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## Hold it right there! An examination of the Approach-Aversion Effect in Virtual Reality

Ivane Nuel<sup>a\*</sup>, Marie-Pierre Fayant<sup>a</sup>, and Theodore Alexopoulos<sup>b</sup>

<sup>a</sup>*Department of Psychology, Université de Paris, 71 avenue Edouard Vaillant, 92100 Boulogne-Billancourt, France. [ivane.nuel@gmail.com](mailto:ivane.nuel@gmail.com) ; [marie-pierre.fayant@u-paris.fr](mailto:marie-pierre.fayant@u-paris.fr)*

<sup>b</sup>*Centre de Recherches sur la Cognition et l'Apprentissage, CNRS, University of Poitiers, 5, rue T. Lefebvre, 86073 POITIERS, France. [theodore.alexopoulos@univ-poitiers.fr](mailto:theodore.alexopoulos@univ-poitiers.fr)*

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Correspondence concerning this article should be addressed to Ivane Nuel, Laboratoire de Psychologie Sociale, EA 4471, Université de Paris, 71 avenue Edouard Vaillant, 92100 Boulogne-Billancourt, France. email: [ivane.nuel@gmail.com](mailto:ivane.nuel@gmail.com). Data and materials for all experiments are available in Open Science Framework ([here](#)).

## Abstract

The approach-aversion effect refers to a devaluation of approaching (vs. static) stimuli and is attributable to the fact that being approached is threatening. However, the explanation and the generalisability of this effect still remain unclear. To fill this gap, we provide a powerful test of the approach-aversion effect using Virtual Reality. Participants evaluated approaching and static virtual individuals for which we manipulated the threatening nature via their emotional facial expressions (Experiment 1), their group membership (Experiment 2), and the agency of their movements (Experiment 3). The results suggest a general approach-aversion effect which is attenuated when the self (vs. the target) initiates the movement. We thus bring convergent evidence that being approached is threatening.

Keywords: agency; approach-avoidance; threat; Virtual Reality; grounded cognition

As social beings, individuals are constantly engaging in social interactions infused with a broad range of interpersonal behaviours that shape their course. For instance, proximity behaviours such as distance reduction are picked up and reciprocated during an interaction (Word et al., 1974). This distance reduction may serve an affiliative purpose and create social bonds. Evidence shows that enacting an approach behaviour leads individuals to evaluate the approached person more positively (Slepian et al., 2012; Woud et al., 2008). Granting the positive evaluative effect of approach behaviours, previous research may not tell us the whole story as the social interaction relies on a dyadic sequence, embedded in a physical and social environment. In fact, from the perspective of the one who is approached, approach may be threatening and bear negative evaluative consequences, an effect termed approach-aversion (Hsee et al., 2014). Nevertheless, previous research reveals contradictory findings (Hsee et al., 2014; Mühlberger et al., 2008) and has some methodological issues (i.e., movement ambiguity, lack of mundane realism) questioning the explanation as well as the generalisability of this effect. The present contribution fills the gap of equivocal findings by adequately addressing these issues. Across three well-powered preregistered experiments conducted in Virtual Reality (VR), we tested the reasoning that, in the context of everyday social interactions, facing an approaching individual may be threatening and thus yield *an approach-aversion effect*.

### **Interpersonal Approach Behaviours: Always Positive?**

The bulk of research suggests that approach behaviours, hereafter defined as behaviours enacted in order to reduce the distance between the self and the surrounding stimuli, yield more positive evaluations of those stimuli as compared to avoidance behaviours, enacted to increase this distance (Cacioppo et al., 1993; Slepian et al., 2012; Van Dessel et al., 2018; Woud et al., 2008). During social interactions, when approaching others, individuals perceive them as more positive (Woud et al., 2008, but see Vandenbosch & De Houwer, 2011) and trustworthy (Slepian et al., 2012), and could contribute to prejudice reduction when performed repeatedly (Kawakami et al., 2007; Phillips et al., 2011; Van Dessel et al., 2016; 2020).

In these studies, the influence of approach behaviours on evaluations was investigated solely from the perspective of the interaction partner who displays these behaviours (but see Hütter & Genschow, 2020; Van Dessel et al., 2018). The fact that the literature focuses mainly on the behaviour

emitter may be due to the core idea that the self is the steering force behind the enactment of approach-avoidance behaviours (Robinson et al., 2014). However, the course of a social interaction depends mutually on all parties involved. Taking this notion into account, one could easily conceive cases in which the social situation may be perceived in a diametrically opposite way from the perspective of the person being approached. In the present paper we seriously consider this idea: Taking up the social interaction as a whole-bodied dynamic sequence, we investigate the evaluative consequences of a distance reduction on the part of the perceiver.

### **Approach Behaviours From the Receiver's Side: A Potential Looming Threat**

When a distance reduction occurs from the social environment rather than from the bodily self it may be perceived as threatening. In the face of approaching stimuli one may need to promptly defend oneself (Franconeri & Simons, 2003). It is therefore crucial to quickly detect approaching stimuli in order to prepare adaptive responses (Skarratt et al., 2014). Research shows that individuals' sensory systems are especially attuned to movement perception and more specifically to approach movements (for a review, see Riskind and Rector, 2018); Approaching stimuli benefit from attentional prioritisation (Judd et al., 2004) and speed up behavioural reaction times (Spaccasassi et al., 2019). These stimuli trigger a state of defensive action preparedness, eliciting eye blink responses (Schmuckler et al., 2007) and backward head movements (King et al., 1992). This approach sensitivity is heightened for trajectories directed straight toward the self as compared to trajectories getting close but bypassing the self (Lin et al., 2009).

