of crowdsourced tasks. Factors that influence the quality of work in crowdsourced tasks is in particular important as low quality has been reported as a major drawback of this new kind of labor. In this paper we investigate the impact of different cognitive and non-cognitive worker skills on the quality of work they provide in such environments. We conducted an experiment on a popular crowdsourcing site and the obtained results providing evidence that the performance of workers in such environments depends on three basic components namely work effort, character skills and cognitive skills as well as on the GDP per capita of the country of origin.

Index Terms: Crowdsourcing, online labor, quality of work, cognitive abilities, personality traits, workers

1. Introduction
The emergence of the Web 2.0 paradigm has -among others- transformed the way labor is nowadays demanded and supplied. In such context, crowdsourcing is one prominent example: it refers to a wide range of web-based activities characterized by the contribution from the crowd (Marsden 2009). More specific crowdsourcing, as a term, is a strategic model to attract an interested, motivated crowd of individuals capable of providing solutions superior in quality and quantity to those that even traditional forms of business can (Brabham, 2008a).

In traditional economic theory quality of work is motivated by reward (i.e. the item which constitutes the most immediate return to express the set of advantages and disadvantages related to transaction costs) (Berardi et al. 2014) or employees’ self-determination (Gagne & Deci, 2005). In crowdsourcing environments however, it is still unclear which are the exact factors and to what degree they affect the quality of work submitted by workers.

In this paper we report on the factors that influence the quality of work in crowdsourcing environments. Towards this we conducted an experiment on the well-known crowdsourcing website microworkers.com requesting from workers to complete a task. The task was preceded by a demographic survey in which workers were asked to report on their gender, age, country of origin, computer & English language skills as well as their education level. Workers were also asked to fill in a questionnaire related to the Big Five Personality Test (John et al. 1999). In addition, we take into consideration the impact of GDP per capita for the year 2015 as published by Knoema (Knoema, 2016). We construct an econometric model aiming at explaining and predicting the quality of work based on skill group factors. Using the model and analyzing the results, it is shown that there is a strong correlation between the quality of work and specific skill groups.

2. Related Work
With crowdsourcing gaining momentum and becoming mainstream, collective behavior on social media platforms has attracted increasing attention from both academia and industry (Cheung and Lee, 2010 and Turel and Zhang, 2011), while at the same time research efforts focus on developing comprehensive frameworks for managing the accuracy and the quality of the submitted crowdsourcing work (Wang et al. 2013).

In this regard, it may be more appropriate to examine if the quality of results is directly influenced by crowd behavior and their characteristics. In the literature, work quality has been related to crowd demographics (Ross et al. 2010; Sheng et al. 2008), contributors’ gender, profession and age (Downs et al. 2010) and workers’ personality traits (Kazai et al. 2011). In general, the literature lacks studies that examine the quality of results under a combination of workers’ cognitive and non-cognitive skills and effort. This paper adds to the growing body of research, which seeks to investigate the predictive power of workers’ behavior (effort) and skills (cognitive, non-cognitive) on expected quality of results (Kautz et al. 2014).

Although non-cognitive skills are overlooked in most contemporary policy discussions and in economic models of choice behavior, personality psychologists have studied these skills for the past century. Psychologists primarily measure non-cognitive skills by using self-reported surveys or observer reports (Cunha et al. 2010). They have arrived at a relatively well-accepted taxonomy of non-cognitive skills called the Big Five Personality Test, which stands for: Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (Linden et al. 2010). This type of test had the form of 44-likert scaled personality questions that measures an individual on the Big Five Factors of personality (Goldberg et al. 1993).

