Chapter accepted for the book

“The Oxford Handbook of Psychological Situations”

Edited by

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The use of Virtual Reality for understanding situations:

A fixed effects design

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Introduction

Heraclitus stated that no (wo)man ever steps in the same river twice, for it is not the same river and (s)he is not the same (wo)man. The same applies to situations: no person is ever in the same situation, for it is not the same situation and (s)he does not construe it the same way. Since situations are dynamic, continuously evolving systems, their study involves taking their complexity into account. Persons and situations are tightly interwoven. Therefore, understanding and measuring how persons and situations interplay is an endeavor of paramount importance for psychological science. Actually, persons and situations have been usually confronted throughout the history of psychology as if they were opposed, while they are actually two sides of the same coin (Fleeson & Nofle, 2008; Funder & Ozer, 1983). Nowadays some authors still argue in favor of this confrontation (Bond, 2005; Cooper & Withey, 2009), but personality and social psychologists have started to reconcile these two aspects of human behavior (Funder, 2007; Reis, 2008). In any attempt to improve our knowledge on the relationships between persons and situations, a major and necessary step is adequately conceptualizing and measuring them, and understanding how the relationships relate to each other.

In this chapter, we will address how recent developments in the conceptualization of situations, along with the development of standardized situational assessment tools, enable us to disentangle the interplay of persons and situations. We will also illustrate how these new concepts and measurement instruments can be combined with clever designs and technologies seldom used in personality and social psychology settings.

Standardizing a real-life situation can be problematic as well as costly. So far, a number of different methods have been used for this purpose. For instance, using actors or confederates is a widely extended practice in psychological experiments. However, actors may become a

spurious source of variability by inadvertently interacting in a number of different ways with participants (Kuhlen & Brennan, 2013). This is just one among many possible “hidden moderators” that may impact the effect size, stability, or reliability of social and psychological phenomena (Van Bavel, Mende-Siedlecki, Brady, & Reinero, 2016). Recent replication attempts of the “facial feedback hypothesis” offer a cautionary tale in this regard. In the original study, Strack, Martin, & Stepper (1988) showed that participants holding a pencil between their teeth (emulating a smile) found comic strips funnier than when holding the pencil between their lips (as though they were pouting). This was interpreted as evidence for the facial feedback hypothesis (i.e. that facial expressions can influence an individual’s emotional state, rather than the other way around). Though this finding was uncritically accepted for decades, a large, multicenter replication study reported the magnitude of the effect to be indistinguishable from zero (Wagenmakers et al., 2016). Yet, unlike the original study, in the replication attempt participants were recorded with a video camera. In order to test whether this was indeed a potential hidden moderator of the effect, an additional replication was conducted. As suspected, the difference in reported amusement between the smiling and pouting conditions was larger when subjects were *not* recorded by a video camera, as compared to when they were (Noah, Schul, & Mayo, 2018). The correct standardization of social context is thus not only important empirically, but is also crucial for science reproducibility (Van Bavel, Mende-Siedlecki, Brady, & Reinero, 2016).

In the present chapter, we show how the use of virtual reality and fixed-effects designs can shed new light to old social psychology classics by illustrating this case with the Milgram’s obedience to authority experiment, perhaps the most well-known (but still poorly understood) experiment in the history of social psychology. Finally, we exemplify how the combination of

virtual reality with psychophysiological measures and novel behavioral metrics can complement the approach presented herein.

Contemporary study of situations

Many years ago, Kurt Lewin stated that behavior “depends upon the state of the person and at the same time on the environment, although their relative importance is different in different cases” (Lewin, 1936). This statement still spurs flurries of debates among researchers in personality and social psychology. Although personality psychologists have made a gigantic effort in order to provide general theoretical frameworks for the study of personality variables, the same cannot be said for social psychologists studying situation variables. There are many experiments and partial approaches to the study of the situations, and they have been claimed to near-entirely explain behavior (Mischel, 1968; Ross & Nisbett, 1991). However, these claims have not been systematically scrutinized until very recently (Funder, 2016). In contrast to the situationist tradition, more integrative proposals have been put forward approximately at the same time by Funder (2016) and Rauthmann, Sherman, and Funder (2015). These authors provide complementary theoretical frameworks that aim at guiding researchers to understand psychological situations.

On the one hand, Funder (2016) proposed the Situation Construal Model, in which personality, situations, and its construal interplay and influence behavior. More specifically, he regarded “individual’s construal of a situation as a joint function of his or her personality and the objective situation and his or her behavior as a function of this construal, effects of personality not mediated by construal, and objective attributes of the situation visible to others” (p. 205). Here, Funder integrated the three legs – persons, situations, and behavior – of what he calls the *personality triad*. It is important to note that according to this model, non-mediated (i.e., direct)

main effects of situations on behavior stem from its objective structure, such as incentives, potential dangers, rules, or other aspects that have an impact on individuals. Direct main effects of personality on behavior are summarized elsewhere (e.g., Ozer & Benet-Martínez, 2006). Construal is over and above these situation and personality processes and refers to how every individual uniquely interprets that situation.

