## Citizen Science in Psychology: Challenges, Opportunities and Recommendations

Accepted for publication in Behavior Research Methods


https://doi.org/10.3758/s13428-026-03019-8

# Citizen Science in Psychology: Challenges, Opportunities and Recommendations

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## Abstract

Human society is characterized by an interest in understanding the world and its phenomena. However, for most of society, science is a distant endeavor, reserved for a select group and a wide gap exists between scientists and citizens. This gap is even more striking in psychology, where humans are the study subjects of interest. Citizen science (CS) is a recent approach that incorporates perspectives of non-professional scientists or “citizens” through their active participation in scientific research. Because CS remains largely unexplored within several subdomains of psychology, including cognitive psychology, this review highlights the opportunities that CS can offer for our field. After situating the relation between science and society and the emergence of CS in the history of science, we provide an overview of existing definitions and models of CS, which we then synthesize into a new model. We also describe CS studies within the field of psychology, with a specific focus on cognitive psychology. Crucially, we discuss the main opportunities and challenges of CS, zooming in on specific challenges that CS faces within psychology and cognitive psychology in particular. Ultimately, this review aims to bridge the gap between psychologists and their study subjects, by stimulating the development and application of a citizen science approach within cognitive psychology.


**Keywords:** citizen science, participatory research, psychology, cognitive psychology

In a recent comment, we highlighted that citizen science, where citizens actively participate in scientific research, is still underrepresented in the field of psychology and cognitive psychology in particular, and we advocated for a cognitive citizen science (Van den Bussche et al., 2024). In the current extensive review paper, we provide a thorough background on citizen science, define the concept and propose a new citizen science model, give an overview of the state of the art of citizen science in psychology, with a specific focus on cognitive psychology, and discuss the opportunities and challenges that citizen science can have within our field. Ultimately, we propose several recommendations for psychology researchers who want to embark on citizen science.

## The history of citizen science

Ever since its earliest days, humanity has been characterized by a great interest to understand, explore and control the world and its phenomena. This natural curiosity is what has always driven the growth of knowledge. Individuals would spend their time studying phenomena and postulating theories about them. Although some spent a considerable part of their lives devoted to this curiosity, the formal profession of "scientist" did not exist for most of human history (Barton, 2003; Beer & Lewis, 1963; Ross, 1962). This implies that science was originally conducted by citizens (Haklay, 2015; Strasser et al., 2018). Of course, this does not mean that scientific activities were within reach of each citizen (Hecker et al., 2018). Illiteracy, for example, created boundaries for citizens to engage in science (e.g., Baten, 2022).

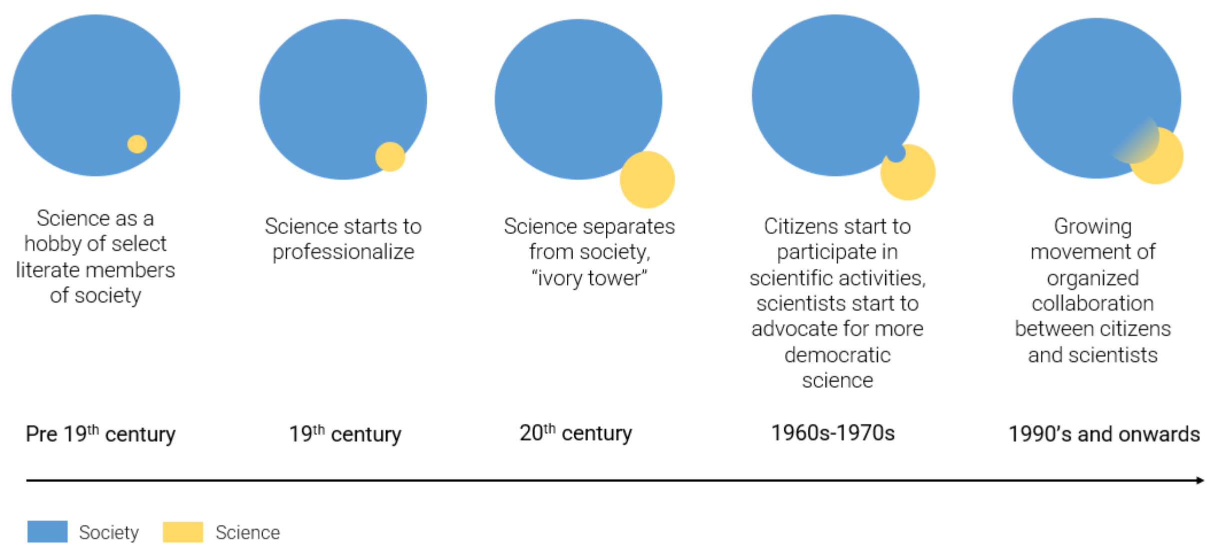
During the 19th century, science started to professionalize and a gap between amateur scientists and professional scientists started to emerge, as professional science became an academic endeavor (Barton, 2003; Beer & Lewis, 1963; Ross, 1962). During this time, the term "scientist" was first used, although it was not the preferred term (e.g., Barton, 2003; Ross, 1962) and did not have the same meaning as the one we use today. Initially, the word "scientist" had a negative connotation, as professionalism and the monetary pursuit of scientific activities were in conflict with the ideal of the curious intellectual for whom science was a passion, not a business (Daniels, 1967; Ross, 1962). Only later did the term "scientist" become a more neutral word used to describe anyone who practices science professionally (e.g., Ross, 1962). The gap between professional scientists and amateurs widened as science professionalized (Haklay, 2015). The scientific world started to "purify" science, formulating more specific characteristics of the scientific method (e.g., Oreskes, 2019) and advocating for a focus on science for its intellectual value, rather than its usefulness for society (Daniels, 1967). There was a strong tendency towards "pure" science, and to distinguish "real" science from amateur science (Daniels, 1967; Lucier, 2009).

Over the course of the 20th century, scientific discoveries have impacted the "average citizen" more tangibly than ever before, for example through medical advancements (e.g., discovery of penicillin, development of vaccines) and technological inventions (e.g., tele-communication), especially in the decades after World War II (Aguiar De Medeiros, 2003). However, these advancements were not only a source of hope and progress, but also of fear and frustration (Jones, 2001; Koerner, 2014; Reed, 2000; Rome, 2003; Strasser et al., 2018). People became aware of the potential adverse effects of science (e.g., use of the atomic bomb), and started to fear them (e.g., fear of "mind control"), which was accompanied by a mistrust in and higher scrutiny of science (Jones, 2001). In the 1960s and 1970s views of science were also shaped by a more general sense of mistrust of the institutions of government by citizens, who started to protest against injustice, war and environmental pollution, and demanded more rights

(Reiss, 2007; Rome, 2003; Strasser et al., 2018). During this period, a radical science movement emerged within the scientific community that was increasingly critical of the scientific world and demanded that science should be used for a greater good: for the advancement and benefit of society (Strasser et al., 2018). This meant science was urged to become more democratic and accessible for anyone. During this era of science critique, citizens sometimes took matters into their own hands and particularly focused on topics that science had left unstudied, such as the impact of environmental pollutants on health (Brown, 1997) and women's health (Nichols, 2000). By increasingly focusing on science in the interest of society and accessibility of science to the members of society, these movements show some early resemblances with current-day Citizen Science (CS). However, they mostly lacked an organized collaboration between scientists and citizens that characterizes modern CS (Cooper & Lewenstein, 2016). Figure 1 offers a simplified overview of the assumed relationship between science and society over the past centuries and the recent emergence of CS. When considering this relationship, it becomes clear that citizens have been involved in science for centuries in various ways. However, the emergence of CS as we know it today is a fairly new development of the past three decades (Haklay, 2015; Woolley et al., 2016).

**Figure 1**

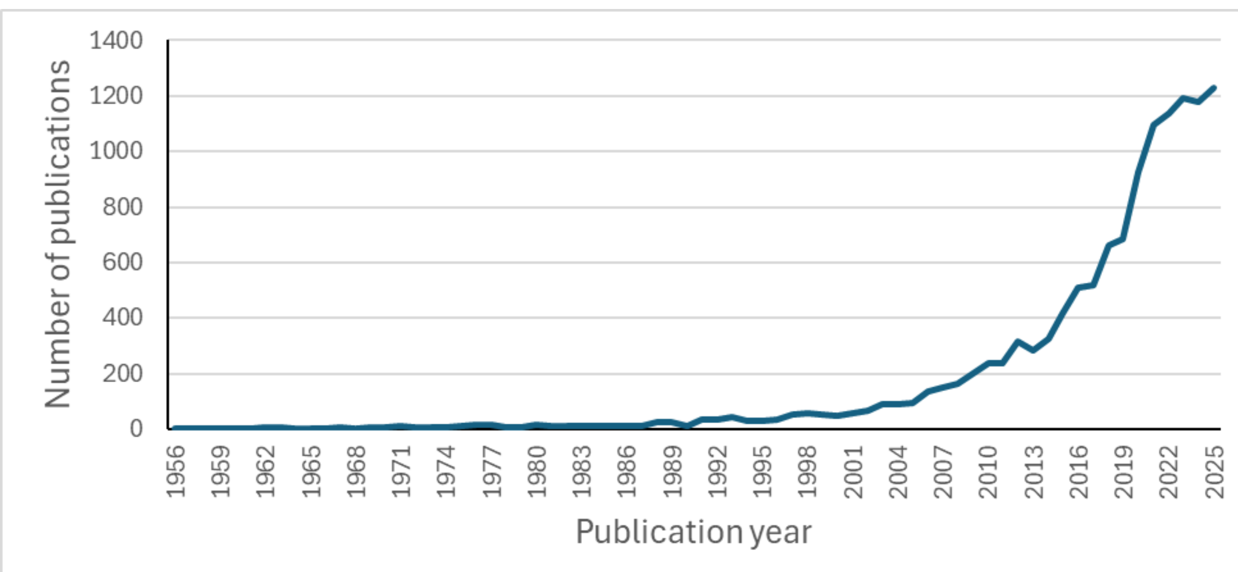
*The relationship between science and society over time and the emergence of Citizen Science.*




At the end of the 20th and beginning of the 21st century, the arrival of the internet and social media gave a new boost to the call for more accessible, relevant and transparent science (Haklay, 2015; Irwin, 2018; Newman et al., 2012). As people found easier ways to join forces and spread their message and low-cost technology became more available, scientists started to actively involve citizens in their research (Irwin, 2018). Although several terms have been used (Haklay, 2015), this approach has been labeled mostly as "Citizen Science", a term that emerged in the 1990s (Cooper & Lewenstein, 2016; Haklay, 2015). Since then, the interest in CS has increased tremendously. Over the past decade, several CS organizations have been founded (e.g., Citizen Science Association or CSA, 2013; European Citizen Science Association or ECSA, 2014) and multiple CS conferences have been organized (e.g., CSA conference, since 2015; ECSA conference, since 2016). Today, the broader scientific community has begun to embrace CS as a valuable way to approach scientific research questions, with the emergence of large-scale projects (e.g., Cooper et al., 2010; Masters & Galaxy Zoo Team, 2019; Meysman et al., 2020), online platforms to organize CS (e.g., SciStarter), and national and international organizations facilitating CS (e.g., Citizen Science Global Partnership, ECSA). Additionally, CS has received increasing attention from large organizations and instances such as the National Institute of Health (NIH; CITSCI Working Group, 2021), the European Commission (European Commission, 2021) and the US Government (Federal Crowdsourcing and Citizen Science Community of Practice; National Coordination Office for the Federal Community of Practice on Crowdsourcing and Citizen Science, n.d.). Consequently, the number of published studies using a CS approach has increased over the past decade (see Figure 2). However, for a substantial part of the scientific community, CS is still undiscovered territory and, as a consequence, the CS approach is only starting to develop its potential.

