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**Title:** Face mask use conditionally decreases compliance with physical distancing rules against Covid-19: gender differences in risk compensation pattern

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Abstract

**Background.** In the context of the Covid-19 emergency, the concern has been raised that people may compensate the reduction in risk ensured by mask use with an increase in risk induced by lower adherence to physical distancing rules.

**Purpose.** The paper investigates if people compensate risk in this manner when their interaction partner wears a face mask, examining if risk compensation further depends on gender, signaled social status and perceived race.

**Methods.** An experiment was conducted in two waves (June, n=1396 and September 2020, n=1326) in front of the traffic lights of four busy roads in Paris. A confederate asked a randomly selected pedestrian for directions following a script and keeping the recommended distance. Confederates were locally recognizable as Blacks or Whites and alternatively presented themselves with a costume indicative of high or low social status. An observer recorded whether the pedestrian kept the recommended distance.

**Results.** Both in June and September, men are less likely to comply with the distancing rule when the confederate wears the face mask, and particularly so when the confederate signals high status. When the confederate wears the mask, female pedestrians observe less the one-meter rule in September than in June.

**Conclusions.** Men's risk compensatory behavior is constant over time. In contrast, women's depends on the time period.

Keywords: risk compensation, gender differences, face mask, interpersonal distance, Covid-19

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## Introduction

On January 30, 2020 the World Health Organization declared the Covid-19 outbreak an international health emergency. From the beginning of the emergency to nearly the end of 2020, non pharmaceutical interventions represented the only measures on which governments and the general population have had to rely to contain the spread of the virus. Under the form of mandates or recommendations, the most usual interventions were hand hygiene, physical distancing, face mask use, and the most radical of all, locking down the entire population.

A particular feature of the rapidly evolving situation created by the novel coronavirus is that changes in policy regarding these interventions have not always reflected an enlargement of the evidential basis in their support. Two notable cases in point are the rule to keep a minimal one-meter distance from others and the generalized use of the face mask outside of healthcare settings. A widely cited meta-analysis published in June 2020 recommended keeping a physical distance of 1 m or more, drawing on evidence indicating that at such distance the probability of virus transmission is lower [1]. A few days later, a posted commentary questioned the evidential basis of the cited meta-analysis, recalling that it relies only on observational studies, of which most from SARS and MERS instead of Covid-19 [2]. The same authors, in an alternative review appearing in August, concluded that the one-meter rule is “based on outdated science” [3]. Similarly, the aforementioned meta-analysis [1] found evidence in favor of a face mask policy, acknowledging however that controlled randomized trials (instead of observational studies) focusing only on Covid-19 (instead of SARS or MERS) would be necessary to give a firmer basis to the recommendation. At the time of this writing the report of the first controlled randomized trial assessing the effects of the mask on the risk of contracting Covid-19 has been published, and the results from this Danish sample (n=4862) do not confirm that wearing a face mask in community settings reduces that risk [4].

Not only the respective individual abilities of the one-meter rule and the face mask to prevent virus transmission have been asserted and questioned but also the combination of both. The concern has been raised that face mask use might lead people, presumably through the mediation of a “false sense of security” [5], to comply less with physical distancing rules, thereby compensating the decrease in risk ensured by the mask with a corresponding increase in risk induced by shorter interpersonal distances. This phenomenon is often termed “risk compensation” [6, 7]. Also here, the scientific controversies, or more precisely the disagreements between scientists, have not necessarily reflected the expansion and differentiation of the evidential basis. The advocates of face mask policies [8] argue that *the concept* (not the fact) of risk compensation poses a threat “through slowing the adoption of effective public health interventions” [9]. The detractors, in turn, lament such “unequivocal advocacy of a contested position”, pointing out the gaps in evidence that make any general conclusions on this matter uncertain [10].

The general aim of the present report is to contribute evidence to this ongoing debate. A field experiment was performed in the streets of Paris (n=2722) to investigate if randomly selected pedestrians, in the context of a brief face-to-face conversation with a stranger (a confederate), comply less often with the one-meter rule when the stranger wears a face mask. In this article, risk compensation is treated as a brute fact, consisting in the simultaneous performance of two behaviors, one of which subtracts a quantity of risk (e.g. covering one’s mouth and nose with a mask), while the other adds back a quantity of it (e.g. interacting closer).

