From web-forms to virtual worlds: Opportunities and Challenges posed by Four Types of Online Experiment

Wybo Wiersma
Oxford Internet Institute
mail@wybowiersma.net

1 Introduction

The internet as a medium for conducting experiments could potentially be all that social scientists have ever dreamt of. It has global reach, is fully malleable as a virtual space, and allows for unobtrusive observation of every detail of the participants online interactions. Yet, even though several researchers already make fruitful use of online experiments, the majority do not. Are they standing back for good reasons, or do they misjudge the great potential of this relatively new medium?

In this paper, the opportunities and challenges posed by online experiments are going to be discussed. And as the internet gives rise to multiple types of on-line experiments, we are going to distinguish between web-based experiments, and those in virtual worlds, and between virtual lab- and field-experiments. Our hypothesis is that field-experiments in virtual worlds offer more new opportunities than those that use traditional web-technologies. In addition, we expect experiments in online virtual worlds to pose fewer challenges than web-based ones, as virtual worlds afford more control, and are potentially more engaging.

The paper proceeds as follows: First the limits of the papers approach are set out. Then four types of online experiment will be distinguished, and a classification-scheme for opportunities and challenges will be introduced. Followingly, the opportunities and challenges offered by online experiments are discussed: Opportunities are introduced first: such as the ability to study novel phenomena, to observe them in great detail, and to recruit participants globally. Lastly, the challenges, such as dropout, technical differences, and the physical participant not being visible, are discussed, followed by a visual summary.

1.1 Limits

First of all, no experiments were performed for this paper, nor was any new data gathered. It is solely based on an analysis of the literature. Secondly, the focus will be on those aspects of online experiments, in which they

differ, relative to traditional lab- and field-experiments. This means that things such as basic computerization, and the standardisation, branching logic, and automated data-analysis that computers afford, will not be discussed, as they are routinely deployed in lab-experiments as well.

Similarly, there are several technical aspects that will not be discussed, such as the practical complications involved in setting up online experiments, the use of Javascript and other programming languages, browser-plugins; and pitfalls in the usage of HTML-forms, and other interactive elements. Server security will not be discussed either. While crucially important, these all can be tackled to a reasonable extent with proper care, and thus should not pose any insurmountable problems.[46,58]

In addition, the focus here will be less on validity than in most other papers dealing with online experiments. The reason for this, is that the opportunities and challenges posed by online experiments are mostly determined by the properties of the medium, and only impact validity indirectly. In addition, most validity issues, such as those with field-experiments, are not unique to online experiments, and are better described elsewhere.[37] Nevertheless, where relevant, validity will be referred to; particularly external (generalizability across populations, time and place), and internal validity (establishing the causal relationship between the treatment and its effects, excluding extraneous factors).[7,10,28]

Finally, it should be noted that certain particularly physical things cannot (easily) be tested on-line, such as the strength of handshakes, or peoples reactions to pheromones. However, the domain of online experiments being limited, does not lessen the fact that they offer new opportunities and challenges. Online experiments are not considered as a replacement for laboratory experiments, but merely as an useful addition to the methodological repertoire of the social scientist.

1.2 Four types

The distinction between the offline and online realms is not a straightforward one. There are many intermediate cases, such as lab-experiments preceded by online pre-surveys, experiments carried out over VOIP, computerized lab experiments validated across multiple locations, or the use of e-mail as the stimulus in offline field experiments; and then we have not even mentioned internet-related experiments carried out in physical laboratories, or the use of mobile devices in experiments.[17,19,23,35,43,49] Yet, as we restricted ourselves to online experiments, we will not be

taking these intermediate cases into account, especially as there are important distinctions to be made within the online sphere as well.

The first such distinction is that between web-based experiments, and experiments taking place in virtual reality. Web-based experiments use websites as their medium, and generally try to either replicate stimuli and traditional lab-tests online, or test things such as the impact of user interface elements on online purchases (often called A/B testing).[31] In the former case, they generally use the same elements as found in paper tests, such as images, checkboxes and data fields. Experiments in virtual reality, on the other hand, provide an immersive environment, and instead of asking participants what they would do, or would have done, their behaviour is directly measured.