**Figure 2**

*Number of published studies using a Citizen Science approach from 1956 until 2025.*



*Note.* *Publications found in the Web of Science database on December 17 2025, using the search query: ((((((TI=(citizen science)) OR TI=(participatory research)) OR TI=(co-created research))) OR TI=(community science)) OR TI=(public participation in scientific research)) OR TI=(civic science)

**What is and isn't citizen science?**

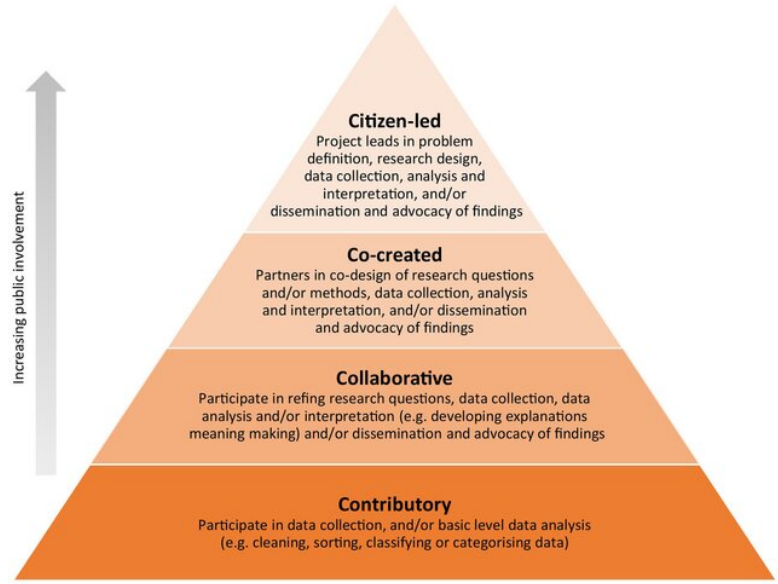
It is difficult to delineate the concept of CS, as there is debate on its exact definition and diversity in its elaboration (Haklay et al., 2021). Haklay and colleagues (2021) stress that narrowing down to one simple definition of CS may not be appropriate, as its meaning is specific to the context and purpose of a particular CS project. Providing an overview of the most prevalent CS definitions, they argue that it is important to select a definition that is aligned with the purpose of a specific context (e.g., communicating with other professional scientists, citizens, funders, policy makers). Still, generally, CS can be regarded as a research approach in which non-professional scientists, referred to as "citizens", actively participate in scientific research, often, but not always, in collaboration with professional scientists (Haklay et al., 2021; Vohland et al., 2021). The ECSA (2015) has created the Ten Principles of CS, in which they stress, among other aspects, the importance of active involvement of citizens in scientific research.

There is great variety within CS research, which has led several researchers to create models of CS, identifying different types of CS. One prominent model of CS was proposed by Bonney et al. (2009). This model distinguishes between contributory, collaborative and co-created research. Contributory research is designed and planned by scientists. Citizens are involved by contributing to the project, usually by providing data, such as observation data, personal records or data generated using the computing power of their personal computer (i.e., distributed computing or volunteered computing). Collaborative research is also designed and planned by scientists and citizens also contribute data to the project, but in addition, citizens are involved in the refinement of the design, the analysis of data or the communication of research results. Thus, it involves more active participation that goes beyond data providing. Co-created research is collaboratively designed, planned and carried out by scientists and citizens. This means at least some of the citizens are involved in most to all steps of the research cycle. Research conducted entirely by citizen scientists, with limited or even no involvement of professional scientists, would also be considered co-created research under this model.

The model by Bonney can be depicted as a pyramid, based on the level of citizen participation. Several variations of this pyramid model of CS exist, typically dividing citizen participation into in four categories (e.g., English et al., 2018; Marks et al., 2022; OpenScientist, 2013). As seen on Figure 3, the category with the minimal involvement level serves as the base and the most active level as the top of the pyramid. OpenScientist (2013) explains that the pyramid visualization is particularly fitting, because there are fewer projects available and fewer citizens involved per project at the highest activity level (i.e., the top of the pyramid). In other words, the pyramid reflects how common projects in each category of the pyramid are and how many citizens are involved in these projects.

**Figure 3**

*Example of the pyramid model of Citizen Science.*




*Note.* From Marks et al. (2022). Copyright CC BY.

While Bonney's model is widely appreciated for its clarity and practical categorization of citizen participation, it primarily focuses on which steps of the research cycle citizens engage in. A final prominent model proposed by Haklay (2013), builds on this foundation by adding another important dimension: the nature of the contribution citizens make. Rather than grouping projects solely by participation type, Haklay's model also differentiates levels based on whether citizens provide non-cognitive resources (e.g., time or computing power) or actively contribute their cognitive skills and decision-making. This perspective offers a more nuanced understanding of citizen involvement, highlighting that participation is not only about the nature of tasks but also about the depth and type of engagement. The model contains four levels of CS. The first level is the level of crowdsourcing, wherein citizens act as sensors in their environment (e.g., measuring air quality by installing sensors around their home) or participate in volunteered computing (i.e., researchers use the unused processing capacity of citizens' personal computers for calculations that require large computing power). In other words, citizens provide a non-cognitive resource to the researchers. The second level is the level of distributed intelligence, where the cognitive ability of citizens is used as a resource by asking them for example to collect data (e.g., watching and/or counting birds in their garden) or conduct a simple interpretation activity (e.g., identifying galaxies, comets and asteroids by observing the night sky). The third level is the level of participatory science, which involves participation in the definition of problems and questions, as well as the design of the study. Afterwards, citizens collect the data, after which scientists analyze and interpret the data. The fourth level is the level of extreme citizen science, where citizens participate in the definition of the problem and research questions, data collection and potentially also in data analysis or even publication of the results. In this type of CS, the scientists are there to facilitate and guide the process as experts in scientific research. Similar to the pyramid models of CS, the different levels of Haklay's model (2013) are defined based on the level of citizen activity, with the first level having the lowest level of activity and the fourth level having the highest level of activity.

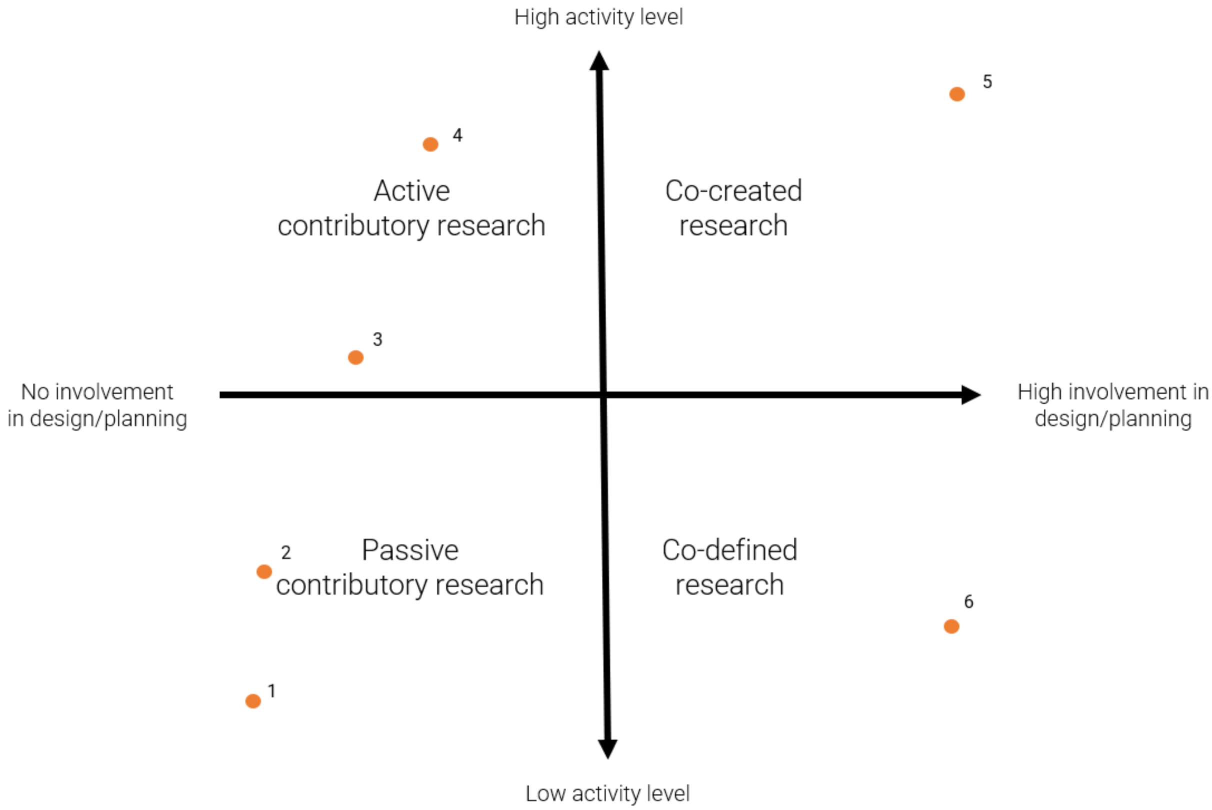
However, these types of pyramid structures could lead to the assumption that there is a hierarchy or dependency between the different categories of CS, with the minimal involvement level as a necessary foundation on which the other categories of CS are built (OpenScientist, 2013), and with the maximal involvement level as the ultimate to-be-strived-for ideal. This is not the case: CS projects with higher activity levels do not depend on the existence of lower activity level CS projects. Furthermore, although co-created research constitutes a complete implementation of CS principles, it is not necessarily the holy grail of CS. In some studies (e.g., where the research design process is complex and requires a professional scientific background), actively involving citizens in all steps of the research process might not be warranted. We argue that, although pyramid models might imply that there is a hierarchy in citizen participation, the optimal level of participation depends on the context and aims of the research.

## Towards a new model of citizen science

Although these models provide useful ways of categorizing different types of CS projects, it is not always easy to determine when a project belongs to a certain category in the models. This lack of clarity may stem from the fact that CS researchers point out that it is difficult to delineate the exact boundaries of CS and its subtypes (Haklay, 2013). We argue that capturing the large heterogeneity of CS projects with a model with simplified discrete categories is difficult to achieve, due to the specific contexts and unique characteristics of different research domains. We therefore propose a *two-dimensional model of CS (2D-CS)*. What all previous models seem to have in common is the focus on two important dimensions. The first dimension is the *level of activity* that characterizes the level of citizens' effort in the project. On the low end, the effort of individual citizens is minimal (e.g., volunteered computing) or very low (e.g., crowdsourcing). On the high end, the effort is high, with citizens participating in multiple time-consuming activities such as data collection and data analysis. The second dimension is the *level of involvement in the design and planning* of the research project. On the low end, citizens are not involved and follow a predefined set of instructions to answer predefined questions. On the high end, citizens co-create the research questions of the project and are involved in the design of the research. This two-dimensional model of CS is visualized in Figure 4.

**Figure 4**

*The two-dimensional model of Citizen Science (2D-CS) based on activity level (dimension 1) and involvement in design and planning (dimension 2).*




*Note.* Vertical axis represents the first dimension of level of citizen activity. Horizontal axis represents the second dimension of level of citizen involvement in research design and planning. Dots numbered 1 to 6 indicate examples of different types of projects (see main text) and where they could be situated in this model.

To illustrate how different forms of CS can be situated within the two-dimensional model, we outline six broad types together with representative examples (see Figure 4, dots 1-6), but note that this may differ depending on the specific project. These types include: (1)

volunteered computing where participants donate computing time to scientific purposes (e.g., MilkyWay@Home, Newberg et al., 2013); (2) crowdsourced research where citizens generate data by for example playing games (e.g., The Great Brain Experiment, Brown et al., 2014); (3) crowdsourced research where citizens aid in analysis, such as classifying information (e.g., Galaxy Zoo, Masters & Galaxy Zoo Team, 2019) or generating solutions through online gaming (e.g., FoldIt, Koepnick et al., 2019; EyeWire, Kim et al., 2014); (4) research where citizens actively collect data such as registering observations in nature (e.g., bird counting, Nugent, 2020); (5) extreme or co-created citizen science where citizens are involved in most or all aspects of the research (e.g., Chiaravalloti, 2021); (6) projects where citizens mostly contribute to the problem definition, research questions or design of studies (e.g., the Dignity Project Framework, Chapman et al., 2022).