In a nutshell, while approaching a target leads to more favourable evaluations of the target, the same behaviour could be perceived as threatening from the target's standpoint, having ironically a deleterious effect on the unfolding of social interactions.

### **The Approach-Aversion Effect**

Some research directly illustrates the negative evaluative consequences of being approached by revealing an approach-aversion effect (Davis et al., 2011; Hsee et al., 2014; Mühlberger et al., 2008). For instance, Hsee and colleagues (2014) showed that participants felt more negatively vis-à-vis approaching social stimuli (e.g., schematic face icons) as compared to receding or static ones. This approach-aversion effect supposedly occurs because of the threatening nature of approach movements

(*the threat hypothesis*). Indeed, Hsee and colleagues (2014) found that measured fear mediated the negative effect of approach on evaluation. However, although these seminal studies have the merit to highlight the potential negative consequences of being approached, there are still open questions.

First, previous studies mostly manipulated the approach movement ambiguously by creating a zoom effect through changes in stimulus size (Hsee et al., 2014, Studies 1-4; Mühlberger et al., 2008). This induction is ambiguous as the size of a stimulus may increase as a result of: (a) the self performing an approach movement toward the stimulus, or (b) the stimulus itself approaching the self (Hsee et al., 2014, Study 4). Perceptual cues stemming from the surrounding environment could disambiguate between these two cases. Indeed, performing an approach movement during a social interaction generally involves concurrent changes in visual angles of both the surrounding environment and the other (Rougier et al., 2018)<sup>1</sup>, while this is not the case when one is being approached by another individual. We therefore need to fine-tune the approach movement by including surrounding cues.

Second, previous research presented dynamic stimuli on a computer screen (but see Hsee et al., 2014; Study 6). In doing so, researchers adopted a too passive conception of social cognition and missed its interactive nature (Nesser, 1980). Indeed, the way individuals perceive a social situation is grounded in individual-environment interactions (Smith & Semin, 2004) and depends on a multiplicity of multimodal cues, on the representation of oneself in the environment and on action possibilities offered by the environment (e.g., Grade et al., 2015). Therefore, one could object that previous research lacked *mundane realism* (i.e., the extent to which an experiment is close to situations encountered in everyday life; Aronson & Carlsmith, 1969). It is therefore crucial to fill this gap in order to generalise the approach-aversion effect.

Third, it is not clear whether the approach-aversion effect concerns either: All stimuli unrestrictedly, only specific types of stimuli, or whether it is stronger for some stimuli than others. From a threat hypothesis perspective, one expects that even non-negative stimuli would trigger an

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<sup>1</sup> Concurrent changes in visual angles of both the surrounding environment and the stimulus do not apply to arm approach behaviours. Indeed, bringing an object toward the self through an arm movement (e.g., bringing a cup of coffee to the mouth) is often considered as an approach behaviour (Phills et al., 2011; Woud et al., 2008) but does not involve changes in the surrounding environment.

approach-aversion effect, but that this effect should be stronger for negative ones. Indeed, as they generally entail beneficial consequences, positive approaching stimuli should appear as less threatening than negative approaching ones. There is tentative evidence for a generalised approach-aversion effect, suggesting that approaching stimuli lead to negative evaluations independently of their initial valence (e.g., frowning or smiling faces; Hsee et al., 2014). Other research instead shows more negative evaluations only for approaching negative stimuli, but not for neutral or positive ones (see Mühlberger et al., 2008 for real, and Davis et al., 2011 for imagined stimuli), and therefore questions the scope of the threat hypothesis. Because of these contradictory results, it is unclear whether this approach-aversion effect applies to all valenced stimuli, and whether the threatening nature of approach is responsible for the approach-aversion effect. It is possible that this inconsistency is just a matter of too small an effect size to be detected, and therefore calls for a thorough examination of this approach-aversion effect with sufficient power.

To recapitulate, researchers have intensively investigated the (positive) consequences of enacted approach behaviours on interpersonal evaluations (Slepian et al., 2012; Woud et al., 2008). However, when one considers the social interaction as a whole dynamic process, the necessity emerges to take into account the effect of approach on all individuals enmeshed in the behavioural episode. Here, we gauge the potential negative consequences of an approach movement on the part of the perceiver (i.e., the approach-aversion effect). Crucially, to date, it is unclear whether this approach-aversion effect: (a) generalises to non-ambiguous manipulations, (b) generalises to everyday settings, and (c) depends on stimulus valence. If the effect indeed exists, the positive intention accompanying the enactment of approach behaviours could translate negatively to the perceiver facing these behaviours, with deleterious consequences in the unfolding of social interactions (but see Harmon-Jones et al., 2013, for the case of anger).

