Nature Conservation 18: 61–78 (2017)
doi: 10.3897/natureconservation.18.13429
http://natureconservation.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
Nature Conservation
Launched to accelerate biodiversity conservation

The influence of motivational factors on the frequency of participation in citizen science activities

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Academic editor: *S. Bell* | Received 26 April 2017 | Accepted 5 July 2017 | Published 21 July 2017

http://zoobank.org/0068DE7B-C2E5-444D-9CD3-CBA6744A1218

Citation: Tiago P, Gouveia MJ, Capinha C, Santos-Reis M, Pereira HM (2017) The influence of motivational factors on the frequency of participation in citizen science activities. Nature Conservation 18: 61–78. https://doi.org/10.3897/natureconservation.18.13429

Abstract

Citizen science has become a mainstream approach to collect information and data on many different scientific subjects. In this study, we assess the effectiveness of engagement and meaningful experience of participants in citizen science projects. We use motivational measures calculated from a web survey where respondents answered questions regarding to their motivation to participate in BioDiversity4All, a Portuguese citizen science project. We adapted the intrinsic motivation inventory (IMI) and considered seven categories of measurement: Interest/Enjoyment, Perceived Competence, Effort/Importance, Perceived Choice, Value/Usefulness, Project Relatedness, and Group Relatedness each of them with statements rated on a seven-point Likert scale. We received 149 survey responses, corresponding to 10.3 % of BioDiversity-4All Newsletter's receivers. We analyzed for possible differences among the categories pertaining to gender, age, level of education and level of participation in the project. Finally, we assessed the different patterns of motivation existing among the users. No statistical differences were found between genders, age classes and levels of education for the averages in any category of analysis. However, IMI categories presented different results for respondents with different levels of participation. The highest value of Interest/Enjoy-

ment and Perceived Competence was obtained by the group of respondents that participate a lot and the lowest by the ones that never participated. Project Relatedness had the highest value for all groups except for the group that never participated. This group had completely different motivations from the other groups, showing the lowest levels in categories such as Perceived Competence, Value/Usefulness, Project Relatedness and Group Relatedness. In conclusion, the results from our work show that working deeply on people's involvement is fundamental to increase and maintain their participation on citizen science projects. If, for initial recruitment and in countries with low participation culture, mechanisms of external motivation may be necessary, to guarantee higher levels of long term participation, citizen science projects should foster intrinsic motivations which can be done by incorporating in project design experiences of relatedness, capacity building, positive feedback and adapted participation modes.

Keywords
Citizen Science, Self Determination Theory, Intrinsic Motivation

Introduction

Citizen Science can be defined as the general public involvement in scientific research activities and has recently become a mainstream approach to collect information and data on many different scientific subjects (Miller-Rushing et al. 2012). The huge number of data collectors engaged in citizen science allows scientists to tackle questions that were previously out of their reach (Silvertown et al. 2011). With traditional scientific methods, the cost of such data collection would become a limitation due to budget and time constraints. Therefore, an increasing number of researchers have started to work with citizens, realizing that those directly involved in research activities exhibit a rapid increase in scientific literacy (Bonney et al. 2009; Lowman et al. 2008; Silvertown 2009). As such, citizen science has been recognized not only as an instrument for a given research experiment, but also as an education and outreach tool for researchers.

The level of participation in citizen science studies is however remarkably different between regions and countries (Dierkes and von Grote, 2000; Forte and Lampe 2013). For citizen science projects to become successful, it is therefore essential to understand the motivations behind the different levels of participation of citizens. These motivations may be different, depending on the local historical and cultural background and among different societal groups.

Some studies aimed to identify the main motivations for people to participate in citizen science projects and have identified several reasons. The desire to learn more about scientific issues behind the project, the feeling that they are helping the environment and the enjoyment of developing activities in nature were recognize as important motivations to participate (Bell et al. 2008; Van den Berg et al. 2009; Raddick et al. 2010, Rotman et al. 2012). It was also described that getting to know other people with similar interests, making new friends, having the feeling that they are an active participant and co-owner of the project and gain recognition for their input and achievements were also reasons that encourage people to participate in citizen science projects (Bell et al. 2008; Van den Berg et al. 2009; Raddick et al. 2010, Rotman et al. 2012).