The added value of the present study lies not only in the realism of the experimental setting and the size of the sample, the largest to date for a study dealing experimentally with this topic, but also in its relatively complex factorial design. The experiment investigates pedestrians’ probability of keeping at least a one-meter distance from the confederate as a function of the confederate’s wearing a standard surgical face mask, the social status signaled by the confederate’s clothing (worker vs. manager) the race locally ascribed to the confederate (Black vs. White), the sex of the pedestrian, and the fact that the pedestrian him- or herself wears a mask (the last two factors are

obviously not randomized). Importantly, this design allows to assess if the influence of the mask on compliance with the one-meter rule varies across levels of the other factors, opening the way to the idea of *conditional* risk compensation. Thus the specific aim of the article is to examine whether risk compensation depends on the confederate's social status, the confederate's race, the pedestrian's sex, and the fact that the pedestrian wears a mask.

With minor changes, the experiment was conducted in two waves beginning in June 2 and September 17, 2020, respectively. The first wave was conducted in June because this was the earliest that field work could be conducted after the French complete lockdown that lasted until May 2020. The second wave was scheduled for September because this was the earliest (after the Summer break) that, relative to the situation in June, important changes regarding the pandemic and the response to it were clearly in view. In effect, these two periods differ in many respects, but two salient contrasts deserve mention as potential sources of variability with regard to face mask use and physical distancing. On the one hand, in June wearing a mask in the streets of Paris was merely recommended, whereas in September it had become mandatory. On the other hand, the measures of risk available to the public and widely echoed by official communication and the mass media indicated that in France the number of intensive care admissions and deaths related to Covid-19 had been substantially higher in the thirty days preceding the June study than in the thirty days preceding the September study (+430% for admissions and +488% for deaths), and dramatically more so if those periods are allowed to cover sixty days (+895% and +1496%) (Santé publique France, 2020b). Given that the meanings attached to the mask and perceptions of risk are unlikely to remain stable in such a rapidly evolving situation, the potential influence of the time period on risk-compensatory behavior will also be explored.

## **Overview of studies on the effects of the mask on interpersonal distance in the Covid-19 crisis**

To date, the available evidence coming from experiments designed to examine the influence of face mask use on adherence to interpersonal distance recommendations following the Covid-19 outbreak does not allow to draw any general conclusions. In part, the inconclusiveness of this research is imputable to differences in the population sampled, the period of sampling, the exact phenomenon of interest and the method. The present section offers a brief overview of these studies in the order in which they were carried out.

A field experiment in the sidewalks of Venice conducted between February and April 2020 shows that pedestrians walking past the experimenter keep larger distances when the latter wears a facial protection (sample size not reported) [11]. Similarly, a field experiment performed in front of shops in Berlin, first in April (n=240), then in May 2020 (n=240), finds that in the context of queuing people maintain larger distances from an experimenter when the latter wears an FFP2 respirator [12]. At the time of writing the reports of both studies are non peer-reviewed pre-prints.

Two other experiments argue for the opposite trend. An online experiment with a French sample (n=457) completed during the lockdown period (ending in May 11, 2020) indicates that, over a range of possible interpersonal distances in a suggested indoors setting, participants are less likely to judge a realistic virtual character to be “too close” for interacting when the character appears with a face mask [13]. In a similar fashion, an online experiment initially conducted in June 2020, when the mask was merely recommended, then replicated in July 2020, when it was mandatory, with a British sample (n=730) shows that over activities (standing on line, sitting side-by-side, walking past another person) and locations (inside vs. outside) participants place a stylized image of themselves closer to the stylized image of a stranger when the participant and/or the stranger are pictured as wearing a face mask. Additionally, the study brings to light differences between the time periods. In a consistent manner across the three activities (queuing, sitting, walking), in the second study the decrease in distance due to the fact that the participant wears the mask is larger when also the stranger wears it [14]. The report of the British study is a non peer-reviewed pre-print at the time of this writing.

## Predictions

### *Main effects*

From the cited evidence ([11] and [12] for P1a, [13] and [14] for P1b), the following predictions can be readily derived:

P1a: when the confederate wears the face mask pedestrians will be *more* likely to comply with physical distancing recommendations.

P1b: when the confederate wears the face mask pedestrians will be *less* likely to comply with physical distancing recommendations (risk compensation hypothesis).

The immediacy hypothesis [15] offers a plausible basis to derive predictions about the potential influence of the confederate's signaled social status and perceivable race on the pedestrian's probability of complying with the distancing rule. Simply put, the immediacy hypothesis states that people tend to physically approach those they evaluate more positively or less negatively. Common sense (confirmed by surveys, e.g. [16]) indicates that in contemporary France people tend to evaluate more positively managers and Whites than workers and Blacks. By virtue of the immediacy hypothesis, this implies that pedestrians should approach more the manager-looking confederates (regardless of race) and the White confederates (regardless of status), resulting in a decreased probability of complying with the physical distancing rule when the confederate has those appearances. Thus,

P2: when the confederate wears the manager costume, pedestrians will be less likely to comply with physical distancing rules.