### **Overview of the Experiments**

Here, we tested the hypothesis that during a social interaction, an (unknown) approaching person is generally threatening. If it is the case, one should observe an approach-aversion effect independently of idiosyncratic valence (see Hsee et al., 2014). Furthermore, if the threat hypothesis

holds, the threatening nature of the individual should moderate the effect. We tested this rationale across three experiments. Participants had to evaluate approaching and static individuals displaying different levels of threat (based on their emotional facial expression, their group membership and the agency of their movements). We focused our investigation on a common situation, namely the encounter of unknown people at a bus stop. We relied on VR settings to increase the mundane realism of the experiments, while maintaining a high level of experimental control (Pan & Hamilton, 2018). We are aware that VR cannot be equated with reality itself. Nevertheless, in VR, a realistic and natural behaviour is more important than photographic realism to create a genuine experience of social interactions (Blascovich et al., 2002). With the use of VR we were able to test the approach-aversion effect by manipulating approach unambiguously, taking into account both visual information about the individual and its surroundings. If being approached is threatening, approaching individuals should be evaluated more negatively than static ones, and this effect should be stronger for menacing target individuals. Therefore, we expect an interaction between movement and target threat level. We preregistered all hypotheses, the sampling plan, the materials, the procedure, as well as the exclusion criteria and analyses for all three experiments of this paper (corresponding links are provided in each experiment section)<sup>2</sup>. For each experiment, all measures, manipulations and exclusions were reported. We collected and analysed anonymously all data in accordance with the American Psychological Association's ethical principles. However, we did not seek the explicit ethics approval as it was not required for the present studies as per the University's guidelines. The 90% confidence intervals reported hereafter are based on the estimated percent reduction in error index (*PRE*, Judd et al., 2011)<sup>3</sup>.

## Experiment 1

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<sup>2</sup> Experiment 2 was the first of the series but we decided to reverse the presentation order as the underlying reasoning was similar and starting with the close replication should ease the reading. Moreover, we conducted a fourth experiment in which we manipulated the movement in two counterbalanced blocks. This experiment is not reported here as we obtained a block order effect precluding the clear interpretation of the results (although they pointed in the expected direction).

<sup>3</sup> The *PRE* index is an estimation of the true effect size in the population ( $\eta^2$ ) based on the experimental sample. In keeping with the statistical formalisation norms, we used the *PRE* index rather than the Greek notation.



In Experiment 1, we aimed to replicate the approach-aversion effect in a setting derived from a real-life situation. To manipulate the target threat level, we relied on smiling and frowning facial expressions as was done in the seminal study of Hsee and colleagues (2014; Study 3). During social interactions, individuals may manifest various facial emotional expressions to convey specific communicative intentions (Frijda, 1997) and thus various threat levels. By relying on a VR setting and securing sufficient statistical power, we predicted more negative evaluations for approaching virtual individuals than for those staying on spot, and this effect should be more important for frowning than for smiling individuals. As the effect has never been investigated in VR before, it was difficult to estimate the anticipated effect size. Therefore, we conducted a sensitivity analysis based on the available resources and preregistered to sample at least 100 participants which met our inclusion criteria. This sample size enabled us to detect an effect size  $\eta^2$  of at least .008 with a power of 80% (see [preregistration](#)).

## Method

### Participants

One hundred and sixty-five participants took part in the experiment in exchange for 5€ or partial credit course. They were assigned to a 2 (movement: approach, static)  $\times$  2 (facial expression: smiling, frowning) within-participants design. Here and in all following experiments, we applied a conservative exclusion criterion concerning hypothesis suspicion: We excluded 32 participants who spontaneously mentioned anything about evaluations or bodily movements in their broadest sense (e.g., distance, position). We thus analysed the data of the remaining 133 participants ( $M_{Age} = 19.61$ ,  $SD_{Age} = 2.56$ ).

### Procedure

Participants initially signed a consent form. The experiment was presented as a development phase of a VR application in which users were offered the possibility to interact with others via their avatar. Participants were informed that the goal of the experiment was to test whether the avatars supposedly created by previous participants were able to faithfully represent their real-human

counterparts. Then, participants were immersed in a virtual bus stop environment (see Figure 1) and received all instructions via headphones connected to the headset (Vive™, HTC). After one training encounter with a virtual individual (staying on spot), participants encountered the 16 critical ones (four smiling men, four smiling women, four frowning men and four frowning women) one by one. Each virtual individual entered in the virtual scene from the left and stood in front of the participants at a distance of 85 cm. This distance corresponds to the optimal comfortable distance that participants wish to maintain between them and the virtual individual as revealed by a pretest ( $N = 10$ ,  $M = 84.1$ ,  $SD = 14.82$ ). Then, half of them performed an approach movement toward the participant (one step), while the other half stayed on spot. Participants gave their impression of the virtual individual verbally on a scale ranging from -3 (*very negative*) to +3 (*very positive*). After each evaluation, the virtual individual left the scene on the right side. For each participant, the order of trials as well as the assignment of virtual individuals to the experimental conditions were randomly generated with R before the session. After having performed the VR task, we measured the feeling of presence (i.e., the subjective experience of being in one environment, even when one is physically situated in another, Witmer & Singer, 1998) with the Multimodal Presence Scale by Makransky and colleagues (2017).<sup>4</sup> Then, participants indicated any consequent sickness symptoms (i.e., oculomotor disorders, disorientation and/or nausea due to the VR; 0 = *Not at all*, 1 = *Slightly*, 2 = *A lot*, 3 = *Severely*) and reported any preexisting cognitive impairment and/or substance intake. They also indicated their age, gender and their French language ability. Finally, participants were probed for suspicion and debriefed.