Whether projects in the bottom left quadrant of the 2D-CS model (i.e., low scores on both dimensions) can truly be regarded as CS is under debate and the answer depends on the particular scientific domain and the research task that citizens fulfill (Haklay, 2013). In the natural sciences such as biology and physics, low effort involvement is typically already considered as CS, given that citizens are typically not involved at all in research in this domain. For example, Meysman and colleagues (2020) completed a CS project called CurieuzeNeuze where over 20,000 citizens collected air quality samples across Flanders in order to obtain important air quality measures that satellites are not able to measure and that are too expensive for scientists to measure without the help of citizens. Participants simply had to attach a premade set of sensors to their window and send it back to the lab after four weeks. The citizens were not involved in the design or planning of the study, nor with analysis, so the required activity level was low. Still, because of the help of the citizens, the scientists were able to, for the first time, create detailed maps of air quality at face height (Irwin, 2018; Meysman et al., 2020). This provided value for the citizens by informing them on the air quality around their homes and even acted as a tool for policy change (Huyse et al., 2019). However, domains studying human participants such as medicine or psychology typically already involve volunteer participants to some extent in their research. In these domains, the mere participation in data collection would typically not be considered as CS, unless the citizen plays an active role in one or more of the research steps instead of passively undergoing specific questionnaires, interviews, experiments or tests (Haklay, 2013). For example, in the BBC Internet study (Reimers, 2007) thousands of people completed a web-based survey and a series of cognitive tasks (see also Nosek et al., 2002 for a similar web-based approach and Reips, 2001 for an overview of web-based data collection in psychology). In addition, platforms exist that group several ongoing (psychological) studies or tasks seeking volunteers (e.g., https://psych.hanover.edu/research/exponnet.html, https://childrenhelpingscience.com/ or LabintheWild as described in Reinecke & Gajos, 2015). While web-based data collection certainly brought participation in science closer to citizens, the role of the citizens in these and other web-based studies is typically limited to providing data. Similarly, in experimental psychology, it is typical to recruit volunteer participants that are tested in specific predefined lab experiments, where they simply follow instructions without any participation in the formulation of the research questions, analysis or interpretation. Furthermore, data is collected from them, not by them. Thus, in the 2D-CS model, this would place this type of research in the bottom left quadrant (i.e., low activity level and no involvement in design and planning). In other words, these volunteer participants are subjects of, rather than active participants in the scientific research at hand. However, as volunteer participants do provide their cognitive resources to generate data, one could argue that most of the research in these domains is low-level CS, and can be placed in that bottom left quadrant of the 2D-CS model. This is recognized as such for large-scale open-entry online crowdsourcing studies (for an overview, see Li et al., 2022), but not for studies that basically use the same approach on a smaller scale. In human-centered sciences, studies where participants have a more active rather than passive role are more easily labeled as CS (i.e., top left quadrant of the 2D-CS model). For example, in the medical field, Lebeer and colleagues (2023) recently received the first European Union Prize for Citizen Science (Team Isala, 2023) for a project where they instructed 3345 women how to self-collect a vaginal sample. Through this project, they were able to generate knowledge about reproductive health in the general female population that was previously scarce. Where participants would typically be tested in the lab without any active participation, this project involved women who applied to receive a test-kit, learn about the sampling procedure, self-sample and send the sample back to the lab. Hence, the citizens were actively participating data-collectors, albeit still with relatively low effort. In other words, if and when a study is labeled as CS seems to depend on whether the involvement of the participants goes beyond what is typical for a given field, both in terms of quantity and quality. One could also argue that attaching sensors, donating computing time, completing questionnaires or taking part in experiments for purposes that were determined and designed by researchers does not really actively involve citizens in the scientific process, which would go against the idea of CS. Indeed, passive citizen participation can prevent a feeling of meaningfulness that citizens experience during participation in research and even lead to alienation (Malmqvist, 2019). Establishing a shared commitment between citizens and researchers by connecting participants to the research project (e.g., by informing them about the goals of the study and the potential outcomes), or by more actively involving them can mitigate this risk (Schonfeld & Rasmussen, 2019).

In the upper-right quadrant of the 2D-CS model, we situate CS projects in which citizens are actively involved not only in the design and planning of the study (including formulation of research questions), but also actively participate in most to even all phases of the research cycle. This form of CS is sometimes also referred to as co-created research or “extreme CS” (Chiaravalloti et al., 2022; Haklay, 2013; Stevens et al., 2014). Extreme CS has been used in conservation projects with local populations. For example, Chiaravalloti (2021) led a project that helped local fisher families in Brazil map their traditional fishing territory and practices in the use of natural resources after being displaced due to the protection of the wetland area in which they lived. The local families involved in the project were guided in a series of decisions and ultimately collected data to create maps. The output of the project directly led to the creation of a large community reserve for these fisher families (Chiaravalloti, 2021). In some fields, such as education, co-created research with teachers and pupils has already been implemented quite commonly for decades, often under the term “participatory (action) research” or PAR (Cornish et al., 2023; Jacobs, 2016). For example, Parrello and colleagues (2019) conducted participatory action research on educational wastage together with teachers in schools in disadvantaged areas, involving the teachers from the generation of hypotheses to the implementation of research outcomes in practice. CS can be seen as an extension of PAR: they both aim to include non-professional scientists in research, but PAR typically involves citizens with lived experience to tackle societal issues (Cornish et al., 2023), while CS encompasses citizen involvement in all its forms. In that respect, PAR is typically less focused on the generation of new (academic) knowledge and more on the creation of solutions for citizens (Parrello et al., 2019).

In sum, the two-dimensional model we propose is able to include all types of CS projects and shows that the CS approach is easier to grasp as a continuous rather than a categorical concept with varying levels of citizen activity and involvement in design and planning. The model offers the flexibility to capture the heterogeneous nature of CS initiatives, and does not impose strict boundaries between categories of CS. Intriguingly, projects situated in the bottom left quadrant of this model can be identified as CS or not, depending on the field of study. We note that sample size also plays an important role in CS and might be (in part) determined by the two dimensions in our model. As suggested by OpenScientist (2013), projects will arguably involve fewer citizens as the required activity level and involvement in design and planning increases, although this does not necessarily need to be the case (see for example Gignac et al., 2022). Furthermore, within a single project, multiple approaches with differing positioning according to the two dimensions can be incorporated (e.g., a smaller sample is involved in design and planning and data collection, while a larger sample is involved only in data collection).

## Citizen science in psychology

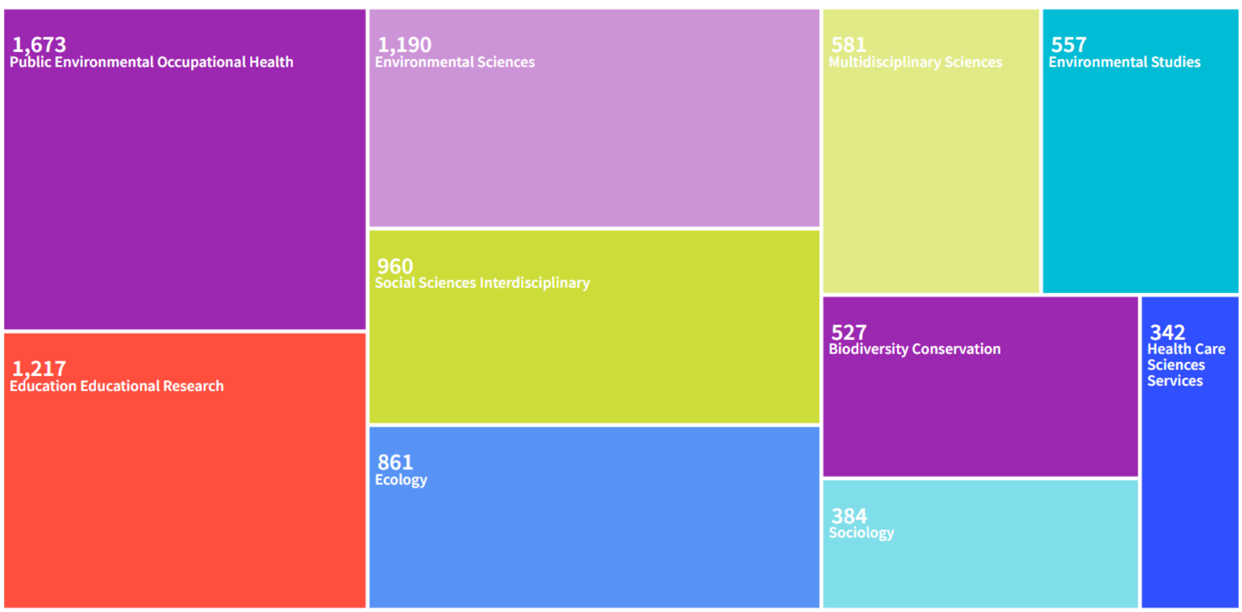
As argued above, whether studies in the bottom left quadrant of the 2D-CS model can truly be regarded as CS is debatable and depends on the particular scientific domain. In psychology, mere participation in data collection would typically not be considered as CS, as this would basically render almost all research in psychology CS. This is also the position we will take here: we depart from the premise that CS in the field of psychology requires that the citizen plays an *active* role in one or more of the research steps instead of passively providing data and time. As such, studies that can be categorized in the bottom left quadrant of our model, will not be considered here.

As Figure 5 illustrates, most published CS studies can be situated in domains within the natural sciences (e.g., biology and environmental sciences) (Tauginienė et al., 2020). In contrast, CS, that goes beyond low-level CS as argued above, is still relatively unexplored within psychology (Funke, 2017), and especially in some of its subdomains. Using the search string described on Figure 5, only 5.9% of the published CS studies so far are published with a subfield of psychology as main/first Web of Science category (e.g., Psychology Multidisciplinary, Psychology Clinical). One reason for this underrepresentation may again be the inconsistent definitions of CS across research fields. For example, a study in environmental sciences where citizens place sensors in their homes might be labeled as CS, whereas a study in psychology where citizens complete a questionnaire would typically not. As noted above, passive citizen involvement is generally not considered CS in our field, while it may qualify as CS in other domains. In psychology, where most data are collected from humans, the definition of CS tends to be stricter: active involvement of citizens is usually required for a study to be classified as CS.

Projects with higher levels of citizen activity or involvement in design and planning are scarce within certain domains of psychology, although in others they are increasingly emerging. Some participatory CS initiatives have been carried out, particularly in fields such as psychopathology, mental health, and neurodiversity. In 2009, Becker and colleagues already advocated for community-partnership research to help distribute empirically-supported interventions for psychopathology, and den Houting et al. (2020) showed that community stakeholders call for increased community engagement in autism research. A recent systematic review by Todowede et al. (2023) identified nine CS studies within the domain of mental health, one of which used a co-creation approach where high school students proposed and explored local sustainable changes in the neighborhood to increase youth social inclusion (Winther et al., 2023). In a CS project by Bonhoure et al. (2023), citizens, including people with mental health conditions, co-created experiments with social dilemmas to map social interactions within the mental health community. Similarly, within the neurodiversity field, Fletcher-Watson et al. (2019) called for autistic voices to be used to shape the future of autism research. This rallying call has been taken up by many researchers in this field. As an example, Sonuga-Barke et al. (2024) incorporated the voices of neurodivergent people in a research program aimed at understanding the role of emotional experience of neurodivergent youth.

**Figure 5**

*Tree chart of top ten Web of Science categories with citizen science publications*




*Note.* Publications found in Web of Science database on December 17 2025, using search query: ((((((TI=(citizen science)) OR TI=(participatory research)) OR TI=(co-created research))) OR TI=(community science)) OR TI=(public participation in scientific research)) OR TI=(civic science)

## Citizen science in subdomains of psychology: Cognitive citizen science as a case study

The examples above show that, in some subdisciplines within psychology, CS is increasingly emerging. However, in others, such as cognitive psychology, CS is currently almost non-existent. This is startling, as we argue that CS can provide excellent opportunities for enriching cognitive research. As cognitive psychology aims to unfold how humans think, perceive, talk, decide, memorize, reason and navigate, CS can offer a broader, more diverse and real-life perspective. Cognition is intertwined with daily life throughout the lifespan, so all of us have lived-experience about cognition. Cognition develops tremendously during childhood, supported by parents and teachers. As adults, we face numerous cognitive challenges, such as studying, learning new skills, and meeting work demands. Older adults experience some cognitive decline at a certain point, which can impact their independence and quality of life (Murman, 2015). Numerous individuals will face cognitive impairment during their lives (Allen et al., 2018; Hale et al., 2020). Even scientists studying cognition are subject to the boundaries of cognition. It is therefore safe to say that cognition is personally relevant to all humans, and many of these unique perspectives currently remain unexplored.

Beyond practical and ethical challenges (see below), deeper philosophical factors may help explain why CS remains rare in psychology, and especially in cognitive psychology, where laboratory studies are often the norm. The field has traditionally operated within a positivist paradigm that prioritizes objectivity, control, and replicability as markers of scientific rigor (Oreskes, 2019). Inviting citizens to co-create research questions or designs challenges these assumptions by introducing subjective perspectives and context-specific priorities. This might lead some researchers to fear that neutrality becomes compromised and that the role of the trained scientist as the gatekeeper of research might be in danger (Funke, 2017). Accepting citizen input therefore requires a shift toward a relational and constructivist view of science, where knowledge is co-produced rather than discovered. As Gergen (2015) argues, research is not merely a mirror of reality but a “world-making” activity with collaborative meaning-making as a cornerstone. This perspective aligns with broader calls for democratizing science (Hecker et al., 2018) and integrating participatory approaches into psychological research (den Houting et al., 2020). Embracing CS in cognitive psychology therefore demands not only methodological innovation, but also a cultural shift toward recognizing the legitimacy of participatory and context-sensitive approaches.