In this study, we aim to analyze differences in motivations concerning gender, age, level of education and level of participation in one of the largest and longest running citizen science project in Portugal, the biodiversity web portal Biodiversity4all (www.biodiversity4all.org). The BioDiversity4All is a nationwide project that aims to increase citizens' biodiversity knowledge. Currently BioDiversity4All has nearly 2500 registered users, a network of 50 partners representing different citizen groups and other stakeholders and a validation panel already encompassing 49 taxonomic experts. The project has currently over 400000 observations of 7000 species, and includes nearly 98000 pictures associated to sightings. Users can add to the database either point species observations (sightings) or polygon areas for species occurrence which are later validated by taxonomic specialists (invited scientists or non-academic experts) and through this validation process, users progressively learn to identify and recognize local and national biodiversity.

In order to understand the level of intrinsic motivation of Portuguese participants in this citizen science project, we tested the self-determination theory (SDT). SDT is grounded in the assumption that people have basic psychological needs to feel competent, autonomous and have a sense of belonging or relatedness to others (Ryan and Deci 2008). Autonomy involves feelings of willingness and choice in regards to activities undertaken; relatedness refers to feelings of closeness to other people; and competence involves feeling able to master challenges and having effective interactions with the environment (Katz and Assor 2007) (Figure 1). SDT predicts that, as a result of developmental experiences that engender competence, autonomy, and relatedness, individuals will advance towards more autonomous motivational orientations (in other words, the amount of self-determined motivation increases) (Katartzi and Vlachopoulos 2011). The most self-determined form of motivation is intrinsic motivation, representing the motivation to engage in an activity purely for the sake of the activity itself and because it is inherently pleasurable (Deci and Ryan 1985; Lepper et al. 1973). Intrinsic Motivation Inventory (IMI) is a multidimensional measurement instrument intended to assess participants' intrinsic motivations related to a target activity's subjective experience. It has been used in several experiments related to intrinsic motivation and self-regulation (e.g. Ryan 1982; Ryan et al. 1983; Plant and Ryan 1985; Ryan et al. 1990; Ryan et al. 1991; Deci et al. 1994). It assesses participants' Interest/Enjoyment, Perceived Choice, Perceived Competence, Pressure/Tension, Effort, Value/Usefulness and Relatedness. The category Interest/Enjoyment is the most direct measure (self-report) of intrinsic motivation. This category assesses the interest and inherent pleasure when doing a specific activity. Perceived Choice and Perceived Competence are theorized as positive predictors of intrinsic motivation and are related to the SDT innate psychological needs of autonomy and competence. Perceived Choice evaluates how individuals feel they engage in one activity because they choose to do it, and Perceived Competence measures how effective individuals feel when they are performing a task. Pressure/Tension, conceived as a negative predictor of intrinsic motivation, evaluates if participants feel pressure to succeed in an activity. Effort is a separate variable, which is important when taking into account motivation in specific issues and contexts. It assesses the person's

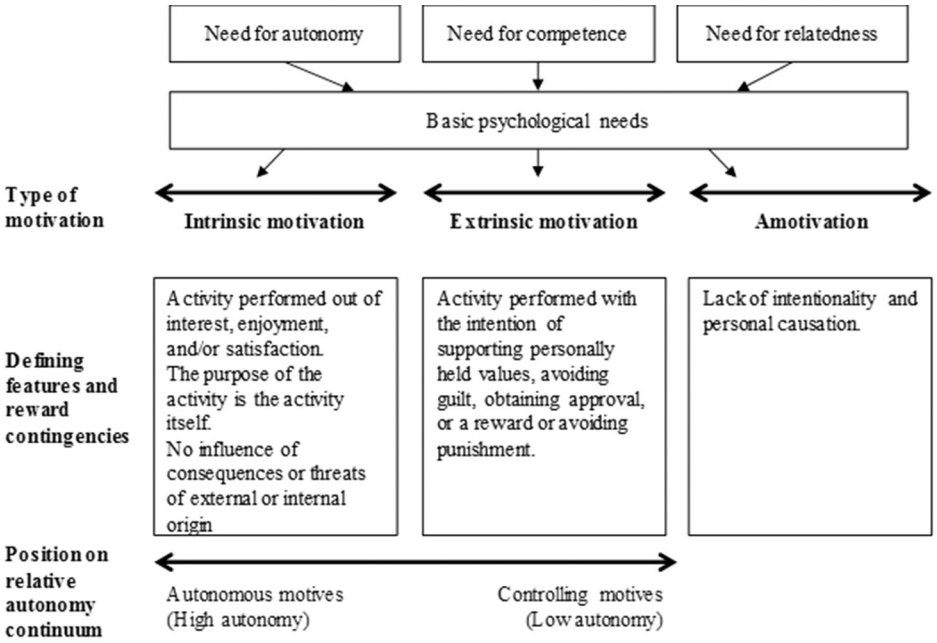

Figure 1. Self-determination theory, illustrating basic psychological needs, defining features of the types of motivation and position in the relative autonomy continuum (adapted from Ryan and Deci, 2007).