On the other hand, Rauthmann, Sherman, and Funder (2015) suggested three principles around which situational research may pivot: *processing*, *reality*, and *circularity* principles. The *Processing principle* states that situations are only psychologically meaningful when they are “processed” at least by one individual, although situations can exist independently. The *Reality principle* assumes that any situation is grounded in psycho-biological cues (i.e., physical reality), canonico-consensual aspects (i.e., social reality), and subjective-functional aspects (i.e., individual reality). Finally, the *Circularity principle* posits that situation variables blur the distinctions among persons, situations, and behavior when they are only defined by person’s variables (e.g., one participant’s perceptions).

Derived from these principles is a distinction between two basic aspects of situations, namely *cues* and *characteristics*. This distinction lies on the differentiation between *objective* and *subjective* aspects of a situation, and it allows for a better operationalization of situational and personality research, as we will see next.

Measuring situations: The development of standard assessment tools

Situations are not easy to assess, but many attempts to taxonomize situational information (i.e., cues of situations, characteristics of situations, or entire situations themselves) have been made (Rauthmann et al., 2014., p. 680). As an example, the authors listed up to 21 systems which attempted one or more mutually non-exclusive forms of classification based on situation

classes, situation characteristics, and situation cues. A few of them are based both on classes and characteristics, and just one is based on cues. Most of them, however, classify situations *ex post facto*, and their use is problematic since, in any case, participants actually rate any characteristics. Also, different methods have been used to derive situation variables, so they are likely to show *a priori* restricted domains of situations. For instance, previous tools were biased towards interpersonal situations, perhaps because these are the most commonly studied by social and personality psychologists. However, there are many more situations than those involving interpersonal exchanges (Guillaume et al., 2016). This shortage of situational measures is in sharp contrast with the bounty of well validated personality measures. To fill in the gap, the Riverside Situational Q-Sort (RSQ; Sherman, Nave, & Funder, 2010) was introduced as a comprehensive mean for assessing situations related to content that is relevant for personality traits and behaviors. The RSQ draws on previous work on behavioral (Funder, Furr, & Colvin, 2000) and personality descriptions (Block, 1961) to provide a forced-choice situational measurement tool.

More recently, Rauthmann and colleagues (2014) ran a set of six studies using the RSQ as a starting point in order to capture any latent dimension(s) that could explain how people perceive situations. The purpose was to identify a plausible set of dimensions of psychologically meaningful situation characteristics. Across all the studies, and using different techniques and samples, they identified eight characteristics labeled the DIAMONDS (Duty, Intellect, Adversity, Mating, pOsitivity, Negativity, Deception, and Sociality). These were related in nomologically sensible ways to situational cues, goal/trait affordances, and behaviors. Very briefly, *Duty* refers to characteristics of situations in which there is something related to a task that needs to be done. *Intellect* is related to intellectual capacities that might be expressed in a situation. *Adversity* refers to characteristics that are shown in potentially conflictive situations.

When there might be potential romantic partners to court or attract, then *Mating* is elicited. While *pOsitivity* is related to potentially enjoyable situations' characteristics, *Negativity* represents the opposite, where anxiety can be induced by the situation. *Deception* entails the degree of suspicion that a person might be lied to or tricked in a given situation. Lastly, *Sociality* reflects the extent to which meaningful social interactions are possible. Hopefully, this taxonomy of dimensions will prove useful for organizing major dimensions of situation characteristics (Horstmann, Rauthmann, & Sherman, 2018). Most importantly, this taxonomy should allow to study situations in a similar manner as personality. That is, just as personality researchers are able to measure individual differences in traits, the DIAMONDS framework permits measuring differences in characteristics of the situation, giving way to the study of situations' structure, stability, change, and contributions to behavior prediction. This taxonomy also opened the door to understanding intra- and inter-individual processes of situation perception (Rauthmann & Sherman, 2018).

Disentangling random effects versus fixed effects

When it comes to the analysis of complex data, one can attempt to decompose variance into its smaller components (i.e. its sources of variation). This latter approach was first introduced to the study of interpersonal perception by Lee Cronbach (1955). In that seminal paper, Cronbach illustrated the diverse components that influence how individuals perceive each other. These components comprised, among others, the assumed typicality or generality of others' behavior, which are in many aspects comparable to situational perception scores. There, Cronbach defined the term "componentiality" or componential analysis as the analysis of the accuracy of such perception. However, componentiality can also be generally understood as identifying the sources of variance underlying variation in social or situational perception.