Furthermore, several methodological factors likely contribute to the scarcity of CS initiatives in cognitive psychology. First, high-involvement CS approaches often rely on qualitative methods, such as interviews, focus groups, or participatory workshops (Cornish et al., 2023). These methods might be less familiar and sometimes even undervalued in cognitive psychology as opposed to controlled experimental designs. Second, our field emphasizes experimental control and standardization, which might be more difficult to maintain in real-world settings where CS typically operates. Many cognitive tasks require precise timing and controlled environments, making them trickier to implement outside the lab or via citizen-led protocols. Third, involving citizens in data collection introduces concerns about data quality and adherence to protocols, particularly in paradigms where small measurement errors can significantly affect results.

Today, only a few cognitive psychology researchers have adopted a CS approach in their research. Crucially, these studies show that the methodological hurdles can be overcome, and CS is feasible in the field of cognitive psychology. In the United Kingdom Booth and colleagues (2020) carried out a large-scale CS study on the impact of classroom breaks to perform physical activity on cognitive performance in schools across the country, with over 7000 participating children. In this study, volunteering teachers guided children in collecting data of themselves, while also educating them on the scientific method. Using this approach, the researchers were able to address shortcomings in the existing literature on the topic, such as a lack of statistical power and the failure to consider important mediators (Booth et al., 2020). The study showed that outdoor activity improved pupils' cognition and wellbeing compared to other activities, and hence was able to provide support for wide-spread practices that were not yet well-researched (Booth et al., 2020). After analysis, the children received their summarized individual results, and anonymized group-level results were given to teachers so that they could use them for discussion in class, along with provided materials on physical activity and scientific methodology. Another CS study by Szigeti et al. (2021) on the effects of psychedelic microdosing on cognitive function and psychological well-being, trained citizens to collect their own data and to self-anonymize. Note that data collection went beyond passively having data collected from participants, as they self-administered the microdoses and implemented their own placebo control condition using online instructions. By collaborating with the citizens, the researchers were able to conduct the largest placebo-controlled study on psychedelics to that date. Interestingly, the results of this study suggested that previously claimed benefits of microdosing psychedelics are driven by the placebo effect. Due to the restrictive policies on drugs, a typical (i.e., non-CS) clinical study of this kind would not only have been difficult, but also expensive to conduct. CS allowed the researchers to overcome these barriers, thereby providing access to new knowledge on the effects of microdosing on well-being and cognition. Although the citizen involvement in the design and planning of the study in these two examples was low, the high effort of the activities (e.g., teaching children about the methodology, learning to self-anonymize, following the study protocol, collecting data using multiple measures), situates these projects in the top left quadrant of the 2D-CS model (see Figure 4).

Interestingly, there are also a few studies where co-creation was part of the CS approach, situating them in the top right quadrant of the model. A first example is a study carried out by Gignac et al. (2022) on the effect of short-term exposure to nitrogen dioxide on cognitive control performance. More specifically, residents of Barcelona co-designed the study and a larger group of residents self-collected data, providing repeated measures of cognitive control, well-being and lifestyle and situational factors at the time of measurement (e.g., alcohol consumption in past 24 hours), as well as GPS location data. These location data were then linked to nitrogen dioxide concentrations measured by different air quality monitoring stations across the city. The study showed that an increase in nitrogen dioxide was related to fewer correct responses and slower response times on the cognitive control task, and higher self-perceived stress. A second example is an experimental study that included the participation of teachers in a randomized control trial where children either received an inhibitory control training or a control condition. Children in the inhibition group showed a greater improvement in their inhibitory than the control training group. Crucially, the teachers co-designed the training activities, randomly assigned the children to the experimental conditions and collected the data (Letang et al., 2021). This latter study shows that also fully experimental designs can lend themselves to CS.

Aside from these examples that have taken important initial steps in the use of CS within cognitive psychology, to our understanding, the potential of CS, and particularly higher effort and involvement implementations such as co-creation, remains largely underutilized by cognitive psychologists.

## Opportunities

This underusage of CS in psychology is surprising, as the examples provided above already illustrate several opportunities that CS has to offer. CS provides advantages for scientists and citizens alike, making it an excellent and necessary complement to traditional, fundamental and theory-driven research.

First, CS allows scientists to consider new perspectives on their research topics and to access the unique experience-based knowledge that citizens have about specific situations, such as their physical environment (e.g., Storme et al., 2022), personal experience (e.g., Heyen et al., 2022; Storme et al., 2022; Tran et al., 2019) or professional context (e.g., Smit et al., 2023). For example, Storme and colleagues (2022) led a CS project in which the perspectives of adolescents were used to create detailed maps of (perceived) road safety, which is difficult to estimate using traditional approaches (such as analyzing registered crashes). As mentioned earlier, studies using a PAR approach also highlight the importance of including input from people with lived experience on the topic under investigation. New perspectives can give rise to novel, timely and relevant (perhaps even unexpected) research questions and approaches. For example, in the study of Gignac et al. (2022) on the effect of nitrogen dioxide on cognitive control, citizens prioritized research questions that they felt needed to be studied with regards to air pollution and health. They highlighted a need to study effects of air pollution on cognition, which opened up new research avenues. Another compelling example was the approach of Collins et al. (2020), who used Facebook to target parents of young children to co-create eight projects where parents delineated the questions they wanted to have answered by scientific research, which were not necessarily topics that the researchers would have considered before (i.e., “the Parenting Science Gang”).

Second, when the subject of scientific research is defined in a bottom-up way, based on the needs and concerns of citizens, research becomes more relevant for society and more impactful (Hecker et al., 2018). It is easier for research to have an impact on a policy level, if it is focused on topics that are important to society. Policy impact has been proposed as a CS aim (Van Brussel & Huyse, 2019). This can be achieved by, for example, including (local) governments in the project and maintaining dialogue throughout the project (Van Brussel & Huyse, 2019). Of course, the potential of policy impact is highly dependent on the specific topic and results of the research. Still, previous CS projects have shown that the impact can go from receiving attention in parliamentary discussions of policy changes (e.g., Huyse et al., 2019) to the creation of protected areas for local people (Chiaravalloti, 2021). Within cognitive psychology, impact on policy through citizen engagement is also possible. For example, CS studies on cognitive processes organized by and with teachers and pupils (cf. Booth et al., 2020), could inform educational guidelines and classroom practices on how to stimulate executive function in schools. Citizen-driven research on cognitive aging might shape public health strategies for maintaining cognitive health or increasing cognitive reserve in older adults. Co-created projects examining environmental impacts on cognition (e.g., air pollution; cf. Gignac et al., 2022) could support urban planning and environmental regulations. Even studies on emerging practices, such as microdosing (cf. Szigeti et al., 2021), can inform regulatory policy decisions. These examples illustrate how CS can bridge cognitive research and societal needs, creating pathways for policy impact.

Third, research relevant to society that actively engages citizens is also easier to communicate to a broader audience. CS could therefore help science to reach a larger audience than is traditionally the case. Besides being able to communicate research results to larger groups of citizens, CS projects sometimes receive attention in mainstream media because of their wide reach and societal impact. For example, the cognitive psychology study by Booth et al. (2020) was supported by the BBC and its campaign aired on several TV channels.

Fourth, when research addressing societal concerns becomes more frequent and citizens feel heard, a higher sense of trust in science and scientific experts can develop (Benson-Greenwald et al., 2023). More specifically, CS can shift the perception of the public from science that serves a select privileged unrepresentative subgroup within society that studies topics of their own interest, to science that serves the interest of society. Although the public seems to have a general sense of trust in science (Hendriks et al., 2016), mistrust in science has been observed repeatedly in non-negligible portions of society (e.g., Funk, 2017; Hendriks et al., 2016), particularly in the context of societal challenges such as the COVID-19 pandemic (e.g., Kreps & Kriner, 2020) and climate change (e.g., Funk, 2017; Hendriks et al., 2016; Sarathchandra et al., 2022). It has been found that the trust in science would benefit from a more prosocial and communal perception of science. Benson-Greenwald and colleagues (2023), for example, combined datasets from different survey studies on science perception and public trust in science, and found that the perception of science and scientists as communally motivated promoted respondents' trust in science. Similarly, Queiruga-Dios et al. (2020) found that the implementation of a CS project in a secondary school improved adolescents' attitudes towards science and technology. In sum, CS could help boost the faith that society has in science and operationalize trust-promoting principles (see for example Covitt & Anderson, 2022; Muğaloğlu et al., 2022; Reiss, 2022). Strengthening trust and engagement might be particularly relevant for psychology and its subdisciplines, in light of the replication crisis in psychology (Stanley et al., 2018), which has raised questions about the reliability and transparency of research findings.

Citizen science offers a way to counteract these concerns by promoting openness, large-scale data collection, and inclusive research practices.

Fifth, through participation in CS projects, citizens can become more acquainted with science, its methods and reasoning (Bonney et al., 2016). In addition to serving society in general, CS has the potential to be a particularly democratic learning tool, that can be used as such in education (Harlin et al., 2018). By actively participating in a research project, citizens can experience conducting scientific research and develop their scientific literacy (Phillips et al., 2019; Queiruga-Dios et al., 2020; see for example the cognitive psychology study of Booth et al., 2020). Scientific literacy can play an important role in a world where we have to make decisions all the time, based on the knowledge that is available to us. The ability to scrutinize how that knowledge was achieved can empower citizens to make informed decisions.

Sixth, CS research has the potential to achieve sample sizes that are difficult to obtain using traditional research approaches, because they are too expensive, time-consuming and therefore often impossible for researchers to perform on their own (e.g., Snik et al., 2014). Large scale CS projects with thousands (e.g. Booth et al., 2020; Lebeer et al., 2023; Snik et al., 2014), tens of thousands (e.g., Meysman et al., 2020) or even millions of participating citizens (Spiers et al., 2023) have been completed successfully, often generating knowledge that had not been accessible before. The same argument has also been made for the field of psychology (Hilton & Mehr, 2022). Furthermore, CS can help researchers reach samples that are otherwise difficult to access, by opening up a huge potential participant pool and by bringing studies to the participant instead of vice versa, avoiding barriers to participate such as mobility. For example, Bonhoure et al. (2023) included people with mental health conditions to co-create experiments and Sonuga-Barke et al. (2024) involved neurodivergent people to better understand their emotional experience. These studies reached populations that are typically underrepresented in traditional psychological research due to stigma and recruitment challenges. Li and colleagues (2022) argue that the datasets achievable through CS can provide a solution to the issue of replication and generalization failures, as seen in psychology (Li et al., 2022; Stanley et al., 2018) and medicine (e.g., Baker & Dolgin, 2017).

Finally, CS creates the potential for more democratic, representative and inclusive research (Moustard et al., 2021). Whereas research in psychology often relies on convenience samples (e.g., 1st year psychology students), CS has the potential to include any citizen in scientific research that researchers want to reach (e.g., by inviting citizens with lived experience to co-create research questions, by asking citizens to collect data on others), regardless of their background or circumstances (see for example Bonhoure et al., 2023; Sonuga-Barke et al., 2024). However, this potential exists in theory, and reaching this potential in practice might be challenging. Booth and colleagues (2020) achieved a considerably more balanced sample in terms of socioeconomic status and biological sex than is typically seen in psychological research (Henrich et al., 2010), possibly due to the wide reach and high accessibility achieved through the BBC's Terrific Scientific program. However, Pateman and colleagues (2021) examined demographic variables related to citizen participation in environmental CS and found imbalances in gender, ethnic background and socio-economic status. These biases have been repeatedly observed in other CS studies as well (Cooper et al., 2021; Mahmoudi et al., 2022). Documentation and publication of citizen demographics to monitor citizen diversity could help improve the inclusiveness of CS (Pateman et al., 2021), and so can other actions such as collaborating with organizations that work with underrepresented groups (Pateman et al., 2021), familiarizing citizens with concepts and terms, clarifying expectations and providing multiple ways to participate (Paleco et al., 2021). In addition, Brouwer and Hessels (2019) have compared citizen recruitment strategies and their effects on citizen diversity and found that a targeted recruitment strategy, personally inviting specific households to participate, led to a more diverse group of participating citizens. However, despite its challenges, some extreme CS projects show that CS is possible even in the most underrepresented and disadvantaged groups (e.g., Chiaravalloti et al., 2022).