P3a: when the confederate is White, pedestrians will be less likely to comply with physical distancing rules.

However, a recent representative survey points out that anti-Black prejudice in France appears to vehicle a paradox: on the one hand, Blacks are the target of the most humiliating forms of racism; on the other hand, compared to other minorities they enjoy a good public image [16]. The authors

interpret the paradox as an expression of the underlying stereotype, inherited from colonial times, according to which Blacks are “big children”, that is primitive and naive but ultimately unthreatening beings. If Blacks are deemed less threatening than Whites, the immediacy hypothesis leads to the prediction that pedestrians should approach more (not less) the Black confederates.

Now, the same prediction can be derived from different premises. People use interpersonal distance not only to spontaneously express immediacy, but also to deliberately manage impressions [17]. A surprising yet robust finding is that an actor may approach more (not less) a negatively evaluated other, presumably to make the interaction less unpleasant [18-23]. Thus,

P3b: when the confederate is Black, pedestrians will be less likely to comply with physical distancing rules.

In the specific context of the pandemic, compared to men, women comply more with non pharmaceutical measures including physical distancing rules [24]. More generally, a recent study involving nearly 9000 respondents from over 40 countries finds that in interaction with strangers women prefer greater distances than men [25]. Together, both facts offer a basis for the prediction that

P4: female pedestrians will comply more with the distancing recommendation.

In the absence of a basis to derive predictions, the influence of face mask use on the part of the pedestrian on compliance with distancing recommendations will be merely explored.

#### *Conditional (or “simple”) effects*

A repeatedly observed finding is that men are more likely to take risks, or take higher risks, than women [26]. Extrapolating knowledge on risk-taking in general to the more specific domain of risk compensation, the following prediction can be formulated:

P5: when the confederate wears the face mask, male pedestrians will be less likely to comply with physical distancing recommendations than will female pedestrians.

Face mask use might affect interpersonal distance differently depending on the status and race of the confederate and the sex of the pedestrian. For example, people in higher-status positions are typically thought to be more competent than people in lower-status positions [27]. If this competence attribution extends to face mask use, the mask might be perceived to be a more reliable protection when the signaled status of the mask-wearer is high, compared to low. While there is no basis from which to derive predictions about such interactions, these will be systematically explored in the studies that follow.

Last, extrapolating from the above mentioned British [14], as well as from similar conclusions reached by studies based on cross-sectional survey data from Denmark [28] and the United States [29], it is predicted that

P6: risk compensation will be lower in June 2020 (mask use recommended in the streets of Paris) than in September 2020 (mandatory).

## **Method**

### Experimental design

The first experiment conducted in June 2020 follows a 2 (condition) x 2 (confederate's social status) x 2 (confederate's racial appearance) x 4 (observation site) between-subjects design with random assignment of pedestrians to conditions and with equal sampling time devoted to each of the 32 unique factor combinations. The second experiment conducted in September 2020 is identical in design except for the experimental condition, which includes not two but three levels.

### Selection of observation sites

In France, the government imposed a strict lockdown for the period going from March 13 to May 10, 2020. In the first week after the end of this *confinement*, all the pedestrian crossings equipped with traffic lights in the vicinity of the officially designated commercial streets of Paris [30] were

visited to observe the flow of pedestrians. The selection desiderata were: the highest possible arrival rate of pedestrians, the busiest possible traffic of motor vehicles on the road to be crossed (to ensure that pedestrians would wait until the light turns to green before crossing), and a comfortable spacial arrangement for the envisaged procedure. The visited crossings in the southern half of Paris turned out to show substantially lower arrival rates than those in the northern half of the city and were eventually discarded. The four crossings selected as observation points are located, respectively, at place de la République, place de la bataille de Stalingrad, place de Clichy, and Saint-Lazare station.