According to Kenny and colleagues (2006), componential analysis needs three key elements: perceiver, target, and measure. Situational perception research has now these three elements (Rauthmann et al., 2015), and, indeed, some studies have already adopted a componential analysis approach in situation perception (e.g., Rauthmann & Sherman, 2018; ten Berge & De Raad, 2002). In general, componential analysis applied to situational research can be thought of in similar terms, except for the crucial fact that the target is not a specific person but a given situation. It can also be viewed as a three-way analysis of variance (ANOVA) with factors being perceiver $\times$ situation $\times$ measure. Stemming from this premise, different approaches to variance partitioning have been proposed.

We started this section stating how Cronbach pioneered this effort. Within his approach, however, measure had a major role, and the perceiver was not involved. Another approach was suggested by Kenny and Albright (1987) in the framework of the Social Relations Model (SRM). This model distinguished between perceiver variance (i.e., variability in how individuals perceive others), target variance (i.e., variability in how targets are generally perceived), and relationship variance (i.e., variability in people's unique perceptions toward other concrete individuals) as the main sources of variation in interpersonal judgements. Finally, Judd and Park (1993) extended these principles to the analysis of social group perception by applying a variance decomposition similar to that performed in a classical analysis of variance (ANOVA). Specifically, they suggested to partition variance into attribute effects (i.e., to what extent a given trait tends to be over- or underestimated), target-group effects (i.e., to what extent specific groups tend to be perceived as possessing a given trait to a greater or lower extent), subject-group effects (i.e., to what extent subjects belonging to a given group tend to systematically differ in their ratings), and the complete set of two- and multi-way interactions between them all (e.g., to

what extent subjects belonging to a specific group rate members of a target group differently than others, and if this is specific for negative attributes).

Rauthmann and Sherman (2018) went a step beyond, and drawing from these sources, derived a general variance componential framework to the study of situation perception. The authors' point of departure is that situation perception scores can vary across perceivers (P), situations (S), and characteristics (C), such that the data can be represented in a $P \times S \times C$ matrix. Inspecting two-way breakdowns between the different components permits to answer specific questions regarding the variance attributable to each. For instance, in an $S \times C$ design it is possible to compare perceivers with each other, such that, by averaging across perceivers, we can quantify the variance in situation perception scores that is attributable to S, C and their interaction, plus error. Furthermore, one can also extract effect values that represent, for instance, whether a given perceiver sees a specific situation as especially salient on a certain characteristic, and correlate these with other variables of interest (e.g. personality traits). Importantly, the fixed-effects framework we present herein is a perfect illustration of the 2-way $P \times C$ componential approach proposed by Rauthmann & Sherman (2018). We suggest using this VR *fixed-situations approach* to disentangle perceivers' and characteristics' variance explicitly apart for the very first time.

This is clearly along the lines of previous proposals in interpersonal perception research. It is important to highlight two key issues here: interindividual effects (perceiver variance) and intersituational effects (situation variance). In classical interpersonal research, such effects were easily partitioned using the ANOVA decomposition because the independent variables (i.e., group membership) were categorical and relatively easy to measure (Judd & Park, 1993). However, this approach precludes testing the causal role of these variables. Furthermore, and equally important, only a handful of all possible causal variables can be identified and measured.

It is sometimes possible nevertheless to alleviate omitted-variable bias by reducing or eliminating the association between the unmeasured causes and the cause(s) that we are interested in. The most common way of achieving this is using randomization. However, in research like the one we are presenting here, randomizing over the vast array of possible situations is simply not feasible. While some studies have attempted to grasp the spectrum of situational variability (Guillaume et al., 2016), the conclusions one can derive from such data are merely descriptive (e.g., the average situation is described as pleasant). If we are to meaningfully understand situational characteristics and cues in detail, this level of analysis does not suffice. Therefore, as complexity increases, from a theoretical point of view, variance partitioning can only be achieved under a *fixed-situations* design in which multiple people (multiple raters) perceive the same situation (multiple characteristics). This means actually blocking the situation, or in other words, exposing many participants to “exactly” the same protocol – the same way classical experimental psychologists like Milgram, Asch, or Zimbardo did (recall the PxC component we mentioned above).

Blocking in order to remove the effect of nuisance factors basically means creating groups of blocks of known variables that might affect our dependent variable. A nuisance factor is a factor that has some effect on responses, but is of no interest to us; nonetheless, the variance it adds to the response must be understood. If the nuisance factor is known and controllable, we use blocking and control it by including a blocking factor in our experiment. We could think that interpersonal situations are uncontrollable *per se*. However, the use of virtual reality actually has made situational control possible. According to research design textbooks, variability within blocks must be small. Thus, in a fixed-situations design using virtual reality, we would be “blocking” the whole situation with its specific properties, and we are basically achieving a block which has no variability with respect to the whole situation. Hence, there is no transmission of variability from the “blocked” variance to the dependent variable, and therefore any variance in it can be

attributed to person variables (i.e., personality, situational perception) which are operationally measured. Removing components via research design, but not through componential analysis, has a number of advantages. Some approaches, discussed in Funder (2001), suggest that if there are worries about the confounding effect due to the perceiver, then that effect can be controlled for by asking perceivers to rank-order the targets. In most instances it is better to choose a design that eliminates a bias rather than removing the bias by statistical analysis. Indeed, we suggest fixing the situation for the sake of 1) parsimony and simplicity and 2) claiming causality. This, in conjunction with a thorough, valid, and reproducible assessment of both person and situation, may have important implications for social psychological research. It should lead to a new twist on classical experiments that were put forward as proofs of the power of the situation, since classical situation manipulations were based on arbitrary manipulations.