investment of his/her capacities in what he/she is doing. The Value/Usefulness category embodies the idea that people internalize and develop more self-regulatory activities when experience is considered as valuable and useful for them. Finally, Relatedness refers to the degree of a person's feelings connected to others and is used in studies where interpersonal interactions are relevant (Monteiro et al. 2015). The IMI statements are often slightly modified to fit specific activities. Thus, for example, a statement such as "I tried very hard to do well at this activity" can be changed to "I tried very hard to do well on these puzzles" or "…in learning this material" without effecting its reliability or validity. Concerning redundancy there are statements within the categories that can overlap. Making a randomization of the presentation of the statements makes these categories less evident to the respondents.

Materials and methods

Survey instrument

We prepared a web survey that was sent to citizens registered in the BioDiversity4All project through the project's Newsletter's (Suppl. material 1).

The survey was composed of three sections. The first introduced the research and addressed survey ethics and data security. The second section asked about respondents'

demographic and professional characteristics like gender, age, self-reporting level of participation in the project (from never participated to participate a lot), nationality, profession, and level of education. The third section (see Table 1 for all the questions in this section of the survey) was an adaptation of Fonseca and Brito's (2001) version of the IMI (McAuley et al. 1989).

The seven categories employed, (Table 1) although derived from the Intrinsic Motivation Inventory (IMI), were generated by reviewing the theoretical literature and relevant published instruments. In the present case, these were modified to refer to citizen science activities connected with biodiversity assessments. In the analysis seven categories were considered: Interest/Enjoyment (eight statements), Perceived Competence (nine statements), Effort/Importance (five statements), Perceived Choice (seven statements), Value/Usefulness (seven statements), Project Relatedness (six statements), and Group Relatedness (five statements). All motivational statements were rated on a seven-point Likert scale ranging from one (strongly disagree) to seven (strongly agree), with an intermediate score of four (moderately agree) (Munshi 2014). From the original IMI we excluded the category Pressure/Tension once is not expected to be felt by participants that do this activity in a volunteer basis and included the category Group Relatedness created according to the features of the project. Ryan and Deci (2000) describe relatedness as a sense of belonging and connectedness to the persons, group or culture disseminating a goal. Although the IMI analysis is designed to tap into individual motivation for doing a certain activity, the statements on the Group Relatedness category lend themselves readily to the assessment of the degree to which a person feels connected to other persons that do the same activities.

Because BioDiversity4All is a project developed in Portuguese language, the survey was only available in Portuguese even if the participants were from other nationalities. It was assumed that, if they had registered in the Portuguese platform, they could read in Portuguese.

The link to the web survey was sent in May 2015 to all the Newsletter's receivers of BioDiversity4All Project (N=1450), independently of their participation or not in the project. Five answering reminders were sent till October 2015.

Data analysis

The results from the survey were ranked and analyzed considering the questions referring to the participants' socio-demography and the IMI-related statements. All results describing the characteristics of participants and their motivation to participate were reported as a percentage of total responses.

To analyze differences between gender, of the average scores of the statements ranked on Likert-scales, we did a Mann-Whitney-Wilcoxon test. After calculating the medians with an interquartile interval (Q3-Q1) for age classes, levels of education and levels of participation, a multiple comparisons analysis was performed with the Kruskal-Wallis test (multiple comparisons and unbalanced sample sizes). Significant

Table 1. IMI categories used in the survey with corresponding statements. The (R) after a statement is just a reminder that the score attributed is the reverse of the participant's response on that particular statement.