Another important distinction, is that between experiments carried out in the lab and in the field. Field-experiments leave participants in their daily environment, and are often natural quasi-experiments, where the treatment (moving to college, a new law, or a natural disaster) is introduced for other reasons than the experiment, and 'participants' are not assigned to treatment- and control-groups randomly.[11,2,29,37] In the lab, on the other hand, there is random assignment, and complete control over the environment. The lab-settings also makes participants aware of the fact that they are in an experiment, though they might be kept in the dark about the specific hypothesis that is being tested.[8,11,57]

Combining these two distinctions, leads to the following cross-table with four types of online experiment (table 1). Exemplars, such as Harvard's Project Implicit web-experiments, A/B-testing live websites, operating a virtual laboratory in Second Life, and observing a natural experiment in World of Warcraft, are provided in every cell.[12,45] In the following sections we will be entering the challenges and opportunities into this table. At the end of the paper they will be visualized in a way that gives us a clear picture of the relative merit of each type of experiment.

Table 1: *Lab and field experiments crossed with those on the web, and in virtual worlds*

Modality	Lab	Field
Web	web Proj.Implicit	web-field A/B testing
Virtual	virtual lab 3D Lab in SL	virtual world WoW nat.exp.

2 Opportunities

The first opportunity offered by online experiments, is that they allow one to examine, and **experiment with novel phenomena**

(tabulated opportunities are shown in bold). First of all there is behaviour that is unique to the online sphere, and thus best studied there, such as identity switching, tie formation on Facebook, and voluntary co-production in Free Software projects.[53,25,44,55] Secondly, there is offline behaviour which previously could not be studied (or not as easily), but can now, to some extent, be observed online; such as the behaviour of large social groups in virtual worlds (clans for example), or changes in large social networks introduced by historic events (such as popular uprisings).[3,13,32]

Next, the online sphere also offers a new, precise, and **thorough way of observation**, at least for everything that happens inside the machine/virtual realm (see section 3 for the offline part). In web-based experiments, the participants response-times can be tracked in addition to his answers, as can mouse-movements, and every link and button that was clicked. In virtual worlds, this even goes further, and every movement, social interaction, (chat) conversation, and achievement can be recorded. Moreover, these are mostly recorded in a format that can easily be processed further (no hand-coding of events in video-recordings, or such).[27,34] In addition, detailed longitudinal data can be gathered from online worlds, as players participate in them over the span of months, and sometimes years.[55,41]

Moreover, all these **observations can be done in an unobtrusive manner**. In web-field experiments the UI's of websites can be varied and extended without (new) visitors noticing that they are in an experiment. And in virtual worlds, tracking is even a natural part of their operations, as anything not counted by the computer in some way, cannot be rendered, and thus does not exist in virtual space. Therefore, participants will not be able to know that they are in an on-line experiment.[3] Naturally, there are ethical issues introduced by this. Aggregating and anonimizing data is the minimum that should be done, and informed consent might be neccessary, but even then, ethical issues remain that are beyond the scope of this paper.[4,16,56]

In addition to unobtrusive observations, very precise and **encompassing interventions** are possible online as well. As is known from computerized lab-studies, stimuli can be presented in a very controlled way. Yet in online experiments, they can be re-adjusted automatically, based on the results of other participants, if needed.[31] Moreover, virtual reality offers even greater malleability. The complete ontology of online virtual worlds, including their laws of physics, can — in theory — be manipulated, even to the level of varying the perceptions of each member of a

group. For example, N. Yee made an avatar seem tall and attractive to the participant controlling him (from a 3rd person perspective), while it looked small and ugly to other participants.[59] Also, detailed control over participants visual perceptions, allows one to expose them to different intensities of the same treatment, so the exact strength of the treatment-effect can be inferred.

Another opportunity offered by online experiments, is that participants can be drawn from a **global population**. This allows one, among other things, to replicate experiments across cultures.[48] More importantly, internet users are also relatively diverse. In a large, comparative study, it was found that participants in online experiments are more geographically dispersed, but also older, and more evenly distributed across the sexes, than those participating in lab-experiments in psychology.[20,34] This may not be surprising, as 80% of psychology experiments exclusively use students (mostly sophomores studying psychology).[21] Nevertheless, this shows that for all its biases (slightly wealthier, educated, urban, etc.) the online population is still more diverse than typical participants.[6] Finally, several studies comparing online participants to those coming into labs, have found them to be similar along several important metrics, such as personality types.[9,50,51]

It should be noted here, that random assignment to treatment- and control-groups in experiments, makes random sampling of participants less important than it is in polls. This is because the latter require maximum external validity in order to be able to establish population estimates, whereas in experiments the primary aim is to test theories (which then might be validated across experiments).[1,5] Also, having a homogeneous sample, makes statistical tests more powerful, as such samples have smaller random variations, and thus introduce less noise.