However, there is a basic difficulty which is inherent to social sciences research involving human beings: How can we make sure that a situation is fixed across all participants? We will address this question in the next section.

How can we set a standard situation?

Depending on the degree of complexity that we would like to achieve, there are different ways of exposing many participants to the same protocol. Namely, we can consider simple experiments using 1) computers, 2) actors and scripts for interactions, 3) videotaped environments, or 4) virtual reality.

The use of computers for social psychological research has been around for many years. First experiences of using the computer as the experimenter in social psychology can be traced back to the 70s (Stang & O'Connell, 1974), but its justification goes back to the 60s (McClintock, 1966): "The advantage of the computer derives from its inherent flexibility in

presenting a great variety of stimuli and measuring an equally great variety of responses. At the same time, the machine permits greater standardization, control, and reliability of experimental procedures” (p. 286). These assertions still hold. In fact, beyond the greater flexibility, standardization, and control of an experiment, presenting stimuli on a computer also avoids certain biases that could happen unexpectedly, such as the Experimenter or “E” Effect (Rosenthal, 1964; Rosenthal, Rosnow, & Kazdin, 2009), in which the researcher can inadvertently change the nature of participants’ responses due to their attributes, modeling effects, or expectancy effects. Current examples of computer experiments include social exclusion (e.g., Gallardo-Pujol, Andrés-Pueyo, & Maydeu-Olivares, 2013; Williams, 2007), aggression (e.g., Geniole, Carré, & McCormick, 2011; Buades-Rotger, Beyer, & Krämer, 2017), or even biculturalism (Ramírez-Esparza, Gosling, Benet-Martínez, Potter, & Pennebaker, 2006). In general, computers have been used since the 70s just for serving as surrogates for experimenters (Stang & O’Connell, 1974). Even though in earlier times there were problems linked to the lack of computer skills, computer literacy has become widespread. Computerized experiments suffer nevertheless from a key limitation when it comes to interpersonal situations, namely, that the employed stimuli may be perceived as artificial and are therefore not readily generalizable to “real” social interactions (Zaki & Ochsner, 2012).

Perhaps the most famous type of standardized research that has been associated to psychological research is the use of confederated actors, which inherently involves participant deception. In the 1960s, the percentage of studies using some sort of deception in *Journal of Personality and Social Psychology* increased from 41% to 66% (Gross & Fleming, 1982). In the 1970s, after Milgram’s famous experiments, the use of deception was harshly criticized from outside psychology, especially from journalism and ethics (Sieber, Iannuzzo, & Rodriguez, 1995), and its use was in fact gradually replaced by the widespread utilization of computers and

bogus feedback devices. A clear example of the use of confederates was the conformity study conducted by Asch (1956). As cited in Sieber and colleagues (1995, p. 68): “Asch (1956) studied conformity by telling subjects that they were in a perception study in which each member of the group was to indicate which line matched the standard line. Unknown to the subject, the other seven group members were confederates. On the first two trials, most of the confederates made the correct match, but thereafter all agreed on a wrong number. Asch reports that the real subjects looked bewildered and anxious, and 33% of them gave the same wrong answer as the confederates. That is, they conformed despite what their eyes told them.”

The use of actors is not only common for research, but also for training purposes (Keltner et al., 2011). There is a plethora of research in biomedical sciences that have used actors as standardized patients (Cangelosi, 2008; Jeffries, Bambini, Hensel, Moorman, & Washburn, 2009), and in fact, this use of actors has given rise to a whole subdiscipline which is known as medical simulation. So, as we see, the use of confederates has gradually turned from deception to simulation and training, but there are still recent examples of its use in core social psychology aspects, such as obedience to authority (Haslam, Reicher, & Millard, 2015). In that study, professional actors were trained to recreate the classic Milgram paradigm while remaining naive to the true goals of the investigation, which allowed for a close yet ethically acceptable replication of the original study. Another clever use of acting in social psychological research is that adopted by Gilam and colleagues (2015), in which participants were verbally provoked by actors who followed scripted improvisations. These interactions were followed by blocks of the task proper, an established economic exchange paradigm with a fixed design across participants. In doing so, researchers were able to track individual differences in bargaining behavior during a standardized task immediately following a realistic, relatively spontaneous social interaction.