3. Experiment setup and methodology
The goal of the experiment was to investigate the impact of a group of variables on the quality of the work submitted by workers which include: the country of origin of the workers, their cognitive and non-cognitive skills as well as their effort put into completing the task. The experiment was conducted
on the crowdsourcing website microworkers.com. Workers were asked to listen to an unknown music sample containing lyrics with a total of 56 English words and submit as many of the correctly identified lyrics as possible. The experiment was conducted in two different settings: in the first setting the experiment was performed in the form of an open call soliciting submissions from all workers (called “open call” setting) while in the second setting workers from countries with a low GDP per capita were excluded (called the “excluded” setting). Moreover, each worker that accepted the task were asked to complete a demographic survey which asked them about their age, country of origin, computer & English language literacy skills as well as their education level. In addition, workers were asked to respond to a questionnaire based on Big Five Personality Test. A worker could participate in only one setup of the experiment. We received 50 responses in each experiment, with a cost of $41.06 per experiment setting. In order to gather the appropriate data for our research we needed to consider the basic components of crowdsourcing, each of which plays an integral part in the success of our approach (Keating et al. 2013)(Fig.1). Having already established the goal of our research and having defined the specific audience segments, we had to identify the suitable crowdsourcing platform in which our experiment would take place. We needed a platform that would have workers familiar with microjobs (as the type of our task was) and would provide us with a friendly and effective framework for our experiment (i.e. mechanisms that would allow us to control from which countries the workers would be) (Gardlo et al. 2012). Hence, taking in consideration the above mentioned aspects, we choose the well-known platform microworkers.com (Hirth et al. 2011).

Thus, a microworkers campaign was launched, through which crowdsourcing workers could access a soundcloud link with the music sample and perform the experiment under a 0.75S compensation.

4. Data Analysis

4.1 Overview

As a measure of the quality of submissions, we considered the percentage of correctly identified words in the music sample calculated as the ratio of the number of words correctly identified by the worker divided by total number of words in music sample, henceforth referred to as quality of results. For our analysis we solicited fifty answers in each experiment. The study ran for several hours with the same overall cost in each case. More specifically, in the case of the “open call” setting the workers needed about twenty (20) hours to complete the total number of fifty answers while in the “excluded setting”, the total task’s completion time was about ten (10) hours.

In the first experiment setting the average percentage of correctly identified word was about 45 % (Y1) while in the second setting the corresponding percentage was about 65 % (Y2)(Table 1 & Table 2).

4.2 Demographics

As mentioned before a total of 50 participants in each setting of the experiment was ought to answer to several demographics questions.

- **Age.** The age distribution in each setting of the experiment is shown in the following tables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (exp1)</td>
<td>50</td>
<td>25</td>
<td>6.4</td>
<td>18</td>
<td>49</td>
</tr>
<tr>
<td>Age (exp2)</td>
<td>50</td>
<td>29.9</td>
<td>4.5</td>
<td>20</td>
<td>59</td>
</tr>
</tbody>
</table>

Table 3 Age of each setting of the experiment

- **Gender.** The gender distribution in each setting of the experiment is shown in the following tables.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Freq.</th>
<th>Percent</th>
<th>Cumul.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>30</td>
<td>60.00</td>
<td>60.00</td>
</tr>
<tr>
<td>Female</td>
<td>20</td>
<td>40.00</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Table 4 Gender of the participants in each setting of the experiment

- **Country of origin.** The workers’ continent in each setting of the experiment is also shown in the following figures.

In both experiment settings, workers from South American countries did not submit any work.

4.3 Descriptive Statistics

Regarding the experiment conducted on the crowdsourcing site microworkers.com we had some noteworthy descriptive information in the three groups of skills (cognitive skills, non-cognitive skills, work effort).

4.1.1. Cognitive Skills

For this kind of skills the following information was collected for both experiments.
While differences were observed related to the level of education in all settings, the computer and the English literacy levels were rather close (computer literacy levels mean 3.20 vs. 3.54 and English literacy levels mean 3.28 vs. 3.36).

### 4.1.2. Non Cognitive Skills
This group of skills contains the Big Five Personality Test (Goldberg et al. 1992).

For our crowdsourcing experiments, we examined the workers under the following variables (John et al. 1999):

- (I) Extraversion (talkative, assertive, energetic)
- (II) Agreeableness (good-natured, cooperative, trustful)
- (III) Conscientiousness (orderly, responsible, dependable)
- (IV) Emotional Stability versus Neuroticism (calm, not neurotic, not easily upset)
- (V) Openness to Experience (inventive, consistent, creativity)

Figure 3 shows the distribution of responses to the Big Five Personality questionnaire. For Openness we observe a mean score of 34.02 (std. dev. 5.45) in the first experiment and a mean score of 35.76 (std. dev. 5.21) in the second one, suggesting a tendency toward creativity and active imagination. The mean score of Conscientiousness is lower with 30.30 (std. dev. 5.50) in the first scenario and 32.74 (std. dev. 5.20) in the second one, suggesting that we must expecting a more thorough job from workers in the second experiment than in the first. Extraversion has a mean 21.44 (std. dev. 5.85) (experiment 1) and 23.52 (std. dev. 5.20) (experiment 2) exhibiting no particular disposition on this trait. Moreover, we observe again a moderate score for agreeableness (experiment 1: mean 31.60 std. dev. 4.95 vs. experiment 2: mean 29.82 std. dev. 8.28), which is not allow for us this trait to extract conclusions. Finally, we find a low mean score for Neuroticism (it is the opposite of emotion stability) in both experiments (experiment 1: mean 23.10 std. dev. 5.35 vs. experiment 2: mean 22.90 std. dev. 5.59), which suggests a possible relaxed nature of the workers.