Categories	Statements
Interest/ Enjoyment	I enjoyed doing this activity very much. This activity was fun to do. I thought this was a boring activity. (R) This activity did not hold my attention at all. (R) I would describe this activity as very interesting. I thought this activity was quite enjoyable. While I was doing this activity, I was thinking about how much I enjoyed it. This is one of my favorite leisure activities.
Perceived Competence	I think I am pretty good at this activity. It is important to me to feel that I did this activity as well as or better than other participants. After working at this activity for a while, I felt pretty competent. I am satisfied with my performance at this task. I was pretty skilled at this activity. This was an activity that I couldn't do very well. (R) This activity allows me to increase my competences. To feel that I performed well on this activity made me want to participate again. To feel that I performed worse than the others on this activity made me not want to participate again. (R)
Effort/ Importance	I put a lot of effort into this. I didn't try very hard to do well at this activity. (R) I tried very hard on this activity. It was important to me to do well at this task. I didn't put much energy into this.
Perceived Choice	I believe I had some choice about doing this activity. I felt like it was not my own choice to do this task. (R) I didn't really have a choice about doing this task. (R) I felt like I had to do this. (R) I did this activity because I had no choice. (R) I did this activity because I wanted to. I did this activity because I had to. (R)
Value/ Usefulness	I believe this activity could be of some value to me. I think that doing this activity is useful for helping in the scientific knowledge of national biodiversity. I think this is important to do because it allow us to know better national biodiversity. I would be willing to do this again because it has some value to me. I think doing this activity could help me to be closer to nature and biodiversity. I believe doing this activity could be beneficial to me. I think this is an important activity.
Project Relatedness	I felt really distant to this project. (R) I felt like I could really trust this project. I'd like to have the chance to collaborate more often with this project. I'd really prefer not to collaborate more with this project. (R) I don't feel like I could rely on this project. (R) I feel close to this project.
Group Relatedness	Doing this activity, I feel I can learn with other participants. Doing this activity, I can help other participants to get to know what I already know. With this activity I feel I can relate with other participants. With this activity I get to know people with the same interests than me. Participating in this activity is important to make me feel that I belong to a community.

differences between average scores were determined for $\alpha \leq 0.05$. All the statistical analysis was performed using R 3.1 (R Development Core Team 2014).

Finally, we performed a cluster analysis to group participants according to similarities in the answers they provided. We used hierarchical agglomerative clustering with Ward method (Murtagh and Legendre 2014) and performed the cluster analysis using the package Cluster of R 3.1.

Results

We received 149 survey responses corresponding to 10.3 % of the Newsletter's receivers. Most of the responses were given by Portuguese citizens 92.6% with the remaining representing six other nationalities: Brazilian, Spanish, British, French, Dutch, and Swiss.

From the total amount of responses 77 were given by males (51.7%) and 72 by females (48.3%) and participants' ages varied between 19 and 71 years old with an average of 43.5 ± 11.4 (Figure 2). Concerning the level of education 83.1% had higher education (44.6% bachelor degree, 25.7% MSc, 12.8% PhD) and 16.9% high school (Figure 2).

Respondents that had registered in the project and only occasionally participate were responsible for largest (55.7%) fraction of the survey's responses, followed by those that had registered in the project but never participated (30.2%). Of the remain-

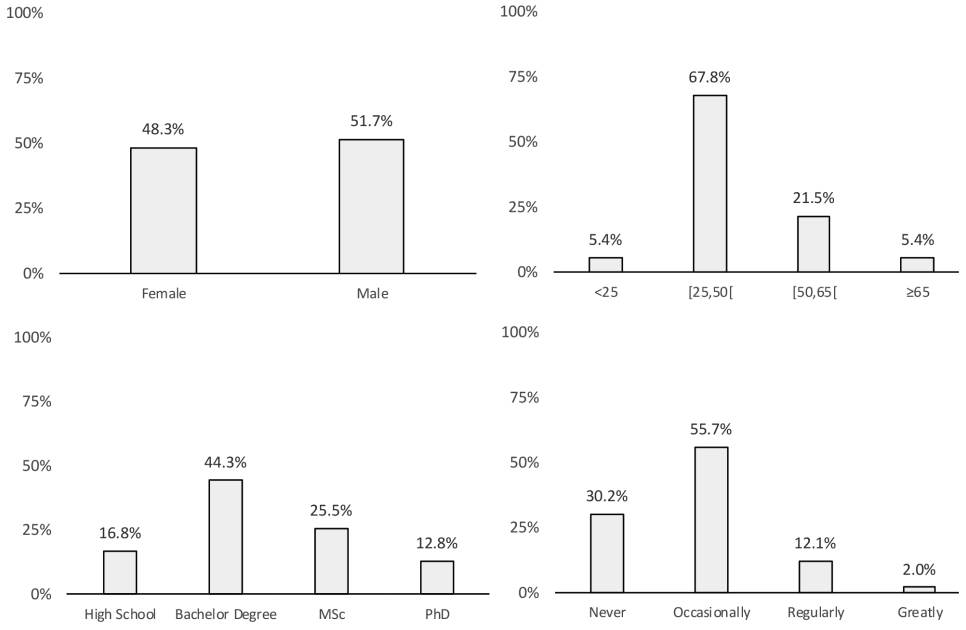

Figure 2. Percentage of responses per gender (**a**), age (**b**), level of education (**c**), and level of participation (**d**).