## Challenges

Besides the many opportunities that CS has to offer, it also faces challenges. First, CS research that involves citizens for the data collection or data processing is often criticized on the aspects of data quality and reliability (e.g., Balázs et al., 2021; Dittmann et al., 2022; Funke, 2017). It has been argued that CS measurements are of low quality because of the use of low-cost technology, substandard protocols or citizen biases during data collection (Bird et al., 2014; Funke, 2017; Kosmala et al., 2016). This may threaten the internal validity and reliability of studies (Balázs et al., 2021). Although this is a valid concern, efforts can be made to counteract this threat. There are controlling mechanisms to check the data collection and processing performed by citizens for errors and biases (e.g., Dittmann et al., 2022; Riesch & Potter, 2014). For example, observations made by citizens can be compared to those of an expert in random checks (Balázs et al., 2021). Also, training in and communication about data collection protocols are important (Balázs et al., 2021; Booth et al., 2020). In some cases, citizen measurements are compared to available traditional measurements (e.g., Snik et al., 2014; who observed good agreement between citizen and traditional measurements). Given the potential of CS to reach large samples, another strategy that can be used in this context, is crowd aggregation. The collective opinion of a large, diverse group of people is often more accurate than that of individuals (i.e., the wisdom of the crowd effect; e.g., Davis-Stober et al., 2014). Cognitive modelling has proven especially worthwhile in improving data quality in wisdom of the crowd applications (e.g., Montgomery et al., 2024). These solutions, training of citizens, drafting standardized protocols, comparison with traditional data, crowd aggregation strategies, also apply to the concern of lack of control and standardization - a concern that might be especially present in cognitive psychology.

Second, although the use of social and mainstream media can facilitate recruitment of citizens, finding citizens who are willing to participate can be a challenge (Rotman et al., 2014), especially when aiming for a representative group of citizens (Cooper et al., 2021). Additionally, most projects face at least some citizen drop-out (Brouwer & Hessels, 2019). Initiators of CS projects can experience difficulty in reaching and engaging a large group of citizens, as scientists are not always prepared for the communication challenge that CS projects may pose and different communication strategies may impact recruitment (e.g., Lee et al., 2018). However, CS organizations, governments and other funders can assist in achieving CS specific project funding and can educate both scientists and citizens on topics such as (science) communication and project management.

The challenges above are of a general nature and apply to all fields. The specific scarcity of CS studies in psychology may be caused not only by a lack of familiarity of researchers with CS, but also by a lack of knowledge on how to overcome certain challenges that are more specific to psychology. One such challenge for CS in psychology is associated with studying human subjects: how can you actively involve citizens when they are also the aware subject of the research that is being carried out? If citizens were to collect data on themselves, this could indeed be challenging, as they would simultaneously take both the role of the researcher and the role of the subject, which we will refer to as the researcher-subject paradox. After all, we often want to avoid that the participant is informed about the hypotheses at hand, to prevent social desirability bias and confirmation bias. In addition, many psychological assessments are not designed for self-assessment. However, this challenge can be mitigated by taking into account three important considerations. First, there are many possible implementations of the CS approach that decouple the role of the researcher and the subject. For example, the citizens collecting data (i.e. role of the researcher) and those being tested (i.e. role of the subject) should not necessarily be the same group of citizens. While receiving support and training from scientific experts, citizens can test each other. For example, teachers can collect data from the children in their classrooms (e.g., Letang et al., 2021), parents can collect data from their children (e.g., Collins et al., 2020) or citizens can collect data from other citizens. Second, it is possible to self-test, for example by teaching participants how to self-anonymize in placebo-controlled studies (Szigeti et al., 2021) or by instructing teachers how to support children in their self-testing (Booth et al., 2020). Third, citizens should not by definition be included in the data collection of a CS study. They can also be involved in the formulation of research questions and design of studies (Ramirez-Andreotta et al., 2015), data processing (e.g., Keshavan et al., 2019), practical implementation (e.g., Parrello et al., 2019; Ramirez-Andreaotta et al., 2015) and discussion of results (e.g., Booth et al., 2020). We argue that co-defined research (i.e., bottom right quadrant in the 2D-CS model, with high involvement in design and planning but low activity level) is a particularly accessible form of the CS approach for psychology to adopt. Citizens could be involved in formulating relevant research questions through focus groups, large-scale demographically representative surveys, mass-communicated calls for questions and concerns or requests from schools, citizen initiatives, patient groups and non-profit organizations. Admittedly, overcoming the researcher-subject paradox requires out-of-the-box thinking and best practices should be developed as psychology embraces CS. However, this effort is important, considering the aforementioned opportunities that CS has to offer.

Another challenge, related to the researcher-subject paradox, is that of the ethical implications of involving citizens. As psychology researchers deal with personal and often sensitive data, research has to follow strict ethical guidelines (e.g., American Psychological Association, 2017; World Medical Association, 2013), as well as General Data Protection Regulation (GDPR) law (Crutzen et al., 2019). If citizens become involved in the data collection or processing of other citizens' personal data, these ethical and legal considerations still apply and, even more so, additional measures should be taken that hold for the data-collecting citizen as well as the tested citizen (Resnik, 2019). Data-collecting citizens could follow an obligatory ethical training (Resnik, 2019) in which they learn about the ethical guidelines and GDPR, ideally applying the newly learned knowledge to exercises and questions in an active workshop and formally agreeing to follow all guidelines. Tested citizens could receive an extended informed consent in which they are informed that their data will be collected by a non-professional scientist who followed an obligatory training and formally agreed to follow the ethical regulations at all times. It should also be mentioned in the informed consent how the CS aspect of their participation affects the way their personal data are handled. Since CS is still relatively uncommon in psychology, efforts must be made to advance knowledge on the specific ethical and legal considerations of CS within psychology (Resnik, 2019).

## Citizen Science and Open Science: a perfect match?

When applying CS in psychology, we need to address how CS can operate in our landscape of increasing open science practices. Over the past decades, tremendous efforts have been made within the scientific community to strive towards more available, accessible and reusable research, referred to as Open Science (OS; UNESCO Recommendation on Open Science, 2021; European Commission, n.d.). OS practices involve opening up access to data, tools and publications, encouraging more transparency of research processes and advocating for more reusability of research. The increasing awareness towards OS manifests itself in the policies of research institutions, governments and global organizations. The United Nations Educational, Scientific and Cultural Organization (UNESCO), for example, formulated specific recommendations for OS, encouraging member states to promote and invest in OS (UNESCO Recommendation on Open Science, 2021). The European Commission formulated a specific OS policy, and regards it as an important component of their research funding and monitors the development of OS practices throughout Europe (European Commission, n.d.). In the US, the White House Office of Science and Technology Policy (OSTP) has declared the year 2023 as their Year of Open Science to encourage Open Science practices on a national level (The White House, 2023). As OS encourages making knowledge more openly available and accessible to anyone in- and outside of the academic community, it becomes clear that OS and CS share important common goals and are therefore well aligned (Hecker et al., 2018). Ultimately, CS can be a particularly immersive and inclusive way of opening up the research process, for example by ensuring citizen access to data and publications and providing first-hand experience of different steps in the research process. To stress the value of CS for OS, the Citizen Science Global Partnership (CSGP) recommended the UNESCO to include Citizen Science as a pillar of Open Science (Wehn et al., 2020). UNESCO specifically encourages member states to invest in

OS infrastructures, among which platforms that foster the co-creation of knowledge (e.g., by using a CS approach) and to promote the development of new participatory methods (UNESCO Recommendation on Open Science, 2021). The EU has included CS as one of eight ambitions in their OS policy (European Commission, n.d.). From these communications, it becomes clear that OS and CS, in synergy, can encourage the global scientific community to strive for a new reality, in which science becomes more accessible, transparent and democratic, and where the distance between scientists and citizens decreases.

## Recommendations

It becomes clear that CS is only starting to find its way to psychology and its subdisciplines such as cognitive psychology, which leaves room for future developments. In line with the current review, further efforts should be made to raise awareness about the opportunities of CS for psychology, encouraging researchers to consider CS approaches in future research projects. In addition, there is a need for discussion about prominent challenges such as the researcher-subject paradox (Resnik, 2019), ethical and legal considerations (Resnik, 2019), data quality (Balázs et al., 2021) and diversity (Pateman et al., 2021), and for communication about inspiring examples that demonstrate creative solutions to overcome these challenges.

One crucial way to stimulate the use of CS in the field of psychology, is by providing good practices for researchers who want to embark on CS and by sharing CS resources. Below, we provide some initial guidelines for beginning CS researchers. Some of these guidelines are more general and apply to implementing CS across disciplines (recommendations 1-4), while others address discipline-specific challenges (recommendations 5-8).

1. Gather information and seek support from citizen science organizations and governments.

A good starting point to explore the possibility of a CS project is to inform yourself about the concept of citizen science, potential funding opportunities, and to seek out advice on best practices, as offered by citizen science organizations and governments. EU-Citizen.Science is a EU-funded online platform with a large database of example projects, resources, trainings etc. Haklay and colleagues (UCL Extend: Introduction to Citizen Science & Scientific Crowdsourcing, n.d.) provided a free online course on CS and scientific crowdsourcing. The ECSA provides several documents on guidelines and policies (Documents - European Citizen Science Association (ECSA), n.d.), including ten principles that can be used as best practice guidelines for the implementation of CS across diverse situations and disciplines (Robinson et al., 2018; Sturm et al., 2017). CitizenScience.gov (the US government platform on CS) provides a toolkit for crowdsourcing and CS (National Coordination Office for the Federal Community of Practice on Crowdsourcing and Citizen Science, n.d.). These are only a few examples of existing resources that can help understand CS to a greater extent. In addition, consider reading comprehensive books on CS such as the freely available book "The Science of Citizen Science" by Vohland and colleagues (2021). We would like to point out that examples from psychology will be less likely included in these resources. However, they do provide a good introduction to CS. In addition, many of the best practices that are shared apply to all domains.

2. Learn from previous CS projects in your field of study.

When considering starting a CS project, it can be helpful to search the literature for studies in your field of study (and neighboring fields) to learn about limitations and challenges that other researchers have pointed out and which suggestions for future projects they provide, to discover creative solutions to barriers that you may encounter in your own project (e.g., how to overcome the researcher-subject paradox) and to find inspiration. Consider contacting authors if you have specific questions about their CS experiences.

3. Reflect on the nature of citizen participation.

After informing yourself about CS and obtaining examples from your field of study, consider which forms of citizen participation provide value *both* for you as a researcher and for the citizens. The 2D-CS model (see Figure 4) can be used as a guideline for orienting your CS project based on citizen activity level and citizen involvement in design and planning. Consider whether citizens would be included in the formulation of research questions and hypotheses, whether they would participate in the design and planning of the study, whether and in what way they would collect data and so on. Note that it should not be an absolute aim for citizens to participate in as many research steps as possible, without considering the value of that participation. For example, if the data collection involves technical methodologies that require extensive training (e.g., brain imaging), it would be less advisable (and also not necessary) to try to involve citizens in that step of the research process. In addition, reflect on the size of the project, both in terms of how extensive the data collection should be and in terms of the target number of participating citizens.

4. Seek support for communication and project management.

Reaching citizens might be a challenge, as discussed above, and a good communication strategy might be key in obtaining the citizen representatives you aimed for. Depending on the size of the CS project, communication efforts may go beyond your acquired skillset and thus, may require strategic planning. It may be helpful to seek the advice of a communication expert who can assist in developing a communication strategy and its implementation. Universities often have their own communication department, which can be a helpful local resource in this regard. In the same vein, the project management might also require additional support, especially if a large group of citizens will participate.

5. Address the researcher-subject paradox

In psychology, participants are often the subjects of study, which raises concerns about bias if they also act as data collectors. To mitigate this, design projects where citizens collect data from others (e.g., teachers testing students, parents testing children) but not themselves, or use self-testing protocols that minimize hypothesis awareness (e.g., self-blinding techniques as in Szigeti et al., 2021). In any case, offer citizens thorough training how to collect data, or others or themselves. This ensures scientific rigor while maintaining active citizen involvement. Finally, be aware that CS is not limited to having citizens collect data. Consider including citizens in, for example, formulation of research questions and hypotheses, study design, and /or interpretation of study results. Involving citizens in these phases of research, is not subject to the researcher-subject paradox.

6. Integrate Citizen Perspectives in Research Design (i.e., co-creation)

In psychology, we study people. This makes CS particularly compelling for our field, as it uniquely allows us to involve our study participants in shaping the research conducted about them. Crucially, consider actively engaging citizens in co-creating research. Ask them about their experiences, concerns, and priorities—what they believe should be studied. Beyond data collection, involve citizens in defining research questions that matter to them, such as cognitive health, neurodiversity, or educational challenges. Practical strategies include organizing focus groups, conducting large-scale surveys, or partnering with schools, patient organizations, and caregivers to ensure research addresses real-world needs. You can also present your ongoing research agenda to citizens and invite feedback, creating a dialogue that strengthens relevance and trust. When studying people, their input is not just helpful—it is invaluable for making psychological research more inclusive, impactful, and connected to everyday life.

7. Consider possible ethical and legal issues.

Although ethical and legal considerations are important for all CS projects, psychological data often involve sensitive personal information. If citizens collect or process such data, provide mandatory ethical training and adapt informed consent procedures to clarify the role of the citizen scientists. Ensure compliance with GDPR and institutional ethical and data privacy requirements. Define the role of the citizens in your data management plan (cf. who will have access to the data, who will store the data, etc.). Local university departments may be an excellent resource for support. Alternatively, citizen science organizations could also be of help.