**Figure 1.**

Illustration of the virtual bus stop environment from the participant's perspective

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<sup>4</sup> In the preregistration, we planned to explore whether the feeling of presence moderated the obtained effects. Across the three experiments, these exploratory analyses revealed that the feeling of presence did not persistently moderate the effects, and crucially when it did, the effects remained unchanged. Therefore, we did not report these analyses which are available in the [Supplementary Material](#).



## Results

Evaluations of virtual individuals were submitted to a 2 (movement: approach, static)  $\times$  2 (facial expression: smiling, frowning) within-participants ANOVA. The results showed the expected approach-aversion effect with more negative evaluations for approaching individuals ( $M_{\text{Approach}} = -0.08$ ,  $SE_{\text{Approach}} = 0.08$ ) than static ones ( $M_{\text{Static}} = 0.52$ ,  $SE_{\text{Static}} = 0.05$ ),  $F(1, 132) = 61.71$ ,  $p < .0001$ ,  $PRE = .32$ , 90% CI [.21, .41]. We also obtained a main facial expression effect. Participants evaluated frowning individuals more negatively ( $M_{\text{Frowning}} = -0.90$ ,  $SE_{\text{Frowning}} = 0.10$ ) than smiling ones ( $M_{\text{Smiling}} = 1.34$ ,  $SE_{\text{Smiling}} = 0.07$ ),  $F(1, 132) = 366.72$ ,  $p < .001$ ,  $PRE = .74$ , 90% CI [.67, .78]. Finally, we obtained an interaction between movement and facial expression,  $F(1,132) = 11.26$ ,  $p = .001$ ,  $PRE = .08$ , 90% CI [.02, .16]. However, contrary to what was expected, the approach-aversion effect was larger for smiling individuals ( $M_{\text{Smiling-Approach}} = 0.96$ ,  $SE_{\text{Smiling-Approach}} = 0.10$  and  $M_{\text{Smiling-Static}} = 1.73$ ,  $SE_{\text{Smiling-Static}} = 0.07$ ) than for frowning ones ( $M_{\text{Frowning-Approach}} = -1.11$ ,  $SE_{\text{Frowning-Approach}} = 0.11$  and  $M_{\text{Frowning-Static}} = -0.68$ ,  $SE_{\text{Frowning-Static}} = 0.10$ ).

## Discussion

In Experiment 1, relying on an innovative VR setting and sufficient statistical power, we replicated the approach-aversion effect: Participants evaluated more negatively virtual individuals who approached them as compared to those who stayed on spot. We also predicted that perceiving an approaching individual would be less threatening when this individual is smiling (vs. frowning) due to

the general positive social meaning of this expression (Niedenthal et al., 2010). However, contrary to expectations, the approach-aversion effect was greater for smiling than for frowning individuals. This unexpected interaction could result from the fact that virtual individuals' expressions faded away as soon as they approached participants. The resulting emotional shift may have created an aversive feeling in the smiling condition which eventually increased the approach-aversion effect. Indeed, research shows that evaluations of emotional expressions are highly flexible with documented evidence for a recency effect for dynamic expressions (Fang et al., 2017). This emotional shift may also have added an inconsistency in the behavioural realism of virtual individuals which contributed to create a feeling of eeriness and potentially increased the approach-aversion effect (MacDorman & Chattopadhyay, 2016). As facial expressions represent much more complex stimuli than originally thought (e.g., Cowen et al., 2019) and may trigger somewhat unexpected reactions, in Experiment 2 we relied on a more straightforward manipulation of threat, namely group membership.

## Experiment 2

Research shows that outgroups may elicit threat reactions (Cottrell & Neuberg, 2005). For instance, compared to their ingroup, European Americans feel fear toward African Americans and perceive them as threatening their physical safety and health. We therefore expected more negative evaluations for approaching virtual individuals than for those staying on spot, and this effect should be more important for outgroup than for ingroup members. We relied on Caucasian vs. Maghrebian group membership because in France Maghrebian people are generally negatively perceived and even more so in the context of recent terrorist attacks (Cohu et al., 2016). We preregistered to run 100 participants that met our inclusion criteria in order to be able to detect an effect size  $\eta^2$  of at least .008 with a power of 80% (see [preregistration](#)).

## Method

### Participants

One hundred and fifty four participants took part in the experiment in exchange for 5€. They were assigned to a 2 (movement: approach, static)  $\times$  2 (group membership: Caucasian, Maghrebian)

within-participants design. In order to ensure that Caucasian was the participants' ingroup, we excluded participants who declared a mother tongue other than French for at least one of their parents ( $N = 28$ ). We also excluded participants who guessed the research hypothesis ( $N = 29$ ) or who reported substance use ( $N = 2$ ). We thus analysed the data of the remaining 100 participants ( $M_{Age} = 24.12$ ,  $SD_{Age} = 8.10$ ).