However, as we noted above, even highly skilled actors may unduly influence participants' reactions. This might be the case when actors introduce unpredictable, uncontrollable, or otherwise unwanted variation in the experimental situation, but it might also occur in subtler ways. For instance, awareness of the experimenter's hypotheses or intentions could bias confederates' behavior towards eliciting the expected responses in study participants, as though the E Effect were "transmitted" through the actors (Kuhlen & Brennan, 2013). This distortion is particularly critical for clinical trials (Frisaldi, Shaibani, & Benedetti, 2017), but it is also a threat to the validity of any study employing experimental manipulation(s). Greenwood (1989) put this in other words: "The activity of the experimenter in isolating an aspect of a real-life social situation, may not only influence the outcome of the experiment, but may alter or transform the nature of the phenomenon that is the putative object of analysis." (p. 184). In this sense, is there any way of creating a standard situation without the involvement of actual people and without the simplicity of computer-applied experiments along with higher ecological validity?

Realistic social scenarios or videotaped immersive environments may fulfill this purpose. This is also known as first-person modeling in educational fields, and it has been used for studying learning (Fiorella et al., 2017), experimental interventions with pain (Vandenbroucke et al., 2015), or remedial education (Mason et al., 2013). The use of videos has been fruitful and is not rare in social psychology and neuroscience (e.g., as triggers of aggression: Lawrence & Hodgkins, 2009; Fehr, Achziger, Roth, & Strüber, 2014). Perhaps one of the most interesting examples of this approach to situations research is that of Dambrun and Vatiné (2009), who created an immersive video environment constructed with a video of a real person (an actor) that is programmed to be shown on a computer screen so it seems real-time and interactive. They programmed a video recreation of Milgram's experiments and they found very similar results in

terms of obedience to authority. Indeed, presenting participants with videos of their alleged co-players can make experimentally simulated social interactions seem more naturalistic and believable. For instance, it has been shown that angry facial expressions of an alleged opponent increase the degree to which economic demands are met (Reed, DeScioli, & Pinker, 2014) and lead to enhanced activation of brain areas involved in social cognition (Beyer, Münte, Göttlich, & Krämer, 2015; Buades-Rotger et al., 2016).

As we have seen, the manipulation of situations in the laboratory involves a tradeoff between external and internal validity, or between “mundane realism” and “experimental control” (Blascovich et al., 2002). The use of actors and direct social interactions prioritizes the former, whereas computerized situations with pre-recorded or programmed stimuli give precedence to the latter. Virtual exposure methods are able to strike a balance between internal and external validity and are hence the most promising option for standardizing situations in experimental contexts. They have several advantages compared to the methods previously presented as they can be seen as an all-in-one option (Blascovich et al., 2002). They combine the advantages of the use of computers with the ecological validity of the use of actors, namely, the use of the same script for all participants, when needed, with the immersive experience of presence. They have another advantage which should make them a first-choice option, which is that they overcome several ethical constraints of social psychological research (Slater et al., 2006). In the following, we will briefly introduce immersive virtual reality (IVR) as a suitable tool for social and personality psychology, highlighting recent advances, limitations, and future possibilities of the field. Further definitions of virtual reality are developed in the next section.

Immersive virtual reality is a tridimensional simulation system that allows perception through sensorimotor contingencies (real-time body and head-tracking). In IVR, participants are actually immersed in a virtual environment which adapts to their body and head movements.

This leads subjects to perceive the environment in much the same way as physical reality (Rovira, Swapp, Spanlang, & Slater, 2009). With IVR it has become possible to explore behavior in extreme social situations, such as behavior in violent emergencies, without ethical determinants that may endanger participants' wellbeing (Rovira et al., 2009; Gamberini et al., 2003). While virtual settings might be perceived to some extent as unrealistic (Stein, & Ohler, 2017), an IVR examination of Milgram's paradigm showed that participants displayed strong subjective, physiological, and behavioral responses despite knowing that the situation was not real. Indeed, participants showed levels of obedience and disobedience that were close to those reported by Milgram (Slater et al., 2006). It could be argued that IVR is not the same as reality and, therefore, that the experimental results do not have the same validity. The counter-argument to this is that carrying out controlled studies in virtual reality leads to a greater degree of ecological validity as compared to traditional lab-based approaches, as well as wiping out the effect of undesired confederate-participant interactions. Virtual reality also allows for an accurate representation of situations which are experienced first-hand. In contrast, traditional lab-based approaches cannot achieve such a level of detail as IVR with regards to the environment's sensory characteristics, thereby reducing the experimental setup and participants' behavior to a proxy of the intended real-life situation. Moreover, IVR provides both enhanced flexibility and reproducibility (Blascovich et al., 2002; Rovira et al., 2009).

What (exactly) is virtual reality?

Virtual reality (VR) is a computer-generated scenario or setting that is intended to simulate a realistic experience. VR technology is projected through virtual reality headsets or multi-projected environments (e.g. Cave Automated Virtual Environments or CAVEs; Cruz-

Neira et al., 1992), sometimes in combination with physical objects to make the experience more realistic.