8. Communicate, educate and build capacity

Finally, as CS is still limited within psychology, develop best practices, guidelines and tools while you conduct your CS projects. Share these openly with others, so that the field of psychology can benefit from a growing knowledge-base. Develop research networks dedicated to CS implementation in our field, allowing researchers to exchange experiences and expertise. Enhance scientific literacy among citizens by explaining the goals, methods, and implications of the research to foster trust and engagement. Make CS a part of your science outreach plan, so CS practices also find their way to a broader audience. Finally, CS does not need to be all-or-nothing. Begin with manageable steps, such as co-defining research questions or piloting citizen-led data collection in schools. Gradually expand involvement as best practices develop within psychology.

## Conclusion

Cognitive psychology has long relied on controlled laboratory studies and convenience samples to advance knowledge. While these approaches have yielded important insights, they often fall short in capturing the complexity and diversity of real-world cognition. CS offers a powerful way to bridge this gap. By actively involving citizens in research, whether through an active role in data collection, co-design of studies, or interpretation of findings, CS can enrich psychological research with perspectives and contexts that traditional methods overlook.

The examples discussed in this paper demonstrate that CS is not only feasible in psychology, but can generate large, diverse datasets, address questions of societal relevance, and foster public trust in science. Yet, its adoption in cognitive psychology remains minimal. This is a missed opportunity. Cognitive processes—such as attention, memory, decision-making, and problem-solving—are deeply embedded in everyday life. There is no one better suited to help shape research questions and contribute to data than the very individuals who experience these processes daily. Citizens can inform psychologists about which questions are important within society and require scientific attention. For example, how can we create environments that are inclusive in light of neurodiversity (Sonuga-Barke & Thapar, 2021)? How can cognition be enhanced in a safe and accessible manner (e.g., Hyman, 2011)? How can brain function be maintained in the face of aging (Blondell et al., 2014; Dumas, 2017)? How do the effects of climate change affect our wellbeing (Cedeño Laurent et al., 2018; Zhang et al., 2018)? These examples illustrate how citizen involvement could enrich research on cognition and its real-world challenges.

We urge researchers in the field of psychology and its subdomains to consider and embrace CS approaches. Start small if needed: involve citizens in defining research priorities, invite them to co-create tasks, or leverage their networks to support data collection. Doing so will not only advance scientific understanding but also make research more inclusive, impactful, and aligned with societal needs. CS is not a replacement for rigorous experimental work—it is a complement that can transform how we study cognition in the real world, leading to new and exciting research avenues. The time is ripe for cognitive psychology to move beyond the lab and collaborate with citizens to tackle the pressing questions of our time.

## Declarations

**Funding.** This work was supported by a grant of KU Leuven awarded to EVDB (grant numbers C14/21/046 and C16/25/004).

**Conflicts of interest/Competing interests.** The authors have no competing interests to declare that are relevant to the content of this article.

**Ethics approval.** Not applicable.

**Consent to participate.** Not applicable.

**Consent for publication.** Not applicable.

**Availability of data and materials.** Not applicable.

**Code availability.** Not applicable.

**Authors' contributions.** EVDB, KAV, BR and GH conceptualized the review; EVDB and KAV conducted the investigation (i.e., literature search); KAV created the new Citizen Science model; EVDB, BR and GH were responsible for project administration, resources and supervision; KAV wrote the original draft; EVDB, BR and GH wrote later versions and reviewed and edited the writing.

## References

Aguiar De Medeiros, C. (2003). The post-war American technological development as a military enterprise. *Contributions to Political Economy, 22*(1), 41–62. https://doi.org/10.1093/cpe/22.1.41

Allen, D. H., Myers, J. S., Jansen, C. E., Merriman, J. D., & Von Ah, D. (2018). Assessment and Management of Cancer- and Cancer Treatment–Related Cognitive Impairment. *The Journal for Nurse Practitioners, 14*(4), 217-224.e5. https://doi.org/10.1016/j.nurpra.2017.11.026

American Psychological Association. (2017). *Ethical Principles of Psychologists and Code of Conduct.*

Baker, M., & Dolgin, E. (2017). Reproducibility project yields muddy results. *Nature, 541*(7637), 269–270.

Balázs, B., Mooney, P., Nováková, E., Bastin, L., & Jokar Arsanjani, J. (2021). Data Quality in Citizen Science. In K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, R. Samson, & K. Wagenknecht (Eds.), *The Science of Citizen Science* (pp. 139–157). Springer International Publishing. https://doi.org/10.1007/978-3-030-58278-4_8

Barton, R. (2003). ‘Men of Science’: Language, Identity and Professionalization in the Mid-Victorian Scientific Community. *History of Science, 41*(1), 73–119. https://doi.org/10.1177/007327530304100103

Baten, J. (2022). *Schooling, literacy and numeracy in 19th century Europe: Long-term development and hurdles to efficient schooling.* UNESCO.

Becker, C. B., Stice, E., Shaw, H., & Woda, S. (2009). Use of empirically supported interventions for psychopathology: Can the participatory approach move us beyond the research-to-practice gap? *Behaviour Research and Therapy, 47*(4), 265–274. https://doi.org/10.1016/j.brat.2009.02.007

Beer, J. J., & Lewis, W. D. (1963). Aspects of the Professionalization of Science. *Daedalus, 92*(4), 764–784.

Benson-Greenwald, T. M., Trujillo, A., White, A. D., & Diekman, A. B. (2023). Science for Others or the Self? Presumed Motives for Science Shape Public Trust in Science. *Personality and Social Psychology Bulletin, 49*(3), 344–360. https://doi.org/10.1177/01461672211064456

Bird, T. J., Bates, A. E., Lefcheck, J. S., Hill, N. A., Thomson, R. J., Edgar, G. J., Stuart-Smith, R. D., Wotherspoon, S., Krkosek, M., Stuart-Smith, J. F., Pecl, G. T., Barrett, N., & Frusher, S. (2014). Statistical solutions for error and bias in global citizen science datasets. *Biological Conservation, 173*, 144–154. https://doi.org/10.1016/j.biocon.2013.07.037

Blondell, S. J., Hammersley-Mather, R., & Veerman, J. L. (2014). Does physical activity prevent cognitive decline and dementia?: A systematic review and meta-analysis of longitudinal studies. *BMC Public Health, 14*(1), 510. https://doi.org/10.1186/1471-2458-14-510

Bonhoure, I., Cigarini, A., Vicens, J., Mitats, B., & Perelló, J. (2023). Reformulating computational social science with citizen social science: The case of a community-based mental health care research. *Humanities and Social Sciences Communications, 10*(1), 81. https://doi.org/10.1057/s41599-023-01577-2

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy. *BioScience, 59*(11), 977–984. https://doi.org/10.1525/bio.2009.59.11.9

Bonney, R., Phillips, T. B., Ballard, H. L., & Enck, J. W. (2016). Can citizen science enhance public understanding of science? *Public Understanding of Science, 25*(1), 2–16. https://doi.org/10.1177/0963662515607406

Booth, J. N., Chesham, R. A., Brooks, N. E., Gorely, T., & Moran, C. N. (2020). A citizen science study of short physical activity breaks at school: Improvements in cognition and wellbeing with self-paced activity. *BMC Medicine, 18*(1), 62. https://doi.org/10.1186/s12916-020-01539-4

Brouwer, S., & Hessels, L. K. (2019). Increasing research impact with citizen science: The influence of recruitment strategies on sample diversity. *Public Understanding of Science, 28*(5), 606–621. https://doi.org/10.1177/0963662519840934

Brown, P. (1997). Popular epidemiology revisited. *Current Sociology*, *45*(3), 137-156.

Brown, H.R., Zeidman, P., Smittenaar, P., Adams, R.A., McNab, F., et al. (2014) Crowdsourcing for Cognitive Science – The Utility of Smartphones. *PLoS ONE, 9*(7):e100662. doi:10.1371/journal.pone.0100662

Cedeño Laurent, J. G., Williams, A., Oulhote, Y., Zanobetti, A., Allen, J. G., & Spengler, J. D. (2018). Reduced cognitive function during a heat wave among residents of non-air-conditioned buildings: An observational study of young adults in the summer of 2016. *PLOS Medicine, 15*(7), e1002605. https://doi.org/10.1371/journal.pmed.1002605

Chapman, K., Dixon, A., Cocks, K., Ehrlich, C., & Kendall, E. (2022). The Dignity Project Framework: An extreme citizen science framework in occupational therapy and rehabilitation research. *Australian Occupational Therapy Journal, 69*(6), 742–752. https://doi.org/10.1111/1440-1630.12847

Chernoff, N. N. (2003, February 13). *What is translational research?* Association for Psychological Science - APS. https://www.psychologicalscience.org/observer/what-is-translational-research

Chiaravalloti, R. M. (2021). Representing a fish for fishers: geographic citizen science in the Pantanal wetland, Brazil. *Geographic Citizen Science Design: No one Left Behind.* UCL Press, London.

Chiaravalloti, R. M., Skarlatidou, A., Hoyte, S., Badia, M. M., Haklay, M., & Lewis, J. (2022). Extreme citizen science: Lessons learned from initiatives around the globe. *Conservation Science and Practice, 4*(2). https://doi.org/10.1111/csp2.577

*CITSCI Working Group*. (2021, April 16). National Cancer Institute. https://www.cancer.gov/research/resources/citizen-science/working-group

Collins, S., Brueton, R., Graham, T. G., Organ, S., Strother, A., West, S. E., & McKendree, J.

(2020). Parenting Science Gang: Radical co-creation of research projects led by parents of young children. *Research Involvement and Engagement, 6*(1), 9. https://doi.org/10.1186/s40900-020-0181-z

Cooper, C. B., Hawn, C. L., Larson, L. R., Parrish, J. K., Bowser, G., Cavalier, D., Dunn, R. R., Haklay, M., Gupta, K. K., Jelks, N. O., Johnson, V. A., Katti, M., Leggett, Z., Wilson, O. R., & Wilson, S. (2021). Inclusion in citizen science: The conundrum of rebranding. *Science, 372*(6549), 1386–1388. https://doi.org/10.1126/science.abi6487

Cooper, S., Khatib, F., Treuille, A., Barbero, J., Lee, J., Beenen, M., ... & players, F. (2010). Predicting protein structures with a multiplayer online game. *Nature*, *466*(7307), 756-760.

Cooper, C. B., & Lewenstein, B. V. (2016). Two meanings of citizen science. *The Rightful Place of Science: Citizen Science, 2*(2016), 51–62.

Cornish, F., Breton, N., Moreno-Tabarez, U. et al. (2023). Participatory action research. *Nature Reviews Methods Primers, 3*, 3. https://doi.org/10.1038/s43586-023-00214-1

Covitt, B. A., & Anderson, C. W. (2022). Untangling trustworthiness and uncertainty in science: Implications for science education. *Science & Education, 31*(5), 1155–1180. https://doi.org/10.1007/s11191-022-00322-6

Crutzen, R., Ygram Peters, G.-J., & Mondschein, C. (2019). Why and how we should care about the General Data Protection Regulation. *Psychology & Health, 34*(11), 1347–1357. https://doi.org/10.1080/08870446.2019.1606222

Daniels, G. H. (1967). The Pure-Science Ideal and Democratic Culture: A new scientific ideal in the late 19th century led to continuing conflicts with democratic assumptions. *Science, 156*(3783), 1699–1705. https://doi.org/10.1126/science.156.3783.1699

Davis-Stober, C., Budescu, D. V., Dana, J., & Broomell, S. B. (2014). When is a crowd wise? *Decision, 1*(2), 79-101. https://doi.org/10.1037/dec0000004

den Houting, J., Higgins, J., Isaacs, K., Mahony, J., & Pellicano, E. (2020). 'I'm not just a guinea pig': Academic and community perceptions of participatory autism research. *Autism, 25*(1), 148-163. https://doi.org/10.1177/1362361320951696

Dittmann, S., Kiessling, T., Kruse, K., Brennecke, D., Knickmeier, K., Parchmann, I., & Thiel, M. (2022). How to get citizen science data accepted by the scientific community? Insights from the Plastic Pirates project. *Proceedings of Engaging Citizen Science Conference 2022 — PoS(CitSci2022), 124*. https://doi.org/10.22323/1.418.0124

Dumas, J. A. (2017). Strategies for Preventing Cognitive Decline in Healthy Older Adults. *The Canadian Journal of Psychiatry, 62*(11), 754–760. https://doi.org/10.1177/0706743717720691

*Documents - European Citizen Science Association (ECSA)* (n.d.). Retrieved August 21, 2023, from https://www.ecsa.ngo/documents/

European Citizen Science Association (ECSA) (2015). *Ten Principles of Citizen Science*. Berlin. http://doi.org/10.17605/OSF.IO/XPR2N

English, P. B., Richardson, M. J., & Garzón-Galvis, C. (2018). From Crowdsourcing to Extreme Citizen Science: Participatory Research for Environmental Health. *Annual Review of Public Health, 39*(1), 335–350. https://doi.org/10.1146/annurev-publhealth-040617-

013702

European Commission. (n.d.). *Our Digital Future - Open Science*. European Union. https://research-and-innovation.ec.eu European Commission. (n.d.). ropa.eu/strategy/strategy-2020-2024/our-digital-future/open-science_en

European Commission. (2021). *The Science of Citizen Science.* https://euraxess.ec.europa.eu/worldwide/south-korea/science-citizen-science

Fletcher-Watson, S., Adams, J., Brook, K., Charman, T., Crane, L., Cusack, J., Leekam, S., Milton, D., Parr, J. R., & Pellicano, E. (2019). Making the future together: Shaping autism research through meaningful participation. *Autism, 23*(4), 943–953. https://doi.org/10.1177/1362361318786721

Funk, C. (2017). Mixed Messages about Public Trust in Science. *Issues in Science and Technology, 34*(1), 86–88.