## Procedure

The procedure for Experiment 2 was similar to that of Experiment 1 except that participants encountered Caucasian (ingroup) and Maghrebian (outgroup) virtual individuals instead of smiling and frowning ones. In order to heighten the salience of group membership, we also added French and Maghrebian prototypical names on the virtual individuals' T-shirts. At the end of the experiment, participants also indicated the mother tongue of their parents in order to ensure the ingroup vs. outgroup manipulation.

## Results

Evaluations of virtual individuals were submitted to a 2 (movement: approach, static)  $\times$  2 (group membership: Caucasian, Maghrebian) within-participants ANOVA. The results yielded the expected approach-aversion effect with more negative evaluations for approaching individuals ( $M_{Approach} = 0.51$ ,  $SE_{Approach} = 0.10$ ) than static ones ( $M_{Static} = 1.03$ ,  $SE_{Static} = 0.08$ ),  $F(1, 99) = 30.47$ ,  $p < .0001$ ,  $PRE = .24$ , 90% CI [.12, .34]. There was also a main effect of group membership. Participants evaluated outgroup members more negatively ( $M_{Outgroup} = 0.66$ ,  $SE_{Outgroup} = 0.09$ ) than ingroup members ( $M_{Ingroup} = 0.89$ ,  $SE_{Ingroup} = 0.08$ ),  $F(1, 99) = 8.73$ ,  $p = .004$ ,  $PRE = .08$ , 90% CI [.02, .17]. However, we did not obtain the expected interaction between movement and group membership,  $F(1, 99) = 0.3$ ,  $p = .59$ ,  $PRE = .003$ , 90% CI [.00, .04]. The approach-aversion effect occurred equally for outgroup ( $M_{Outgroup-Approach} = 0.41$ ,  $SE_{Outgroup-Approach} = 0.10$  and  $M_{Outgroup-Static} = 0.90$ ,  $SE_{Outgroup-Static} = 0.10$ ) than for ingroup members ( $M_{Ingroup-Approach} = 0.61$ ,  $SE_{Ingroup-Approach} = 0.11$  and  $M_{Ingroup-Static} = 1.16$ ,  $SE_{Ingroup-Static} = 0.09$ ).

## Discussion

The results of Experiment 2 further corroborate the existence of an approach-aversion effect: Participants evaluated approaching virtual individuals more negatively than those staying on spot. These findings highlight the threatening nature of approach from the perspective of the one who faces it. Although participants manifested an ingroup favoritism, the approach-aversion effect was not stronger for outgroup members, as predicted. It is thus possible that the group membership manipulation was not optimal to modulate the threatening nature of the movement. Indeed, an important number of participants in our initial sample reported a mother tongue other than French which suggests that the participants of our sample pool are used to interact with members of different groups, including Maghrebian individuals. Because of this diversity characteristic of our pool of participants and the resulting exclusion rate, we decided to change the way to manipulate the threat level rather than replicating Experiment 2 with more power.

Experiments 1 and 2 established the approach-aversion effect in settings derived from real-life situations. However, one limitation to these conclusions is that they are restricted to a specific interpersonal distance reduction implying a penetration of the virtual individuals into the participants' peripersonal space (i.e., the space surrounding the body which specifies the private and protective area of individuals; Coello et al., 2012). Indeed, while static individuals stood at a distance of 85 cm from the participants, approaching ones came closer at an approximate distance of 60 cm from them. Such a distance is somewhat below the average distance at which people feel comfortable with others based on our pretest (see also Iachini et al., 2014), although one should note that this distance of 60 cm remains within the acceptable personal distance bounds (i.e., 45-120 cm; Hall, 1966). Consequently, the effect obtained in Experiments 1 and 2 may not illustrate an approach-aversion effect but rather a "peripersonal space invasion effect". We addressed this limitation in Experiment 3.

### **Experiment 3**

In Experiment 3 we tested the threat hypothesis by manipulating the agency of the movement, that is whether the approach movement was initiated by the virtual agent her/himself (as in Experiments 1 and 2) or by the participant via a verbal approach instruction. Hsee and colleagues (2014) had a similar reasoning concerning agency but asked participants to imagine whether the self or

the other enacted the movement. In doing so, they actually compared two different perspectives instead of manipulating the agency of the same movement. Importantly, by manipulating agency in terms of the initiator of the other's movement we maintained the perspective constant across situations and proposed a more stringent test than Hsee and colleagues (2014). When the other approaches following a request, the movement may be perceived as more predictable and controllable which thus reduces its threatening nature (Wood et al., 2016). Participants should thus perceive approaching individuals as less threatening when asking them to come. In line with this idea, research shows that people tend to allow more interpersonal spatial proximity the more they are susceptible to control the other (e.g., influence their behaviour, Strube & Werner, 1984). Also, Riskind and Maddux (1993) showed that an approaching (vs. receding or motionless) spider elicited greater fear, but only when individuals imagined having no control in the situation (e.g., being unable to escape from, or defend themselves against the spider). Therefore, we predicted more negative evaluations for approaching virtual individuals than for those staying on spot but expected this effect to decrease when these movements were self-initiated.