Some of the earliest experiences involving VR can be traced back to the 50s, with the development of *Sensorama*, which involved engaging multiple senses (sight, sound, smell, and touch). However, digital experiences seem to start in the late 60s, when Sutherland and Sproull created the first *head-mounted display* (HMD; Sutherland, 1968). Since then, VR has developed at an incredibly fast pace, from just five publications in 1991 in Pubmed to 924 in 2017. So far, applications of VR have been developed for cinema, entertainment (especially videogaming), social sciences, psychology (e.g., altering perceptions, emotions, biases, etc.), healthcare (e.g., surgery training, anxiety disorders, pain reduction, etc), education and training (e.g., military, space, vehicular, etc.), engineering, marketing, and fine arts, just to name a few.

Perhaps the most important concept in VR applications for psychology and social sciences is that of *presence* (Sanchez-Vives & Slater, 2005). It was first introduced by Minsky (1980) to describe the feelings that a human operator might experience when interacting through a teleoperator system. More specifically, presence –originally termed “telepresence” – is the degree to which individuals feel immersed in a virtual scenario. It is the cornerstone of VR given that without presence, behavior may be artificial. Some factors that influence presence are (Sanchez-Vives & Slater, 2005):

- 1) *Virtual realism*. Though perhaps the first factor to come to mind, it is not as relevant as one could assume. Rather than the degree of details, textures, or shadows that a virtual environment has, it seems more important how quick the visual feedback is, that is, how fast the environment reacts to the person’s movements (Welch et al., 1996). Additionally, there is some evidence that the “Uncanny Valley” (a drop in the

likeability of avatars when their resemblance to humans is middle to high) also happens in virtual reality interactions (Stein & Ohler, 2017).

- 2) *Sound realism*. With regard to the auditory modality, instead of a high fidelity influencing a higher level of presence, it seems to be “inverse presence” what affects this sensory channel. For instance, adding realistic background noises (e.g., rustling leaves) seems to improve presence, relative to insulation or background silence (Nordahl & Nilsson, 2014). Indeed, a sudden loss of hearing in a virtual world seems to have a profound impact on subjects’ sense of reality (Murray, Arnold, & Thornton, 2000).
- 3) *Haptics*. Tactile feedback generally increases feelings of presence. Both dynamic factors, which require costly equipment that reproduce forces remotely exerted by participants, and static factors, which more cheaply reproduce tactile sensations that correspond with what is seen by the participant, can increase heart rate (Meehan et al., 2002). Haptic stimulation can also be used in combination with other modalities to improve the perceived realism of the presented stimuli (Nordahl & Nilsson, 2014).
- 4) *Virtual body representation*. Presence is increased when a participant’s body is somehow represented, even though it is not his or hers. This phenomenon is quite close to *embodiment* and it has been used to study implicit social processes, such as implicit racial bias (Banakou, Hanumanthu, & Slater, 2016).
- 5) *Body engagement*. When people wear an HMD, their range of movements is limited. It is also limited, though to a lesser extent, in immersive environments where they can walk around relatively free. All in all, mobility increases sensation of presence.

Hence, virtual reality offers several advantages to those interested in its use in social psychological applications. First, presence leads people taking part in virtual reality situations to

behave in ways that closely resemble reality (Slater, 2018; Slater & Sánchez-Vives, 2016). In combination with the flexibility when programming virtual environments, and the reproducibility of each script, it means that current VR methods create a favorable imbalance between *internal validity*, which means the capacity of an experimental design to support statements about causality, and *external validity*, which refers to the extent to which the results from specific studies can be generalized beyond the data in which they rely (Blascovich et al., 2002). In other words, one can reproduce any given environment or situation, regardless of its complexity, and can expose different participants to exactly the same situation. Thus, a VR experimental script becomes a fixed situation.

Therefore, using VR one can treat a fixed-situations either as a special type of a blocked design, or with few manipulations, as a fixed effect. With regard to the former, when we keep one situation absolutely constant for all participants we are actually blocking the situation *by design* to remove the effect of nuisance factors that can affect the experiment. With respect to the latter, we can make sure that the situational variable that we are manipulating is the one to which we can attribute causality. Furthermore, even though using this approach may lead to a significant loss of richness in understanding dynamic behaviors (Rauthmann & Sherman, 2016), we think we avoid using too complex analytic strategies. The required analyses in this approach are simpler straightforward than those afforded by complex multilevel data because in VR experiments the relevant nuisance variables are inherently controlled for.