Table 2. Pearson correlation coefficients between the different IMI categories.

IMI Categories	Interest/ Enjoyment	Perceived Competence	Effort/ Importance	Perceived Choice	Value/ Usefulness	Project Relatedness	Group Relatedness
Interest/ Enjoyment	1.00						
Perceived Competence	0.69	1.00					
Effort/ Importance	0.46	0.53	1.00				
Perceived Choice	0.35	0.18	0.02	1.00			
Value/Usefulness	0.72	0.49	0.33	0.49	1.00		
Project Relatedness	0.77	0.58	0.29	0.48	0.79	1.00	
Group Relatedness	0.67	0.64	0.36	0.21	0.66	0.64	1.00

ing a small fraction (12.1%) regularly participate and very few (2.0%) showed a high degree of participation (Figure 2). Concerning their professional activity, 28.9% of the respondents to the survey have education related jobs and 25.5% have environmental related jobs.

Considering all survey participants, the highest IMI scale-score was obtained by the category Project Relatedness, with an average of 5.8 out of 7, followed by Perceived choice and Value/Usefulness with an average of 5.7. Interest/Enjoyment had an average of 5.3, Group Relatedness an average of 4.7 and Perceived competence an average of 4.5. The lowest average obtained referred to Effort/Importance with 3.8. In the correlation analysis of the different IMI scores, Interest/Enjoyment and Value/Usefulness, Interest/Enjoyment and Project Relatedness, and Value/Usefulness and Project Relatedness were strongly correlated (Table 2).

No statistical differences were found between genders, age classes and levels of education for the averages in any category of analysis. However, levels of participation were significantly different for all categories except Interest/Enjoyment (Table 3 and Figure 3).

The cluster analysis of the answers given by the participants supports the differences of motivations of the respondents with different levels of participation (Figure 4). The first cluster group was composed of people that never participated or that participate only occasionally. The third group included people that participate a lot and most of the people that participate regularly.

The highest value of Interest/Enjoyment and Perceived Competence was obtained by the group of respondents that participate a lot and the lowest by the ones that never participated. For Effort/Importance, the lowest value was obtained by the group that participates occasionally and the highest by those who never participated. For Value/Usefulness, Project Relatedness and Group Relatedness, the highest value was obtained by the ones who show high participation levels and the lowest by the ones that never participated. For Perceived Choice the highest value was obtained by the ones that participate regularly and the lowest by those that never participated.

Table 3. Mann Whitney U Test and Kruskal-Wallis Test summary table for analysis of the median of the scores of each IMI categories by gender (Mann Whitney U Test), age, level of education and level of participation (Kruskal-Wallis Test).

	Mann Whitney U Test		Kruskal-Wallis Test								
	Gender		Age				Level of Education			Level of Participation	
IMI Scales	W	P value	Chi squared	Degrees of Freedom	P value	Chi squared	Degrees of Freedom	P value	Chi squared	Degrees of Freedom	P value
Interest/Enjoyment	2507	0.55	3.58	3	0.31	3.53	3	0.32	2.66	3	0.45
Perceived Competence	2405.5	0.75	6.20	3	0.10	1.19	3	0.76	40.71	3	7.54e-09
Effort/Importance	2705.5	0.15	2.83	3	0.42	1.34	3	0.72	15.83	3	0.00
Perceived Choice	2569	0.39	1.70	3	0.64	1.30	3	0.73	14.30	3	0.00
Value/Usefulness	2551	0.43	4.54	3	0.21	2.83	3	0.42	14.00	3	0.00
Project Relatedness	2542	0.46	2.45	3	0.48	1.65	3	0.65	26.52	3	7.43e-06
Group Relatedness	2536	0.29	3.91	3	0.27	2.50	3	0.48	11.73	3	0.01