Funke, J. (2017). Citizen Science and Psychology: An Evaluation of Chances and Risks. *Heidelberger Jahrbücher Online*, 5-18 Seiten. https://doi.org/10.17885/HEIUP.HDJBO.2017.0.23690

Gergen, K. J. (2015). From mirroring to world-making: Research as future forming. *Journal for the Theory of Social Behaviour, 45*(3), 287–310. https://doi.org/10.1111/jtsb.12075

Gignac, F., Righi, V., Toran, R., Paz Errandonea, L., Ortiz, R., Mijling, B., Naranjo, A., Nieuwenhuijsen, M., Creus, J., & Basagaña, X. (2022). Short-term NO2 exposure and cognitive and mental health: A panel study based on a citizen science project in Barcelona, Spain. *Environment International, 164,* 107284.

https://doi.org/10.1016/j.envint.2022.107284

Haklay, M. (2013). Citizen science and volunteered geographic information: Overview and typology of participation. In D. Sui, S. Elwood, & M. Goodchild (Eds.), *Crowdsourcing geographic knowledge: Volunteered geographic information (VGI) in theory and practice* (pp. 105–122). Springer. https://doi.org/10.1007/978-94-007-4587-2_7

Haklay, M. (2015). *Citizen Science and Policy: A European Perspective*. Woodrow Wilson International Center for Scholars: Washington, DC.

Haklay, M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S., & Vohland, K. (2021). What is citizen science? The challenges of definition. In K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, R. Samson, & K. Wagenknecht (Eds.), *The Science of Citizen Science*. Springer. https://doi.org/10.1007/978-3-030-58278-4_2

Hale, J. M., Schneider, D. C., Mehta, N. K., & Myrskylä, M. (2020). Cognitive impairment in the U.S.: Lifetime risk, age at onset, and years impaired. *SSM - Population Health, 11,* 100577. https://doi.org/10.1016/j.ssmph.2020.100577

Harlin, J., Kloetzer, L., Patton, D., Leonhard, C., & Leysin American School high school students. (2018). Turning students into citizen scientists. In *Citizen science: Innovation, Open Science, Society and Policy.* UCL Press.

Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (Eds.). (2018). *Citizen Science: Innovation in Open Science, Society and Policy*. UCL Press. https://doi.org/10.2307/j.ctv550cf2

Hendriks, F., Kienhues, D., & Bromme, R. (2016). Trust in Science and the Science of Trust. In

B. Blöbaum (Ed.), *Trust and Communication in a Digitized World* (pp. 143–159). Springer International Publishing. https://doi.org/10.1007/978-3-319-28059-2_8

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences, 33*(2–3), 61–83. https://doi.org/10.1017/S0140525X0999152X

Heyen, N. B., Gardecki, J., Eidt-Koch, D., Schlangen, M., Pauly, S., Eickmeier, O., Wagner, T., & Bratan, T. (2022). Patient Science: Citizen Science Involving Chronically Ill People as Co-Researchers. *Journal of Participatory Research Methods, 3*(1). https://doi.org/10.35844/001c.35634

Hilton, C. B., & Mehr, S. A. (2022). Citizen science can help to alleviate the generalizability crisis. *Behavioral and Brain Sciences, 45*, e145. https://doi.org/10.1017/S0140525X22001308

Huyse, H., Bachus, K., Merlevede, T., Delanoeije, J., & Heidi Knipprath, H. (2019). Societal Impact of the Citizen Science Project "CurieuzeNeuzen Vlaanderen": Final report. *HIVA-KU Leuven, Leuven. Available at https://hiva. kuleuven. be/nl/onderzoek/thema/klimaatendo/p/projecten/CurieuzeNeuzen_ Vlaanderen*.

Hyman, S. E. (2011). Cognitive Enhancement: Promises and Perils. *Neuron, 69*(4), 595–598. https://doi.org/10.1016/j.neuron.2011.02.012

Irwin, A. (2018). No PhDs needed: How citizen science is transforming research. *Nature, 562*(7726), 480–483.

Jacobs, S. D. (2016). The Use of Participatory Action Research within Education-Benefits to

Stakeholders. *World Journal of Education, 6*(3), p48. https://doi.org/10.5430/wje.v6n3p48

Jones, R. (2001). "Why can't you scientists leave things alone?" Science questioned in British films of the post-war period (1945-1970). *Public Understanding of Science, 10,* 365–382.

Keshavan, A., Yeatman, J. D., & Rokem, A. (2019). Combining Citizen Science and Deep Learning to Amplify Expertise in Neuroimaging. *Frontiers in Neuroinformatics, 13*, 29. https://doi.org/10.3389/fninf.2019.00029

Kim, J. S., Greene, M. J., Zlateski, A., Lee, K., Richardson, M., Turaga, S. C., Purcaro, M., Balkam, M., Robinson, A., Behabadi, B. F., Campos, M., Denk, W., Seung, H. S., & the EyeWirers. (2014). Space–time wiring specificity supports direction selectivity in the retina. *Nature, 509*(7500), 331–336. https://doi.org/10.1038/nature13240

Koepnick, B., Flatten, J., Husain, T., Ford, A., Silva, D.-A., Bick, M. J., Bauer, A., Liu, G., Ishida, Y., Boykov, A., Estep, R. D., Kleinfelter, S., Nørgård-Solano, T., Wei, L., Players, F., Montelione, G. T., DiMaio, F., Popović, Z., Khatib, F., … Baker, D. (2019). De novo protein design by citizen scientists. *Nature, 570*(7761), 390–394. https://doi.org/10.1038/s41586-019-1274-4

Koerner, C. L. (2014). Media, fear, and nuclear energy: A case study. *The Social Science Journal, 51*(2), 240–249. https://doi.org/10.1016/j.soscij.2013.07.011

Kosmala, M., Wiggins, A., Swanson, A., & Simmons, B. (2016). Assessing data quality in citizen science. *Frontiers in Ecology and the Environment, 14*(10), 551–560. https://doi.org/10.1002/fee.1436

Kreps, S. E., & Kriner, D. L. (2020). Model uncertainty, political contestation, and public trust in science: Evidence from the COVID-19 pandemic. *Science Advances, 6*(43), eabd4563. https://doi.org/10.1126/sciadv.abd4563

Lebeer, S., Ahannach, S., Gehrmann, T. et al. (2023). A citizen-science-enabled catalogue of the vaginal microbiome and associated factors. *Nature Microbiology, 8*, 2183–2195. https://doi.org/10.1038/s41564-023-01500-0

Lee, T. K., Crowston, K., Harandi, M., Østerlund, C., & Miller, G. (2018). Appealing to different motivations in a message to recruit citizen scientists: Results of a field experiment. *Journal of Science Communication, 17*(01), A02. https://doi.org/10.22323/2.17010202

Letang, M., Citron, P., Garbarg-Chenon, J., Houdé, O., & Borst, G. (2021). Bridging the Gap between the Lab and the Classroom: An Online Citizen Scientific Research Project with Teachers Aiming at Improving Inhibitory Control of School-Age Children. *Mind, Brain, and Education, 15*(1), 122–128. https://doi.org/10.1111/mbe.12272

Li, W., Germine, L. T., Mehr, S. A., Srinivasan, M., & Hartshorne, J. (2022). Developmental psychologists should adopt citizen science to improve generalization and reproducibility. *Infant and Child Development, e2348*. https://doi.org/10.1002/icd.2348

Lucier, P. (2009). The Professional and the Scientist in Nineteenth-Century America. *Isis, 100*(4), 699–732. https://doi.org/10.1086/652016

Mahmoudi, D., Hawn, C. L., Henry, E. H., Perkins, D. J., Cooper, C. B., & Wilson, S. M. (2022). Mapping for whom? Communities of color and the citizen science gap. *UMBC Faculty Collection*.

Malmqvist, E. (2019) “Paid to Endure”: Paid Research Participation, Passivity, and the Goods of Work. *The American Journal of Bioethics, 19*:9, 11-20, https://doi.org/10.1080/15265161.2019.1630498

Marks, L., Laird, Y., Trevena, H., Smith, B. J., & Rowbotham, S. (2022). A Scoping Review of Citizen Science Approaches in Chronic Disease Prevention. *Frontiers in Public Health, 10*, 743348. https://doi.org/10.3389/fpubh.2022.743348

Masters, K. L., & Galaxy Zoo Team. (2019). Twelve years of galaxy zoo. *Proceedings of the International Astronomical Union*, *14*(S353), 205-212.

Meysman, F., De Craemer, S., Lefebvre, W., Vercauteren, J., Sluydts, V., Dons, E., ... & Fierens, F. (2020). Citizen science reveals the population exposure to air pollution. doi.org/10.31223/osf.io/ft7mr

Montgomery, L. E., Baldini, C. M., Vandekerckhove, J., & Lee, M. D. (2024). Where’s Waldo, Ohio? Using Cognitive Models to Improve the Aggregation of Spatial Knowledge. *Computational Brain & Behavior, 7*, 242–254. https://doi.org/10.1007/s42113-024-00200-0

Moustard, F., Haklay, M., Lewis, J., Albert, A., Moreu, M., Chiaravalloti, R., Hoyte, S., Skarlatidou, A., Vittoria, A., Comandulli, C., Nyadzi, E., Vitos, M., Altenbuchner, J., Laws, M., Fryer-Moreira, R., & Artus, D. (2021). Using Sapelli in the Field: Methods and Data for an Inclusive Citizen Science. *Frontiers in Ecology and Evolution, 9*, 638870. https://doi.org/10.3389/fevo.2021.638870

Muğaloğlu, E. Z., Kaymaz, Z., Mısır, M. E., & Laçin-Şimşek, C. (2022). Exploring the role of trust in scientists to explain health-related behaviors in response to the COVID-19 pandemic. *Science & Education, 31*(5), 1281–1309. https://doi.org/10.1007/s11191-022-00323-5

Murman, D. (2015). The Impact of Age on Cognition. *Seminars in Hearing, 36*(03), 111–121. https://doi.org/10.1055/s-0035-1555115

National Coordination Office for the Federal Community of Practice on Crowdsourcing and Citizen Science. (n.d.). *Community of Practice.* U.S. Government. https://www.citizenscience.gov/about/community-of-practice/

National Coordination Office for the Federal Community of Practice on Crowdsourcing and Citizen Science. (n.d.). *Toolkit.* U.S. Government. *https://www.citizenscience.gov/toolkit/*

Newberg, H.J., Newby, M., Desell, T., Magdon-Ismail, M., Szymanski, B., & Varela, C. (2013). MilkyWay@home: Harnessing volunteer computers to constrain dark matter in the Milky Way. *Proceedings of the International Astronomical Union, 9*(S298), 98-104. https://doi.org/10.1017/S1743921313006273

Newman, G., Wiggins, A., Crall, A., Graham, E., Newman, S., & Crowston, K. (2012). The future of citizen science: Emerging technologies and shifting paradigms. *Frontiers in Ecology and the Environment, 10*(6), 298–304. https://doi.org/10.1890/110294

Nichols, F. H. (2000). History of the Women's Health Movement in the 20th Century. *Journal of Obstetric, Gynecologic & Neonatal Nursing, 29*(1), 56–64. https://doi.org/10.1111/j.1552-6909.2000.tb02756.x

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Harvesting implicit group attitudes and beliefs from a demonstration web site. *Group Dynamics: Theory, Research, and Practice,* *6*(1), 101–115. https://doi.org/10.1037/1089-2699.6.1.101

Nugent, J. (2020). Citizen Science: Count Birds for Science This Winter With Project Feeder-Watch, *Science Scope, 44*:2, 16-18, https://doi.org/10.1080/08872376.2020.12291369

OpenScientist (2013). *The levels of citizen science involvement - Part 1*. https://www.openscientist.org/2013/01/the-levels-of-citizen-science.html

Oreskes, N. (2019). *Why Trust Science?* Princeton University Press.