### 5. Experiment Results

#### 5.1 Initial Results

The analysis indicates that the best results in terms of quality were achieved on the second experiment (65 % success rate on average) whose users were coming from countries with middle to high GDP per capita. In addition, in both cases of the experiment the workers’ quality of results is strongly correlated with at least one variable of each skill group (cognitive and non-cognitive skills, work effort). It is also noteworthy to point out that the workers’ quality of results coming from countries with middle to high GDP per capita in both experiments were comparable ($\beta_1=0.55, \beta_2=0.65$).

#### 5.1.1. Open call experiment setting

In general, in this setting of the experiment, the quality of results was not satisfactory with average quality ($\bar{y}$) near to 0.45 (tabl.8).

#### 5.1.2. Excluded experiment setting

In the second setup, we excluded workers from countries with low GDP per capita from participating in our experiment based on research that indicated that workers from these countries (specially countries from Asia) are low- trained to crowdsourcing and provide low quality of services (Khanna et al. 2010) due to several factors related to their way of life (Gupta et al. 2014).

The quality of results was satisfactory and in general better in comparison to the results received from workers in the “open call” setting of the experiment ($\bar{y}$ near equal to 0.65). More detailed results are presented on the following table (tabl.9).
5.2 Empirical Model
Towards investigating the impact of the observed variables to the quality of results of workers in crowdsourcing environments, we derived an OLS linear regression model which aims at predicting the quality of work based on the skill groups as well as environmental control variables. Following Heckman and Kautz (2012), we include a variety of “skills” and “environmental” controls for observed performance of crowdsourcing workers. The econometric specification is of the following general form:

\[ Q_i = \alpha + \beta D_i + \gamma C_i + \delta N_i + \epsilon W_i + \epsilon C_i + \epsilon_e \]  

(1)

where \( Q_i \) is the aforementioned quality of results attainment indicator of the \( i \)th worker, \( D_i \) is a vector of demographics outcomes, \( C_i \) is a vector of cognitive skills outcomes, \( N_i \) is a vector of non-cognitive skills outcomes, \( W_i \) is a vector which includes the work effort variables and lastly \( C_i \) is capturing the country specific fixed effect (log GDP per capita of \( i \)th worker’s country of origin).

5.3 Multivariate Regression Analysis
In our prediction model we used the following variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of results (y)</td>
<td>quality of workers’ results</td>
</tr>
<tr>
<td>age</td>
<td>the number of years that someone has lived divided into four categories age&gt;25 &amp; age&lt;=33, age&gt;33 &amp; age&lt;=45, age&gt;45 &amp; age&lt;=55, age&gt;55</td>
</tr>
<tr>
<td>female</td>
<td>gender type</td>
</tr>
<tr>
<td>loggdp</td>
<td>the natural logarithm of GDP per capita (current US$)</td>
</tr>
<tr>
<td>educlev</td>
<td>workers with at least tertiary education</td>
</tr>
<tr>
<td>comlev</td>
<td>levels of workers’ computer competency divided into three categories poor/very poor, average, very good</td>
</tr>
<tr>
<td>anglev</td>
<td>levels of workers’ English language competency divided into three categories poor/very poor, average, very good</td>
</tr>
<tr>
<td>extr</td>
<td>extraversion</td>
</tr>
<tr>
<td>agree</td>
<td>agreeableness</td>
</tr>
<tr>
<td>consc</td>
<td>conscientiousness</td>
</tr>
<tr>
<td>emostab</td>
<td>emotion stability</td>
</tr>
<tr>
<td>opens</td>
<td>openness</td>
</tr>
<tr>
<td>time</td>
<td>task’s completion time [minutes]</td>
</tr>
<tr>
<td>numberOfTasks</td>
<td>number of task repetitions before the final submission (under 3 repetitions excluded/cheating indication)</td>
</tr>
</tbody>
</table>