However, the problem with homogeneous samples, is that there can be interactions between the effectiveness of the treatment, and common participant characteristics.[29] For example, it was found that students had more trouble using a government-website, than adults, when asked to find information on it, without using Google.[14] Such interaction-effects show that having easy access to diverse samples is a good thing. Though, actually getting purely random samples from the internet, is a different matter. Not only is there no sampling frame (near complete list of internet users) to sample from, but self-selected panels (commonly used alternative) do not offer complete randomness either. Nevertheless, compared to first-year students at a specific university, most internet samples can be

made quite random.

A final population-related opportunity, is that it is possible to do **very large studies**, with tens, or hundreds of thousands of participants.[6,48] Previously, such studies were prohibitively expensive.[20] A thing to note here, is that whether experiments in virtual environments can be large, depends on whether an experimenter is directly involved in conducting them, or not (we assume no full automation for virtual laboratories). In addition, through large studies, or alternatively, through well-targeted studies (helped by the public nature of much online communication, or such things as Google Adwords), it is possible to get access to decent numbers of traditionally underrepresented groups, such as Latinos, or Native Americans, and to groups that might be hard to reach before, such as criminals or recreational drug users.[6,30,34,47]

Lastly, participants can access online experiments from the privacy of their home. Clicking a link is all that is needed to get started. This makes them more convenient for participants, so they need less compensation.[47] In addition, participants can be **motivated in more creative ways** online.[6] One of these ways is offering them personalised, and informative debriefings. An early example of this are the various free IQ- and personality-tests that can be found on the web. Virtual worlds potentially offer even more in this regard: experiments could be turned into quests, or whole games, that are played for their own sake. A study that took this approach, was a natural field-experiment which christened the existing game World of Warcraft as a natural experiment, and looked at how the race of characters (such as troll or elf) related to their performance in the game.[59]

To sum up the advantages, all variants of on-line experiments offer some opportunities of studying new behaviours, but because of their potential of engaging large social groups over a long time, their panoptical nature, and total malleability, the greatest are offered by virtual worlds. As for recruitment opportunities, control over the recruited population is strongest for virtual lab- and web-lab experiments, while motivational opportunities are strongest in virtual worlds. Which brings us to table 2.

3 Challenges

The first challenge in online experiments, is that **dropping out is always just one click away** (challenges are shown in bold). So, if participants do not like something, they can leave. And dropout rates are indeed found to be higher in online experiments: on average 34% (from under 2% to over 80%).[40] Such

Table 2: *Opportunities: Online-only phenomena (Onl), Thorough observations (Obs), Unobtrusive observations (Unb), Encompassing interventions (Int), Diverse population (Div), Large studies (Lar), and Intrinsic motivation (Mot) (size of the opportunity is indicated by the number of plus signs)*

Modality	Lab	Field
Web	Onl +	Onl ++
	Obs +	Obs ++
	Unb +	Unb +++
	Int +	Int +
	Div ++	Div +
	Lar ++	Lar ++
	Mot +	Mot ++
	Total 9	Total 13
Virtual	Onl +	Onl ++
	Obs ++	Obs +++
	Unb +	Unb +++
	Int ++	Int ++
	Div ++	Div +
	Lar +	Lar ++
	Mot +	Mot +++
	Total 10	Total 15

high attrition is bad for internal validity, especially if participants leave between receiving the treatment, and the test/observation. As in that case, the treatment (for example if it did not work) could be what causes people to leave, skewing post-test results. Several tricks have been used to lower the dropout-rate, such as offering rewards (Amazon vouchers), and raising hurdles to filter out uncommitted participants; for example, by asking for personal information upfront, or by providing warmup-questions.[18,46] Yet even then, dropout rates remain higher online.[6]

Another challenge is that (except, in a way, in the virtual lab) **no experimenter is present** to explain the proceedings, to make sure the participant understands everything involved, or to encourage the participant to continue.[47] This may bring certain benefits as well, such as excluding experimenter- and Hawthorne effects (people behaving differently because of human attention).[7,24,26] In addition it should lower social desirability effects (people answering in the socially correct way).[46] However, making the observer leave, or hide, at certain stages, could guard against most of these things in offline settings too.

Another issue with online communication, are **variations in end-point technology**. A plethora of devices (PC's, laptops, tablets, smartphones), screen-sizes, operating-systems and browsers, could be used to access ones experiment, some of which display colours differently, stretch images, or have Javascript disabled.[6,47] These factors mostly affect web-based experiments. Virtual environments afford more control, because they usually depend on custom software/3D engines. But even then, they can be affected by things such as differences in band-

width, and latency.[52]

Importantly, everything outside the device **remains invisible to the researcher**, such as whether participants are being distracted by the TV, or even browsing other sites to find answers to questions posed by the experiment. In addition, participants might be very tired, depressed, or even intoxicated while partaking in the experiment, and the researcher would have no direct way of knowing.[34] This is especially true for studies employing traditional web-forms. More advanced analyses might be conceived in virtual worlds, such as comparisons with longitudinal data about how the participant normally behaves (moves the mouse, reaction time). In addition, virtual worlds generally fill the whole screen, and are more immersive, and thus less susceptible to distractions.