In this experiment, we increased the interpersonal distance in order to address the aforementioned limitation in terms of peripersonal space invasion. If peripersonal space invasion partly contributes to the obtained effects in Experiment 1 and 2, the approach-aversion effect could be somewhat overestimated. Therefore, with such a modification, we decided to further increase the sample size in Experiment 3. We preregistered to run a minimum of 200 participants which allowed us to detect a minimum effect size  $\eta^2$  of .004 with a power of 80% (see [preregistration](#)).<sup>5</sup>

## Method

### Participants

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<sup>5</sup> In Experiment 3, we deviated from the preregistration on two points: 1) we included participants who declared not speaking French fluently. Indeed, a minor error has crept in the preregistration as we did not specify this criterion in the two previous experiments and there is no obvious theoretical reason to expect an influence of French fluency on the approach-aversion effect. The experimenter noticed a smooth verbal interaction with two participants who reported being non-fluent. 2) We excluded trials for which participants did not utter an instruction as required due to a microphone (0.61%) or headset issue (0.03%). None of these exclusions change the results in any way.

Two hundred and fifty-six participants took part in the experiment in exchange for 5€ or partial credit course. They were assigned to a 2 (movement: approach, static)  $\times$  2 (other's movement agency: self, other) within-participants design. We excluded 41 participants because of hypothesis guessing ( $N = 37$ ) or because they did not follow instructions ( $N = 2$ ). We thus analysed the data of the remaining 217 participants ( $M_{Age} = 20.19$ ,  $SD_{Age} = 3.27$ ).

## Procedure

The procedure was similar to Experiment 1 and 2 except the threat operationalisation as well as the interpersonal distance between participants and individuals. We informed participants that, in addition to evaluating impressions about virtual individuals we also wished to adjust the audio settings of the device. To this aim, they were asked to instruct the virtual individuals on which movement to execute in some trials (but not others) by asking them to “Come over here” or “Stay on spot” depending on condition. After two training virtual individuals (one per instruction type), participants encountered the 16 critical ones (two men and two women in each of the four conditions). Half of the virtual individuals performed an approach movement toward the participants (one step, arriving at 85 cm from the participants), while the other half stayed on spot (at a distance of 110 cm from participants). In each movement condition (approach, static), participants had to give an instruction to half of the virtual individuals to execute the movement—to come toward them (after a sound signal) or to stay on spot (after a distinct sound signal)—whereas they did not have to give any instruction to the remaining half. Unlike the previous experiments, a Likert-type scale appeared in the virtual environment after each encounter, and participants used the VR controllers to provide their impression toward him/her anchored at 1 (*very negative*) and 7 (*very positive*). The Likert-scale anchors were different from the previous experiments as we used a default scale type included in our VR application instead of oral evaluations. After performing the VR task, participants underwent the Presence questionnaire (Makransky et al., 2017), follow-up questions and debriefing.