Virtual reality in personality and social psychology: The Milgram experiment

Milgram's obedience to authority experiment (Milgram, 1974) is perhaps the most classic and remarkable experiment in social psychology, but still spurs lively debates in our time

(Benjamin Jr. & Simpson, 2009). While person variables' role in this experiment is still unclear (Funder & Ozer, 1983; Gallardo-Pujol, Orekhova, Benet-Martínez, & Slater, 2015), one could think that the situational factors are clearly defined. However, the exact situational variables that play a role in such behavior have been so far arbitrarily categorized (Haslam, Loughnan, & Perry, 2014) or analyzed in isolation (Packer, 2008). Rauthmann, Sherman, and Funder's (2015) theoretical account of situations offers a framework to organize these factors.

According to this framework, most aspects of situations can be classified either as cues or as characteristics. Briefly, while cues are those aspects that could be relatively easy to objectify, characteristics rely on the subjective perspective of the actors of such situation. That is, they are in the eye of the beholder. There are several aspects of Milgram's experiments that could be classified as cues and that were actually manipulated by him. These could in turn be classified according to different criteria (see Gallardo-Pujol & Buades Rotger, 2015 for an alternative classification). Here we will distinguish between physical, spatio-temporal, and behavioral cues, but these are not exhaustive. For instance, *physical* attributes of the experimental setting (i.e. proximity between the teacher and the learner), whether there is an authority figure or not, the number of persons present in the setting, or the appearance of said persons could all be related to interpersonal cues. *Spatio-temporal* cues may include physical objects with which the participant interacts, location's aspects, such as luminance distance between learner and experimenter, the color of the room's painting, or time (hour/day/year). Finally, some examples of *behavioral* cues may be the script that follows the experimenter or the specific behavior of the confederate (Haslam, Reicher, & Millard, 2015). The observable features of interpersonal relationships within this situation would also be included in the realm of behavioral cues.

In a seminal study, Slater and colleagues conducted a virtual recreation of the Milgram experiment in which they experimentally manipulated a crucial physical cue, namely, whether

the Learner (a female 3D avatar) was visible to the participants or not (Slater et al., 2006). In line with meta-analytic evidence (Haslam, Loughnan, & Perry, 2014), participants who could see the avatar showed a slightly higher rate of disobedience and reported increased willingness to stop. Furthermore, subjects showed stronger increases in heart rate and skin conductance when the avatar was visible, relative to when she was not. These results demonstrate the feasibility of VR as a tool for the systematic investigation of situational variability and its impact on behavior.

In the same manner, the DIAMONDS model provides a framework in which situational characteristics can be anchored and measured. Within the Milgram situation, we could hypothesize that on average, and compared with a random situation, participants would be likely to experience that situation as very high in Duty (they have to obey), high in Intellect (since they have to keep track of learner's activities), high in Adversity (there might be exposure to noxious stimuli), low in Mating (there are scarce opportunities of mating in the Milgram situation, unless there is attraction between the confederate and the experimenter). The Milgram situation is also likely to induce low levels of positivity (delivering shocks to strangers is not usually a pleasant activity), high levels of Negativity (delivering shocks might induce guilt or other negative feelings), and high levels of Deception (participants are likely to suspect from the real goals of the study or the setting itself). Participants in the Milgram experiment would also report relatively higher levels of Sociality as some sort of social interaction is required.

We actually tested whether situational perception varied depending on obedience levels in another virtual replication of Milgram's experiment, and found that the more participants perceived Deception in that situation, the more likely they were to disobey (Gallardo-Pujol et al. 2015). As we pointed out there: "those who dropped out of the experiment were less likely to perceive the situation as containing mistrust, deception, lying, betrayal, and hostility. That is, seeing a situation as deceitful is seemingly related to aggression or hostility affordances

(Rauthmann et al., 2014). Not surprisingly, all these elements are present in Milgram's experiment to some extent". The difference in standard deviation units between obedient and disobedient participants was moderate (.70), suggesting that perceived deception does have a non-negligible effect on behavior in such situation.

INSERT FIGURE 1 AROUND HERE

Other experimental contexts might also benefit from this approach. For instance, Woerner et al. (2018) recently reported an experimental study of how alcohol influences male aggression in a heterosexual dating context. In that experiment, the researchers explicitly mentioned cues and characteristics of the situation. However, they interchange both types of features, mentioning cues when they were actually referring to psychological characteristics of their experimental situation. In such study, if we would like to understand which characteristics might be relevant, we could hypothesize different levels of characteristics depending on the experimental manipulation. For instance, does alcohol influence how males perceive Mating characteristics in a dating situation? Assuming that the simulation that happens in such experiment is the same for all participants (i.e., virtual reality), is this effect dose-dependent? The approach that we suggest permits deriving *a priori* hypotheses within the Situation Construal Model.

In our view, standardized, classic social experiments can be regarded as a fixed-situation design, while classic manipulations of the situations (e.g., proximity between learner and teacher) could be portrayed as a cues-manipulation design. As a general tip for future experimental research, we suggest adding standardized reports (i.e., RSQ or DIAMONDS) from bystanders (i.e., the experimenter him-/herself) on the situation, which would shed light on how fixed situations are construed by their actors.