Table 10 Variables used in the OLS prediction model

If we apply model (1) to our data set, we obtain the following OLS linear regression model:

\[
\begin{align*}
\text{OLS Regression} & \quad \text{Open Call} \quad \text{Setting} \\
\text{Age} & \quad 0.036^{*} \quad 0.084 \\
\text{Age} & \quad 0.023^{*} \quad 0.048 \\
\text{Gender} & \quad 0.013^{*} \quad 0.021 \\
\text{Conscientiousness} & \quad 0.012^{*} \quad 0.014 \\
\text{Emotional Stability} & \quad 0.014^{*} \quad 0.017 \\
\text{Time} & \quad 0.036^{*} \quad 0.041 \\
\text{NumberOfTasks} & \quad 0.012^{*} \quad 0.016 \\
\text{Linguistics} & \quad 0.014^{*} \quad 0.018 \\
\end{align*}
\]

Table 11 OLS estimation in each setup of the experiment

6. Discussion
At the outset, we firstly notice, that the effect of computer level is statistically significant across the quality of results among the two setups of the experiment (for high computer literacy levels of workers the results have shown strong correlations at the 1% level of significance and the right hand variable is positively relate to the left hand variable, while for medium computer literacy levels are statistically significant at 5% level of significance and the right hand variable is also positively relate to the left hand variable). It is noteworthy, that the effect of a workers competency in English is detectable only in the “excluded” setup of the experiment. In this context only high levels of English language competency are statistically significant at 10% level of significance (\( r = 0.042, p=0.098 \)). Similarly, education level is a strong predictor only in the “open call” setup of the experiment (\( r = 0.206, p=0.000 \)), meaning that workers with at least tertiary education provided 20% better results than those with non-tertiary education.

Regarding the effect of a worker’s age, we observe that the effect is weak and totally different among the two setups of the experiment. More specifically, in the “open call” setup, the workers in every age category provided worse results regarding the reference age variable (workers aged up to 23 years; while in the “excluded” setup workers aged up to 23 years provided better results.

Among the personality traits, we find that extraversion has a remarkable effect in quality of results, regardless the setup of the experiment (open call: \( r=0.064 \) & \( p \text{value}=0.048 \), excluded: \( r=0.064 \) & \( p \text{value}=0.078 \)) and is positive correlated with the quality of results of workers. For example workers with high levels of extraversion provided 6.4% better results in the “open call” setup and 7.8% better results in “excluded” setup of the experiment. Equally important is that, one more variable of non-cognitive skills group of variables, emotion stability, is strongly correlated (at the 1% level of significance) to the quality of the work submitted (emotion stability: \( r = 0.128 \) & \( p \text{value}=0.001 \)). However, this correlation is evident only when workers from countries with a low GDP per capita are excluded from the “open call” setting of the experiment. Furthermore, there is also a strong correlation between the quality of results and the task’s completion time (at the 1% level of significance) and the right hand variable is positively related to the left hand variable in both setting of the experiment (open call: \( r=0.036 \) & \( p \text{value}=0.001 \) and excluded: \( r=0.037 \) & \( p \text{value}=0.007 \)), meaning that a worker’s work effort is a strong predictor of task performance.

Finally our data analysis reveals a noticeable correlation (at the 5% level of significance) between the quality of results and the GDP per capita of worker’s country of origin, with the right hand variable being positively related to the left hand variable. This may suggest that a country’s economic performance may be considered a useful indicator for assessing a worker’s task performance.

7. Conclusions
Skills are emerging as a critical factor in achieving high quality of work in crowdsourcing tasks. Measuring and assessing these skills is also a crucial aspect, which has received attention (Stasz 2001). In this paper, a first attempt is presented to understand the role of cognitive and non-cognitive skills as well as work effort and their interaction on task performance.

The obtained results indicate that although in general the workers’ quality of results is correlated with their skill levels, different skills sets contribute to the quality of work in crowdsourcing tasks with GDP per capita being the regulating factor. This may be the aftereffect of the difference in socioeconomic status, among crowdsourcing workers, meaning the social and physical environment in which an individual lives and works and culture he is exposed to (including the beliefs, values, behavior and material objects that constitute a person’s way of life)(Sackman, 2011).
8. References