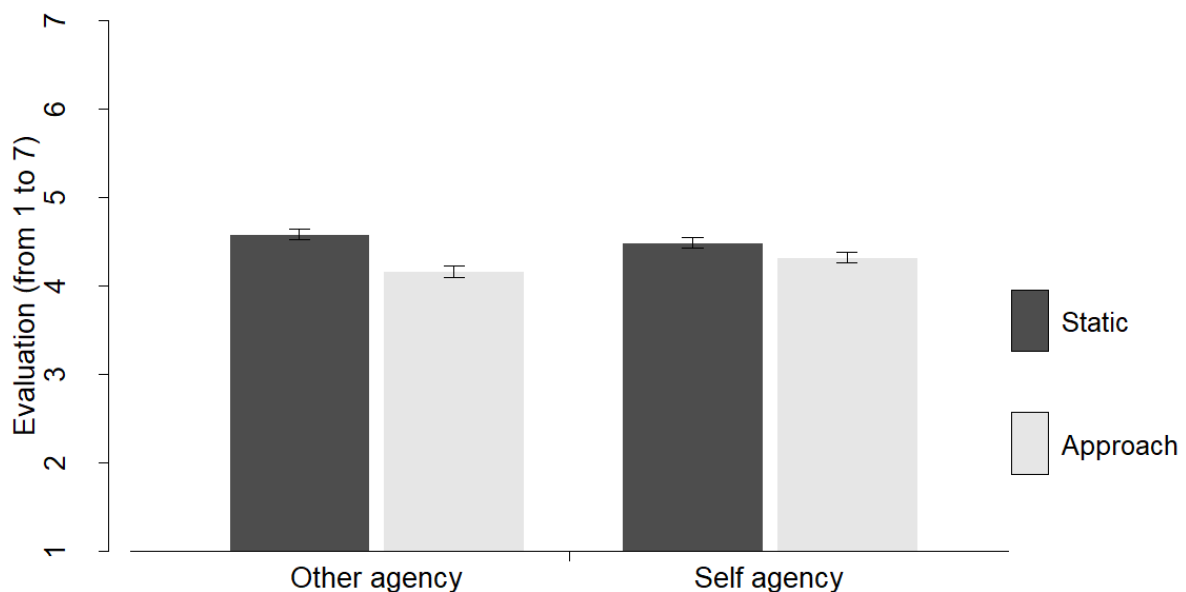
## Results



As pre-registered, we excluded trials for which participants erroneously gave an instruction to the virtual individuals (0.06 %). The evaluations of virtual individuals were submitted to a 2 (movement: approach, static)  $\times$  2 (other's movement agency: self, other) ANOVA with all factors manipulated within-participants. The results showed the expected approach-aversion effect with more negative evaluations for approaching individuals ( $M_{\text{Approach}} = 4.24$ ,  $SE_{\text{Approach}} = 0.05$ ) as compared to static ones ( $M_{\text{Static}} = 4.53$ ,  $SE_{\text{Static}} = 0.05$ ),  $F(1, 216) = 43.66$ ,  $p < .0001$ ,  $PRE = .17$ , 90% CI [.10, .24]. The main effect of movement agency was not statistically significant ( $M_{\text{Self}} = 4.40$ ,  $SE_{\text{Self}} = 0.05$ ;  $M_{\text{Other}} = 4.37$ ,  $SE_{\text{Other}} = 0.05$ ),  $F(1, 216) = 0.51$ ,  $p = .48$ ,  $PRE = .00$ , 90% CI [.00, .02]. Crucially, we obtained an interaction between movement and movement agency,  $F(1,216) = 7.95$ ,  $p = .005$ ,  $PRE = .04$ , 90% CI [.01, .08]. As predicted, the approach-aversion effect ( $M_{\text{Other-Approach}} = 4.16$ ,  $SE_{\text{Other-Approach}} = 0.06$  vs.  $M_{\text{Other-Static}} = 4.58$ ,  $SE_{\text{Other-Static}} = 0.06$ ) observed when the virtual agent initiated its own movement was mitigated when the individuals' movement was initiated by the participants ( $M_{\text{Self-Approach}} = 4.32$ ,  $SE_{\text{Self-Approach}} = 0.06$  and  $M_{\text{Self-Static}} = 4.49$ ,  $SE_{\text{Self-Static}} = 0.06$ ; see Figure 2).

**Figure 2.**

Mean evaluations (and standard errors) according to movement and other's movement agency in Experiment 3.



## Discussion

In Experiment 3, we replicated the approach-aversion effect: Participants evaluated virtual individuals approaching them more negatively as compared to those staying on spot. Importantly, as we reduced the possibility that the virtual individuals entered the peripersonal space, this approach-aversion effect occurs beyond space invasion. However, one should mention that the magnitude of the approach-aversion effect is smaller than in the first two experiments (even in the critical condition where the movement is initiated by the virtual agent). This may suggest that peripersonal space intrusion could have contributed, to some extent, to the results observed in Experiments 1 and 2. Importantly, we observed the expected interaction by the initiator of the movement: The approach-aversion effect is less important when participants initiated the movement of virtual individuals (by inviting them to approach) as compared to when individuals approached by themselves which lends support to the threat hypothesis.

### Reliability of the Approach-Aversion Effect

In order to assess the reliability of the approach-aversion effect, we performed an integrative data analysis (IDA, Curran & Hussong, 2009) of the three experiments. First, we standardised the data by recoding those of Experiment 3 in such a way that they fit the scale range of Experiments 1 and 2. Second, the smiling vs. frowning (Experiment 1), Caucasian vs. Maghrebian (Experiment 2) and self-initiated vs. other-initiated (Experiment 3) conditions were respectively coded as low-threat vs. high-threat conditions. Then, we submitted the overall dataset to a 2 (movement: approach, static)  $\times$  2 (threat level: low, high)  $\times$  3 (Experiment: 1, 2, 3) ANOVA with the first two factors manipulated within participants and the last manipulated between (C1: -1, 0, 1; C2: -1, 2, -1). Two participants were excluded from being outliers on the studentised residual index (i.e., above four, Judd et al., 2011). The results of this analysis further establish the approach-aversion effect showing more negative evaluations for approaching individuals ( $M_{\text{Approach}} = 0.21$ ,  $SE_{\text{Approach}} = 0.04$ ) than static ones ( $M_{\text{Static}} = 0.64$ ,  $SE_{\text{Static}} = 0.04$ ) across the three experiments,  $F(1, 445) = 141.56$ ,  $p < .0001$ ,  $PRE = .24$ , 90% CI [.19, .29] (we did not obtain the movement by threat level interaction, see [Supplementary Material](#)). Importantly, we obtained the same estimation of the approach-aversion effect size by

conducting a random effects mini meta-analysis on the three experiments ( $PRE = .24$ ,  $z = 5.05$ ,  $p < .0001$ , 90% CI [.16, .31]).<sup>6</sup>

### General Discussion

In the present work, we investigated the evaluative consequences of approaching (unknown) individuals and tested the idea that those individuals are perceived as threatening. To this purpose, we aimed to: (a) replicate the approach-aversion effect in everyday settings, and (b) test its moderation by the threatening nature of approaching individuals. Across three experiments, we reliably obtained the approach-aversion effect: Participants evaluated approaching individuals more negatively than static ones. Regarding the moderation by the individuals' threatening nature, results were somewhat mitigated.