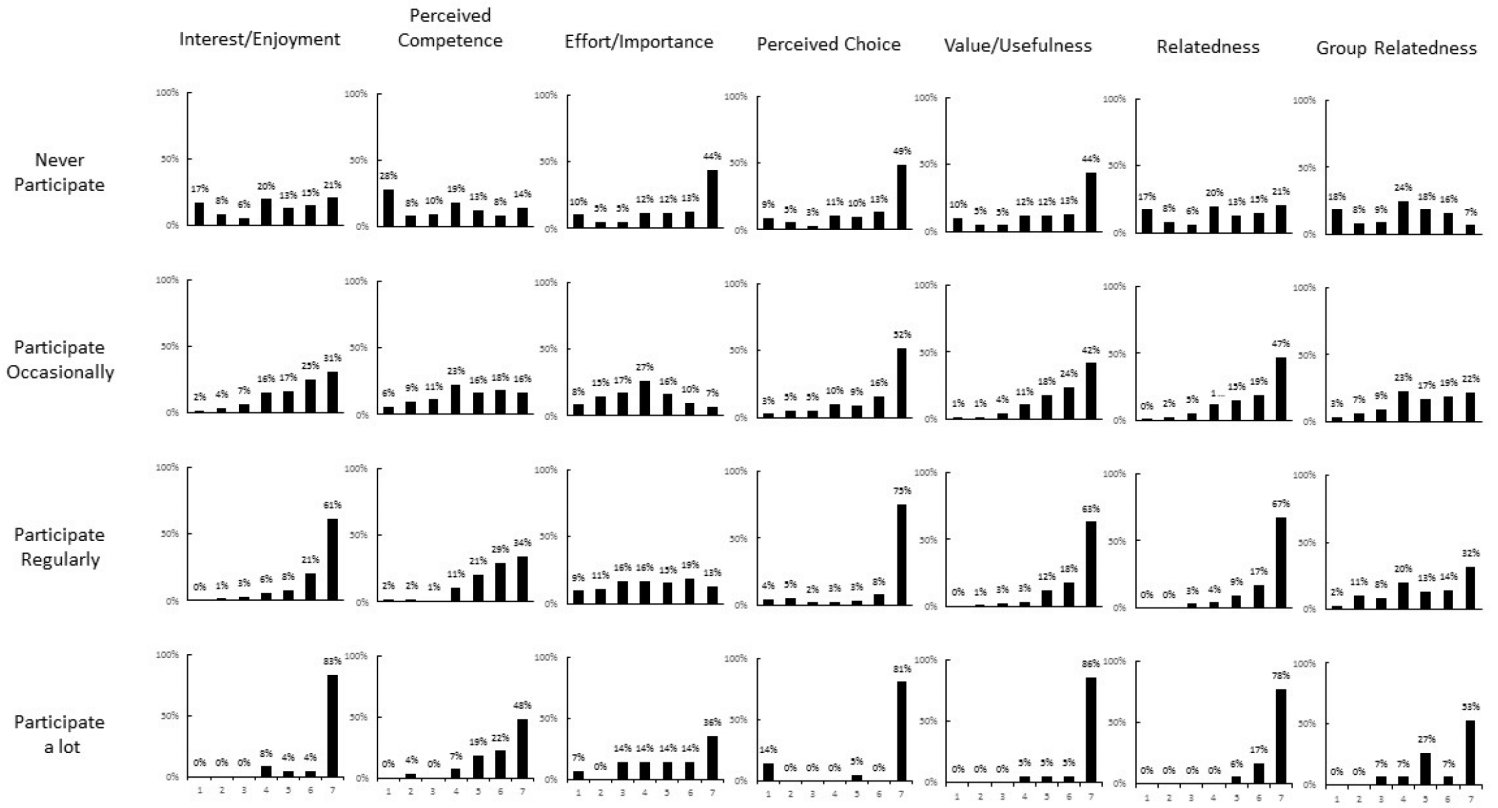

Figure 3. Percentage of answers of the IMI categories, rated from 1 (strongly disagree) to 7 (strongly agree), with an intermediate score of 4 (moderately agree), for the four groups of people with different levels of participation in the project (never participated, participate occasionally, participate regularly, participate a lot).