Another challenge is that **private parties are increasingly involved** in online experiments (especially A/B-testing and user-profiling).[31] Companies such as Google, Facebook and Activision, also gather a lot of data, which they generally do not make available equally, or at all. Scholars face the practical challenge of forming partnerships with private companies to get (privileged) access to data behind (or even right to manipulate) websites and on-line worlds. This rarely succeeds, and academic careers can be made (and broken) in the process. Finally, if they (or motivated amateurs running online experiments) don't intend to publish in journals, they are not subject to academic ethical reviews.[34] Thus, apart from professional codes (such as in market research), they only have to abide by the law, which does not stipulate much about the rights of participants (in the US).[15,3,38,39]

As for publishing results obtained in online experiments, low quality studies in the past, as well as the relative novelty of online experiments, have made reviewers and editors **sceptical of online experimenting** as a method. This is another challenge, and one which was exacerbated by early speculations about security issues in online experiments, such as multiple-, or malicious submissions.[20] Several technical solutions to these problems exist (such as IP-checks, browser cookies, or more recently, requiring a Facebook login). And while none of them are perfect, they are good enough when combined. In addition, even for unprotected experiments, abuse has been shown to be quite low at under 3%.[6] Finally, several traditional experiments have been replicated successfully online.[33,20,22]

To sum up the challenges, most of them apply to all types of online experiment. The risk of dropout is highest in web- and virtual lab experiments, especially if participants are

not motivated by intrinsic rewards. Experimenters generally do not need to be present in field-experiments (other than as observers), so no minusses there. Differences between devices, and limited perception of participants would plague virtual worlds less than web-based experiments, as they can be better standardized across devices. Finally, reviewers' trust is probably greater for experiments in virtual reality, as they are (currently) more costly, and allow for more control.

Table 3: *Challenges: Dropout (Dro), No experimenter (Exp), Differences between devices (Dev), Limited perception of participant (Prc), Private parties being involved (Pri), and Reviewers trust (Tru) (the size of the challenge is indicated by the number of minus signs)*

Modality	Lab	Field
Web	Dro −−−	Dro −
	Exp −−−	Exp
	Dev −−	Dev −−
	Prc −−−	Prc −
	Pri −−	Pri −−−
	Tru −−	Tru −
	Total 15	Total 8
Virtual	Dro −−	Dro −
	Exp −	Exp
	Dev −	Dev −
	Prc −−	Prc −
	Pri −	Pri −−−
	Tru −	Tru −
	Total 8	Total 7

4 Conclusion

To conclude, opportunities and challenges posed by online experiments have been discussed and rated, for four types of on-line experiment: web, web-field, virtual lab, and virtual world. The following graph (1) summarises the scores awarded for all opportunities and challenges. Experiments in online virtual worlds come out best, closely followed by web-field experiments. Virtual lab experiments go beyond offline ones to the least extent, while web-lab experiments are most different, because of the challenges in doing them well.

As for why, it could be argued that field-experiments in virtual worlds, and to some extent web-field experiments on live websites, are truer to the medium. Web-lab-experiments, replicating mostly paper-based experiments and tests, would then be like horseless carriages, in that they try to replicate the old medium in the new, missing out on the opportunities that are peculiar to the internet as a medium. Finally, the relative rarity of experiments in virtual worlds, might be invoked as one reason for why online experiments have not yet come to their full potential. More research will have to be done to test these conjectures.