Paleco, C., García Peter, S., Salas Seoane, N., Kaufmann, J., & Argyri, P. (2021). Inclusiveness and Diversity in Citizen Science. In K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, R. Samson, & K. Wagenknecht (Eds.), *The Science of Citizen Science* (pp. 261–281). Springer International Publishing. https://doi.org/10.1007/978-3-030-58278-4_14

Parrello, S., Iorio, I., Carillo, F., & Moreno, C. (2019). Teaching in the Suburbs: Participatory Action Research Against Educational Wastage. *Frontiers in Psychology, 10,* 2308. https://doi.org/10.3389/fpsyg.2019.02308

Pateman, R., Dyke, A., & West, S. (2021). The Diversity of Participants in Environmental Citizen Science. *Citizen Science: Theory and Practice, 6*(1), 9. https://doi.org/10.5334/cstp.369

Phillips, T. B., Ballard, H. L., Lewenstein, B. V., & Bonney, R. (2019). Engagement in science through citizen science: Moving beyond data collection. *Science Education, 103*(3), 665–690. https://doi.org/10.1002/sce.21501

Queiruga-Dios, M. Á., López-Iñesta, E., Diez-Ojeda, M., Sáiz-Manzanares, M. C., & Vázquez

Dorrío, J. B. (2020). Citizen Science for Scientific Literacy and the Attainment of Sustainable Development Goals in Formal Education. *Sustainability, 12*(10), 4283. https://doi.org/10.3390/su12104283

Ramirez-Andreotta, M. D., Brusseau, M. L., Artiola, J., Maier, R. M., & Gandolfi, A. J. (2015). Building a co-created citizen science program with gardeners neighboring a superfund site: The Gardenroots case study. *International public health journal*, *7*(1).

Reed, L. (2000). Domesticating the personal computer: The mainstreaming of a new technology and the cultural management of a widespread technophobia, 1964–. *Critical Studies in Media Communication, 17*(2), 159–185. https://doi.org/10.1080/15295030009388388

Reimers, S. (2007). The BBC internet study: General methodology. *Archives of Sexual Behavior, 36*(2), 147–161. https://doi.org/10.1007/s10508-006-9143-2

Reinecke, K., & Gajos, K. Z. (2015). *LabintheWild: Conducting large-scale online experiments with uncompensated samples*. Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15) (pp. 1364–1378). ACM. https://doi.org/10.1145/2675133.2675246

Reips, U.-D. (2001). The Web Experimental Psychology Lab: Five years of data collection on the Internet. *Behavior Research Methods, Instruments, & Computers, 33*(2), 201–211. https://doi.org/10.3758/BF03195366

Reiss, M. J. (2022). Trust, science education and vaccines. *Science & Education, 31*(5), 1263–1280. https://doi.org/10.1007/s11191-022-00339-x

Reiss, M. (Ed.). (2007). *The street as stage: Protest marches and public rallies since the* *nineteenth century.* Oxford University Press.

Resnik, D. B. (2019). Citizen Scientists as Human Subjects: Ethical Issues. *Citizen Science: Theory and Practice, 4*(1), 11. https://doi.org/10.5334/cstp.150

Riesch, H., & Potter, C. (2014). Citizen science as seen by scientists: Methodological, epistemological and ethical dimensions. *Public Understanding of Science, 23*(1), 107–120. https://doi.org/10.1177/0963662513497324

Robinson, L.D., Cawthray, J.L., West, S.E., Bonn, A., & Ansine, J. (2018). *Ten principles of citizen science.* In A. Bonn, S. Hecker, M. Haklay, A. Bowser, Z. Makuch, & J. Vogel (Eds.), Citizen Science: Innovation in Open Science, Society and Policy (pp. 27–40). London UCL Press.

Rome, A. (2003). “Give Earth a Chance”: The Environmental Movement and the Sixties. *Journal of American History, 90*(2), 525. https://doi.org/10.2307/3659443

Ross, S. (1962). Scientist: The story of a word. *Annals of Science, 18*(2), 65–85. https://doi.org/10.1080/00033796200202722

Rotman, D., Hammock, J., Preece, J., Hansen, D., Boston, C., Bowser, A., & He, Y. (2014). Motivations affecting initial and long-term participation in citizen science projects in three countries. *IConference 2014 Proceedings*.

Sarathchandra, D., Haltinner, K., & Grindal, M. (2022). Climate skeptics’ identity construction and (Dis)trust in science in the United States. *Environmental Sociology, 8*(1), 25–40. https://doi.org/10.1080/23251042.2021.1970436

Schonfeld, T. & Rasmussen, L.M. (2019). Partnering, Not Enduring: Citizen Science and

Research Participation. *The American Journal of Bioethics, 19*:9, 44-45. https://doi.org/10.1080/15265161.2019.1630504

Smit, D. J. M., Proper, K. I., Engels, J. A., Campmans, J. M. D., & Van Oostrom, S. H. (2023). Barriers and facilitators for participation in workplace health promotion programs: Results from peer-to-peer interviews among employees. *International Archives of Occupational and Environmental Health, 96*(3), 389–400. https://doi.org/10.1007/s00420-022-01930-z

Snik, F., Rietjens, J. H. H., Apituley, A., Volten, H., Mijling, B., Di Noia, A., Heikamp, S., Heinsbroek, R. C., Hasekamp, O. P., Smit, J. M., Vonk, J., Stam, D. M., Van Harten, G., De Boer, J., Keller, C. U., & 3187 iSPEX citizen scientists. (2014). Mapping atmospheric aerosols with a citizen science network of smartphone spectropolarimeters: ISPEX citizen science aerosol maps. *Geophysical Research Letters, 41*(20), 7351–7358. https://doi.org/10.1002/2014GL061462

Sonuga-Barke, E.J.S., & Thapar, A. (2021). The neurodiversity concept: Is it helpful for clinicians and scientists? *The Lancet Psychiatry, 8*(7), 559–561. https://doi.org/10.1016/S2215-0366(21)00167-X

Sonuga-Barke E.J.S, Chandler S., Lukito S., et al. (2024). Participatory translational science of neurodivergence: model for attention-deficit/hyperactivity disorder and autism research. *The British Journal of Psychiatry, 224*(4),127-131. https://doi.org/10.1192/bjp.2023.151

Spiers, H. J., Coutrot, A., & Hornberger, M. (2023). Explaining World-Wide Variation in Navigation Ability from Millions of People: Citizen Science Project Sea Hero Quest. *Topics in Cognitive Science, 15*(1), 120–138. https://doi.org/10.1111/tops.12590

Stanley, T. D., Carter, E. C., & Doucouliagos, H. (2018). What meta-analyses reveal about the replicability of psychological research. *Psychological Bulletin, 144*(12), 1325–1346. https://doi.org/10.1037/bul0000169

Stevens, M., Vitos, M., Altenbuchner, J., Conquest, G., Lewis, J., & Haklay, M. (2014). Taking Participatory Citizen Science to Extremes. *IEEE Pervasive Computing, 13*(2), 20–29. https://doi.org/10.1109/MPRV.2014.37

Storme, T., Benoit, S., Van De Weghe, N., Mertens, L., Van Dyck, D., Brondeel, R., Witlox, F., Zwartjes, L., & Cardon, G. (2022). Citizen science and the potential for mobility policy – Introducing the Bike Barometer. *Case Studies on Transport Policy, 10*(3), 1539–1549. https://doi.org/10.1016/j.cstp.2022.05.013

Strasser, B. J., Baudry, J., Mahr, D., Sanchez, G., & Tancoigne, E. (2018). "Citizen Science"? Rethinking Science and Public Participation. *Science & Technology Studies, 32,* 52–76. https://doi.org/10.23987/sts.60425

Sturm, U., Schade, S., Ceccaroni, L., Gold, M., Kyba, C., Claramunt, B., et al. (2017). Defining principles for mobile apps and platforms development in citizen science. *Research Ideas and Outcomes, 3*:e21283. https://doi.org/10.3897/rio.3.e21283.

Szigeti, B., Kartner, L., Blemings, A., Rosas, F., Feilding, A., Nutt, D. J., Carhart-Harris, R. L., & Erritzoe, D. (2021). Self-blinding citizen science to explore psychedelic microdosing. *ELife, 10,* e62878. https://doi.org/10.7554/eLife.62878

Tauginienė, L., Butkevičienė, E., Vohland, K., Heinisch, B., Daskolia, M., Suškevičs, M., ... & Prūse, B. (2020). Citizen science in the social sciences and humanities: The power of interdisciplinarity. *Palgrave Communications*, *6*(1), 1-11.

Team Isala. (2023). Scoop: Isala receives the very first grand EU citizen science prize. *Isala*. https://isala.be/en/scoop-isala-receives-the-very-first-grand-eu-citizen-science-prize/

Todowede, O., Lewandowski, F., Kotera, Y., Ashmore, A., Rennick-Egglestone, S., Boyd, D., Moran, S., Ørjasæter, K. B., Repper, J., Robotham, D., Rowe, M., Katsampa, D., & Slade, M. (2023). Best practice guidelines for citizen science in mental health research: systematic review and evidence synthesis. *Frontiers in Psychiatry, 14*, 1175311–1175311. https://doi.org/10.3389/fpsyt.2023.1175311

The White House (2023). FACT SHEET: Biden-Harris administration announces new actions to advance open and equitable research. *The White House*. https://www.whitehouse.gov/ostp/news-updates/2023/01/11/fact-sheet-biden-harris-administration-announces-new-actions-to-advance-open-and-equitable-research/

Tran, V.-T., Riveros, C., Péan, C., Czarnobroda, A., & Ravaud, P. (2019). Patients' perspective on how to improve the care of people with chronic conditions in France: A citizen science study within the ComPaRe e-cohort. *BMJ Quality & Safety, 28*(11), 875–886. https://doi.org/10.1136/bmjqs-2018-008593

*UCL Extend : Introduction to Citizen Science & Scientific Crowdsourcing.* (n.d.). Extendstore.ucl.ac.uk. Retrieved August 21, 2023, from https://extendstore.ucl.ac.uk/product?catalog=UCLXICSSCJan17

*UNESCO Recommendation on Open Science* (2021). UNESCO. https://doi.org/10.54677/MNMH8546

Van Brussel, S., & Huyse, H. (2019). Citizen science on speed? Realising the triple objective of scientific rigour, policy influence and deep citizen engagement in a large-scale citizen science project on ambient air quality in Antwerp. *Journal of Environmental Planning* *and Management, 62*(3), 534–551. https://doi.org/10.1080/09640568.2018.1428183

Van den Bussche, E., Verhaegen, K.A., Hughes, G. & Reynvoet, B. (2024). Towards a cognitive citizen science. *Nat Rev Psychol*. https://doi.org/10.1038/s44159-024-00368-z

Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R., & Wagenknecht, K. (Eds.) (2021). *The Science of Citizen Science.* Springer International Publishing. https://doi.org/10.1007/978-3-030-58278-4

Wehn, U., Göbel, C., Bowser, A., Hepburn, L., & Haklay, M. (2020). *Global Citizen Science perspectives on Open Science*. Written input by the CSGP Citizen Science & Open Science Community of Practice to the UNESCO Recommendation on Open Science. https://pure.iiasa.ac.at/id/eprint/16729/

Winther, C.M.S., & Jørgensen, M.S. (2023). Engaging youth in the local environment: Promoting sustainability action competence in Danish high school teaching through citizen social science. *International Journal of Action Research, 19*(3), 238–260. https://doi.org/10.3224/ijar.v19i3.07

Woolley, J. P., McGowan, M. L., Teare, H. J. A., Coathup, V., Fishman, J. R., Settersten, R. A., Sterckx, S., Kaye, J., & Juengst, E. T. (2016). Citizen science or scientific citizenship? Disentangling the uses of public engagement rhetoric in national research initiatives. *BMC Medical Ethics, 17*(1), 33. https://doi.org/10.1186/s12910-016-0117-1

World Medical Association. (2013). World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA, 310*(20), 2191–2194. https://doi.org/10.1001/jama.2013.281053

Zhang, X., Chen, X., & Zhang, X. (2018). The impact of exposure to air pollution on cognitive performance. *Proceedings of the National Academy of Sciences, 115*(37), 9193–9197. https://doi.org/10.1073/pnas.1809474115