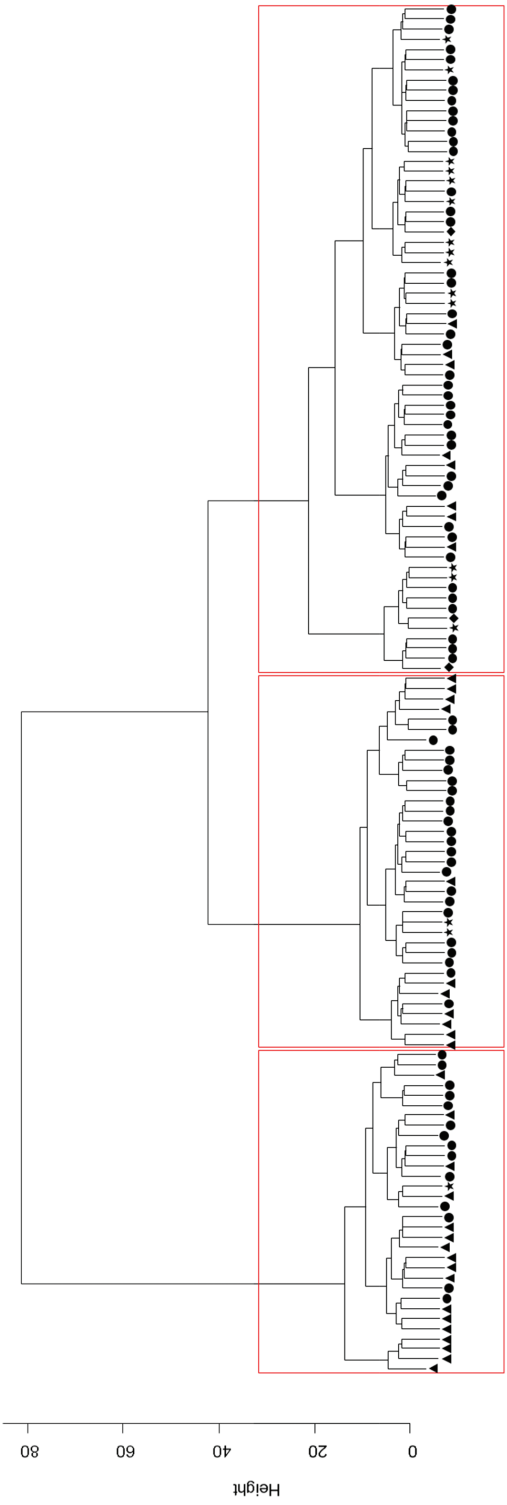

Figure 4. Hierarchical agglomerative clustering of the answers given by the participants, with Ward method. The symbol represents the level of participation in the project (never participated - ▲, participate occasionally - ● participate regularly - ★, participate a lot - ◆).

Concerning the group of people that never participated, the lowest IMI was Perceived Competence and the highest was Perceived Choice. For all the other groups, the lowest IMI was Effort/Importance and the highest was Project Relatedness.

Discussion

In this study, we wanted to assess citizens' engagement and meaningful experience in citizen science projects, using motivational measures. This study revealed lessons of interest for citizen science projects when participants' motivations is concerned, in a country with limited culture of public participation. Assessment of intrinsic motivations in countries with higher levels of engagement with biodiversity and participation in citizen science, could present different results and a comparative analysis would be an interesting approach.

Analyzing survey respondents, the majority of participants have higher education, a fact which is not representative of the Portuguese reality (only 16.5% of Portuguese people have or are undertaking higher education, PORDATA 2015). Moreover, the age groups <25 and ≥65 were the ones with less answers to the survey (5% each); one reason might be that these are the groups with less participants in the project, or that these are the groups showing less willingness to answer to web surveys. For a general characterization of respondents, we also included questions about nationality and professional activity. The survey was developed for Portuguese speakers and this may have hampered people from other nationalities to participate. Several participants from other nationalities collaborate with the project either through the Portuguese project or through the international platform. Some of these participants are residents in Portugal and presumably speak Portuguese however, less than 8% of survey respondents were from other nationalities. Although the professional activities of respondents are diverse, 54.4% of respondents have education or environmental related jobs. The demographic factors of nationality and profession were just used to characterize respondents and not to test the motivational differences. Nationality because the project has an inherently national scope and answers to profession because they were too generic to allow any conclusions.

A high percentage of respondents had registered in the project BioDiversity4All but never participated. When we analyzed the responses to IMI categories given by groups with different levels of participation, we found that people who never participated were the ones responding more differently compared to other groups. This group shows the lowest levels in all categories except Effort/Importance. This might indicate that those people do not have intrinsic motivations for participating in such a project. Of these people, some registered after a project presentation, a media news or a launch of a contest but did not pursue with their participation. A possible lesson to draw from these results is that extrinsic motivations may be needed to foster participation in these cases, while creating mechanisms to increase competence, autonomy and relatedness on participants, to drive more autonomous (self-determined) motivations.