In order to investigate the approach-aversion effect in more realistic situations than previous paradigms, we relied on a VR setting. The obtained approach-aversion effect is rather important as it explains 24% of the variance in the evaluation of others on average. Such an effect size suggests that being approached by others could have deleterious consequences at the outset of an interaction. The effect of approach-aversion was found beyond any peripersonal space invasion (Experiment 3) and could thus have consequences even when no proximal interaction has been engaged. Noteworthy, as in both conditions virtual individuals are actually moving to place themselves in front of participants, the eventuality that the obtained approach-aversion effect reflects a mere movement effect seems highly unlikely. The current work is important from a cumulative science perspective and represents a first important step toward establishing the generalisability of the approach-aversion effect.

To test the idea that approaching individuals are threatening, we examined whether the approach-aversion effect could be moderated by threat. To do so, we manipulated either the features of the approaching individual or the control participants exerted on the movement. Contrary to expectations, the approach-aversion effect was less pronounced for frowning than for smiling

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<sup>6</sup> Male individuals could be perceived as more threatening than female ones. Therefore, based on the threat hypothesis, the gender of virtual individuals could also moderate the approach-aversion effect. Indeed, an exploratory mixed model integrative analysis revealed that the effect is larger for male than for female virtual individuals. For details see [Supplementary Material](#).

individuals (Experiment 1) and was not moderated by group membership (Experiment 2). Experiment 3 supports our reasoning by showing that the approach-aversion effect is mitigated when participants (vs. the virtual individuals) initiated the movements. This moderation by the other's movement agency is in line with a threat explanation as being the agent of others' movements dampens perceived threat (Wood et al., 2016). Moreover, the obtained interaction between movement and agency enables to discard a mere perceptual alternative explanation. Indeed, as virtual individuals came closer, participants could perceive an increasing amount of unrealistic details about them as compared to when they stood on spot. However, the agency manipulation does not affect in any way the perceptual features of individuals. Therefore, this purely perceptual explanation does not hold for the present approach-aversion effect.

We discussed potential explanations for the unexpected results concerning the threat by movement interaction in the first two experiments: A contrast effect for the facial emotional expressions and a lack of relevance for the group membership manipulation. Another potential explanation could reside in the threat manipulation itself: While in Experiments 1 and 2 we manipulated threat through the features of approaching individuals (i.e., group membership, facial expression), in Experiment 3 we manipulated the control over the other's movement (i.e., agency). It is possible that, as soon as individuals approach the self, they elicit the same relevance and preparedness to react independently of their a priori features (Spaccasassi et al., 2019) and thus trigger the same level of perceived threat in participants. With the control manipulation, we may have more directly manipulated the level of perceived threat of approaching individuals. These potential explanations could be investigated in further research by examining the reasons why being approached is threatening and which type of threat underlies the approach-aversion effect.

The current work presents some limitations, especially considering the ecological validity and generalisability of the effect. First, the improvement in mundane realism comes with downsides as the richer becomes the experience of a situation, the greater the necessity to consider several multi-modal features and their consistency in order to warrant realism. Any inconsistency in the situation as compared to its real-world counterpart may produce a disfluent perception and create a negative

impression (Reber et al., 1998) which pollutes the investigated effect. Second, we restricted our investigation to a relatively common, but specific, situation of social interaction (i.e., encountering an unknown person at a bus stop). Future research should investigate the approach-aversion effect with different, and maybe even more realistic, combinations of features as well as different situations and stimuli to increase generalisability.<sup>7</sup>

As asking others to come closer could be reinterpreted as a form of approach, one may have expected that the self agency condition (Experiment 3) would reverse the approach-aversion effect. There are several potential (admittedly post-hoc) explanations for that such as the potential injunctive nature of the request, or the lack of specific modal information involved when enacting an approach behaviours (e.g., visual flow). Further research should address this point. Nevertheless, it is worth noting that the current findings are consistent with recent ones showing that the positive influence of approach is not clear when individuals perform an action (i.e., moving a joystick) that brings the stimulus closer (Hütter & Genshow, 2020). Moreover, the replicated approach-aversion effect should alert researchers not to use feedback suggesting that others are moving toward participants in approach-avoidance training (see also Krishna & Eder, 2018; Van Dessel et al., 2018). Finally, this work qualifies the perspectives for intervention suggested by previous research on approach behaviours (e.g., prejudice reduction, Kawakami et al., 2007; Van Dessel et al., 2020), at least if one wants to transpose them in real-life situations.

This contribution illustrates the importance of considering the interactional aspects of the social situation in the study of human behaviour. Indeed, while the literature showed that approach behaviours improve evaluations of others as compared to avoidance, the present research confirms that, on the part of the perceiver, those performing the approach behaviour could be negatively evaluated. Indeed, social interaction is a dynamic process and the negative consequences of approach behaviours from an observer's standpoint may cancel out the initial positive interactional intention.

### **Open Practices**

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<sup>7</sup> Nevertheless, a non preregistered mixed model integrative analysis suggests that the effect did not vary across our stimulus subset (see [Supplementary Material](#)).

All materials, analysed datasets with the corresponding R scripts can be found in Open Science Framework ([here](#)).

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