Future challenges

Taking into account what we have seen so far, an important first goal is to continue developing the possibilities of IVR or VR for personality and social psychology research. An inspiring example in this regard is proxemic imaging (McCall & Singer, 2015). Proxemic imaging takes advantage of the head sensors built in VR helmets, which permit to track a person's gaze and position continuously. By triangulating the distance and difference in gaze angle between subjects and avatars, proxemic imaging allows measuring patterns of movement in interpersonal space and relate these to other individual difference variables. As a proof of concept for their method, McCall and Singer showed that participants generally approached more avatars who had previously treated them fairly. However, spiteful subjects also tended to get close to unfair avatars and either directly stare at or turn their back on them. In contrast, these individuals only approached the fair avatar from up front. Similar metrics can also be applied to non-social contexts. For instance, the same research group reported that subjects get closer and look longer at positive relative to negative pictures in virtual environments, and that they slow down when faced with stimuli perceived to be threatening (McCall, Hildebrandt, Hartmann, Baczkowski, & Singer, 2016). Remarkably, the latter effects were particularly strong for resilient individuals. These studies show how one can develop novel metrics in the context of VR and relate them to individual differences in social behavior using fixed-effects designs.

Computational modelling has also begun to be used in the context of VR (Cipresso, Bessi, Colombo, Pedroli, & Riva, 2017). The general idea of computational modelling is to a) define mathematically precise models of the interrelationships between parameters of a given system, and b) generate computer simulations of the system's behavior. By comparing the empirical data with model simulations one can test which models (and which parameter values) provide the most accurate representation of the observations, allowing for a mechanistic

understanding of complex phenomena. Although computational models are increasingly popular in experimental psychology, the tasks employed therein remain highly abstract despite tapping into dynamic and complex processes like explore-exploit strategies in foraging (Korn & Bach, 2018) or learning from social feedback (Will, Rutledge, Moutoussis, & Dolan, 2017). Hence, VR provides a unique benchmark to test predictions derived from computational models of person-environment transactions (e.g. Shoda, LeeTiernan, & Mischel, 2002) in realistic situations.

The combined use of VR and physiological measures is also a promising prospect for future research. For instance, it has been shown that subjects with higher heart rate variability (a correlate of emotion regulation skills and general health) report lower arousal during VR-simulated threatening situations (Hildebrandt et al., 2016). Interestingly, participants in that study were able to accurately recall their own moment-to-moment fluctuations in physiological reactivity during a replay of the VR experience, yet VR- and video-induced physiological responses were uncorrelated (McCall, Hildebrandt, Bornemann, & Singer, 2015). Although the video condition was only a passive, repeated experience, these results speak for the superiority of VR relative to videos in inducing genuine emotional reactions. The addition of neural measures is as well bound to enrich the field. A neuroimaging study (Cheetham, Pedroni, Antley, Slater, & Jäncke, 2009) using video stimuli from the previously commented virtual Milgram replication (Slater et al., 2006) showed that trait empathy and neuroticism predicted enhanced reactivity to the avatar's pain in brain regions involved in affective processing. In another interesting application of neuroimaging, it was shown that specific VR-simulated combat scenes can be retrieved from brain activity (Floren et al., 2015). However, as portable measurement devices of brain activity are still in an early development stage (McDowell et al., 2013), VR can nowadays be best used in combination with peripheral markers.

The possibilities of VR are also inherently constrained by its technical limitations. For instance, it has been reported that up to 56% of VR users experience motion sickness, with women being generally more affected than men (Munafo, Diedrick, & Stoffregen, 2017). More importantly, movement in virtual scenarios is inherently limited by the actual physical surroundings. A promising solution to this problem is the implementation of adaptive environments that mutate depending on participants' eye movements, effectively fooling the senses. In these environments, subjects are inadvertently led to avoid obstacles in the room by e.g. walking in circles while they believe to be walking straight (Sun et al., 2018). Such technological hurdles are presumably more influential in dynamic virtual environments (such as simulated emergency situations) than in the typically static social psychological experiments. Nevertheless, they must be overcome in order to reach VR's full potential.

All in all, the use of VR provides a very interesting avenue for social psychological research, especially when combined with properly controlled designs. Running the same script (i.e., situation) across all participants allows exposing them to complex social situations in a feasible and reproducible way. More importantly, considering that the situation is fixed, we can attribute all variability to individual differences, either personality or situation construal. As we can see, it is also an excellent way of testing existing theories on how we construe situations, such as the Situation Construal Model (Funder, 2016), and how it relates to actual behavior. From here, we aim to foster research on complex social situations using VR as a fixed situation. Perhaps we are not that really afar from this scenario.

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Figure 1. Virtual reprise of Milgram's experiment by Gallardo-Pujol et al. (2015).

Source: Personal picture of first author of this chapter.