Frequently, citizen science projects use extrinsic motivation instruments to induce citizens' participation, such as incentives, certificates of recognition and challenges, which stimulate people's interest in the project (Dickinson et al. 2012). Nevertheless, it is important to include mechanisms to foster intrinsic motivations in order to create continued support and involvement in citizen science initiatives after these initial extrinsic motivations erode (Cialdini 2008). For example, one could use contests and prizes that include educational material, feedback on the effort already invested, group activities, interacting with a similar community and different ways of participating, increasing perceived choice.

In contrast with the respondents that never participated a small percentage (2%) participate a lot. This is not unexpected regarding results from other citizen science projects. In the Wikipedia project, with one million registered users, about 10% contribute with ten or more entries and about 0.5% contribute to a large number of tasks to keep Wikipedia running (Tapscott and Williams, 2008). The group of respondents that participate a lot had the highest levels of intrinsic motivation, scoring highest in all categories except Effort/Importance and Perceived Choice.

These findings are aligned with past research on intrinsic motivation which has focused on identifying and examining the activity-level psychological factors that promote or inhibit the development of intrinsic motivation. This approach has yielded important insights, some of which that (1) enjoyment is positively related to competence valuation (i.e. the degree to which one cares about performing well at a given activity; Elliot et al. 2000; Goudas et al. 1995; Harackiewicz and Manderlink 1984; Reeve and Deci 1996; Sansone 1989; Tauer and Harackiewicz 1999), and (2) enjoyment is positively related to the degree to which activities are perceived to be "optimally challenging"— not too easy and not too difficult (e.g. Harter 1978; Keller and Bless 2008; Moneta and Csikszentmihalyi 1996). Stated more generally, the degree to which the potential rewards of ongoing activity engagement are realized would seem to be dependent on the degree to which attentional resources are devoted towards these potential rewards.

Early experiments showed that positive feedback enhanced intrinsic motivation relative to no feedback (Boggiano and Ruble 1979; Deci 1971) and that negative feedback decreased intrinsic motivation (Deci and Cascio 1972). Deci and Ryan (1985) linked these results to the need for competence (White, 1959), suggesting that events such as positive feedback provide satisfaction of the feeling of competence, thus enhancing intrinsic motivation, whereas events such as negative feedback tend to thwart the feeling of competence and thus undermine intrinsic motivation. That is why it is understandable that people who participate a lot in the Biodiversity4All project had the highest levels of Perceived Competence. The feeling of competence leads them wanting to participate more.

These results indicate that citizen science projects should nurture participants with positive feedback and adapted participation modes to their level of competence. This may yield higher levels of motivation to participate and foster intrinsic motivation.

Project Relatedness and Value/Usefulness were the highest scoring IMI categories for all groups except those who never participated. People tend to value the feeling of

relationship and trust in the project, moreover since they feel that the project has an important mission to accomplish.

A note should be given about the category of Perceived Choice. Most respondents feel they had a high level of Perceived Choice which is in line with the voluntary nature of the project. However, we have students participating in the project and some contests with schools and scouts which may explain why some respondents may feel that they had no choice in their participation.

With the cluster analysis we wanted to confirm similarities in the answers given by different respondents to find, if people with the same level of participation, have comparable intrinsic motivations and in fact, we detected the expected result.

In conclusion, in recent years much has been written on communication and recruiting participants for citizen science projects (Dickinson et al. 2012; Roy et al. 2012; Silvertown et al. 2013). However the results from our work show that working deeply on people's involvement is fundamental to increase and maintain their participation on citizen science projects. If, for initial recruitment and in countries with low participation culture, mechanisms of external motivation may be necessary, to guarantee higher levels of long term participation, citizen science projects should foster intrinsic motivations which can be done by incorporating in project design experiences of relatedness, capacity building, positive feedback and adapted participation modes.

Acknowledgements

PT was supported by the Portuguese Foundation for Science and Technology (FCT/MCTES) (SFRH/BD/89543/2012). CC acknowledges support from the Portuguese Foundation for Science and Technology (FCT/MCTES) and POPH/FSE (EC) (SFRH/BPD/84422/2012 and GHTM - UID/Multi/04413/2013). We wish to thank the two anonymous peer reviewers, who helped us to greatly improve the manuscript.

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Supplementary material 1

BioDiversity4All Project Survey

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Data type: Group Projects Data

Link: https://doi.org/10.3897/natureconservation.18.13429.suppl1