A good way to extend our study, would be

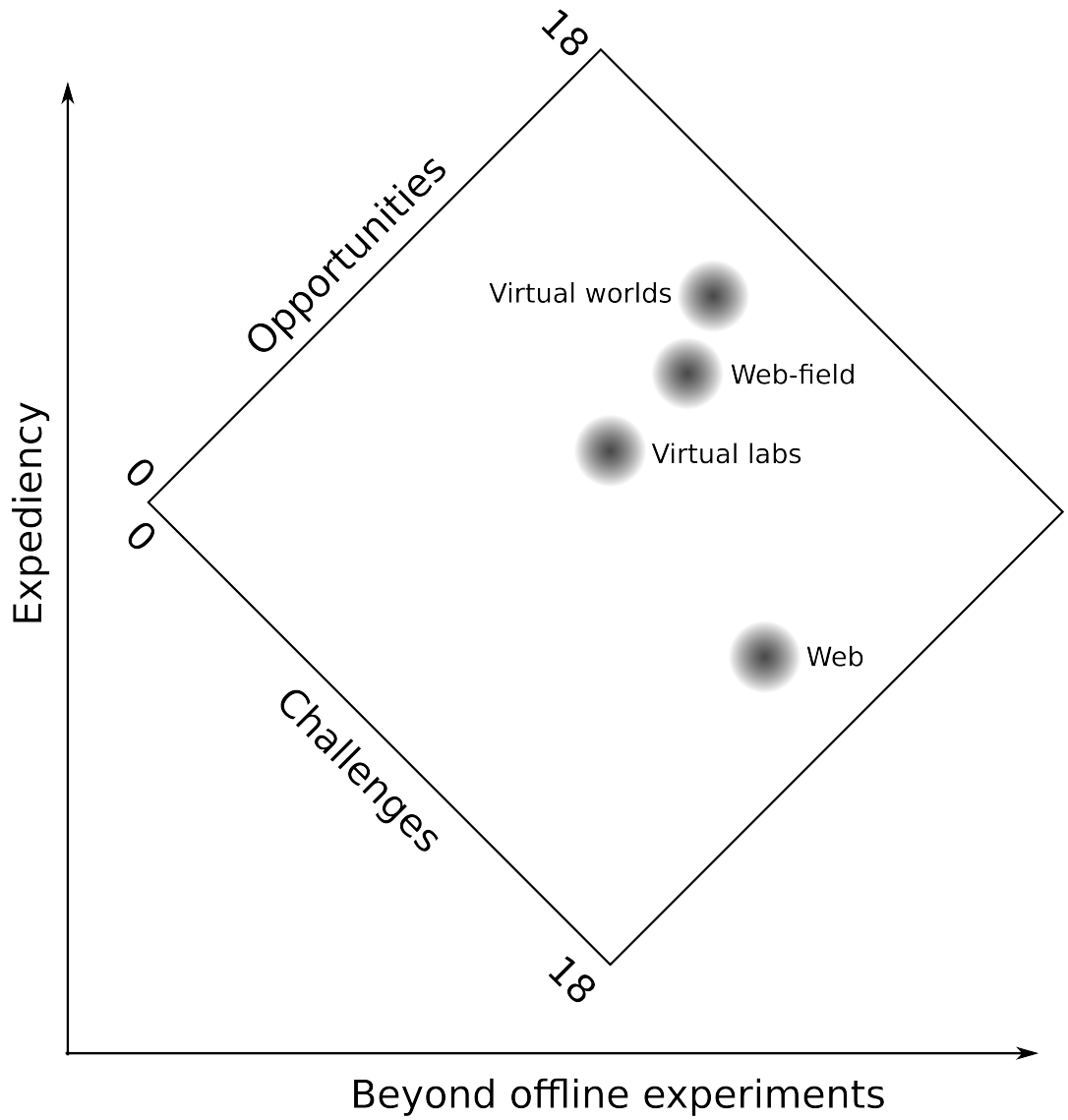

Figure 1: *Opportunities and challenges summarised: Tilted 45 degrees to get the sum of opportunities minus challenges along the vertical dimension, showing the most expedient type of experiment at the top. The horizontal dimension, while a bit harder to interpret, represents the extent to which the types go beyond offline experiments (in terms of cumulative challenges and opportunities).*

to take into account more challenges and opportunities, or to argue for assigning different scores to those discussed here. Such additions could change the picture to some extent. A second way of improving upon it, would be to validate it across, or to contrast it to, fields other than the social sciences. Another, useful endeavour, would be to replicate traditional experiments in online virtual worlds in ways true to the affordances of the medium. A study going into this direction (though carried out in a lab), is a replication of the famous Milgram experiment, in virtual reality.[54]

Finally, it should be noted that, even though experiments in virtual reality offer more opportunities, there will be times when web-experiments are more suitable, such as when one wants to test abstract reasoning, rather than attitudes or intuitions expressed in actions. In addition, virtual lab experiments might shine in cases where field-experiments would not offer the required level of internal validity. Experiments being online, does not make considerations that are important in offline and online settings alike, disappear. So choosing the right method remains a balancing act. Yet, it is hoped that this paper has clarified some of the novel opportunities and challenges offered by the four types of online experiment, and has contrasted their relative merits in an edifying way.

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