### Sampling and experimental treatment

Acting as an Institutional Review Board, the DPD division of Centre National de la Recherche Scientifique approved the procedure. Data collection proceeded from June 2 to 12 (experiment 1), then from September 21 to October 1, with a single catch-up session performed on October 6 (experiment 2). For each experiment, four observation sessions were scheduled in each of the four sites, equally spaced in time. Unfolding in working days only, sessions begun at 16:00 and ended at 19:00, covering the rush hour. In each session, two experimenters acted alternatively as confederate or observer. As confederate, the experimenter asked directions to pedestrians following a script. As observer, he assisted the confederate in the performance of the script and took the measurements. Sessions on the same day were divided into four slots of equal duration, corresponding to each unique combination of experimenter in the role of confederate/observer and experimental condition. Confederates interacted with pedestrians in one of the following conditions: a) wearing a correctly placed disposable surgical facemask; b) wearing no coverings at all; c) wearing a facemask exposing the nose; d) wearing a facemask under the chin, exposing both nose and mouth. Experiment 1 (performed in June 2020 when the mask was only recommended) compares conditions a and b, whereas Experiment 2 (carried out in September 2020 when the mask had become mandatory) examines the differences between condition a, on the one hand, and conditions c and d, on the other.

Experimenters were provided with a set of identical masks to be used one in each session. At the time the experiments were conducted, disposable facemasks of the surgical type represented the most common type of facial protection that could be seen in the streets of Paris. In september 2020, conditions c and d were commonly observed relaxations of mask correct usage in that setting.

To approximate a random sample, the sampling technique systematically exploits a random process, namely the relationship between the traffic signal's regular alternation between red and green light, on the one hand, and the time at which pedestrians arrive at the street crossing under consideration, on the other. As a result of this random process, a given pedestrian's arrival time corresponds to either the green or the red period, and within these, the pedestrian is the first, second,...  $n^{\text{th}}$  pedestrian to arrive in chronological order. The process can be reasonably assumed to proceed at random to the extent that pedestrians' arrival time is generally independent from the green-red alternation (for example, generally pedestrians do not "plan" their arrival time as a function of their knowledge of the timing of that alternation).

In this study, random selection was achieved by exploiting one of the outcomes of this random process: the confederate approached the first pedestrian who came to stand still in front of the traffic light after the latter had turned red. To be eligible, the pedestrian had to be unaccompanied, not talking on the mobile, not carrying encumbering objects (e.g. a shopping cart or a rolling luggage), and able to walk without assistance and/or particular effort.

While pedestrians were selected randomly by exploiting the outcomes of this random process, the experimental condition was assigned systematically by alternating sampling periods in the mask and no-mask conditions. To approximate randomization and neutralize potential confounders (e.g. between and within days: nuances of dry weather, of pedestrian flow, of ambient noise), sessions at the same site were held on different days of the week, each experimenter wore each of the two costumes (see below) at the same site only once (but served both with and without the mask in every session), and within and between sites all the combinations of costume, perceived race (see

below) and experimental condition were distributed evenly and systematically across the available time slots.

### Field team

Four experimenters performed the assays. They worked in sub-teams of two that were assigned to different sites on the same day. Every sub-team was composed of an experimenter locally perceived as *blanc* (White) and of another experimenter locally perceived as *noir* (Black). The Black and White confederates were approximately matched on build in the June experiment and also in age in the September experiment. Whereas in present-day Paris men in their twenties or thirties do approach men or women of all ages if they need to ask for directions, women in that age interval are unlikely to approach men of the same age with that intent, for fear of looking “inviting” and breaching the rules of modesty in public places that are generally believed to apply to women [31, 32]. To keep the design symmetrical, minimize logistic cost and facilitate interpretation of the results, the confederates were all male.

At a given site on a given day of dry weather, one of the experimenters wore a casual-looking costume suggestive of a worker status and the other a corporate-looking costume suggestive of a manager status. The costumes were strictly identical across confederates and differed only slightly in size. Figure 1 shows the four experimenters’ appearance wearing each costume with and without the surgical facemask.

[insert Figure 1 here, in the present manuscript all figures are grouped at the end of the document]

**Figure 1: confederates’ appearance in Experiment 1 (June 2020).** 1a: worker look, no mask. 1b: manager look, no mask. 1c: worker look, mask. 1d: manager look, mask.

[insert Figure 2 here]

**Figure 2: confederates' appearance in Experiment 2 (September 2020).** 2a: worker, mask. 2b: manager, mask. 2c: worker, nose. 2d: manager, nose. 2e: worker, mouth. 2f: manager, mouth.

## Procedure

The experimenter in the role of the observer carried a rolling luggage on the top of which a cylinder (a rolled plastified map) of one meter of width was affixed. In the period during which the first experiment was conducted, the authorities had recommended keeping a one-meter distance in all interactions, and wearing a facemask was not mandatory in the streets, although it was in shops and public transport. The cylinder acted as a standard to help the confederate to approach pedestrians at the recommended one-meter distance, and the observer to measure the distance at which the pedestrian decided to place himself or herself in response.

After the pedestrian had taken position standing still in front of the red light (Figure 3a), the observer approached discreetly from behind carrying the luggage with the cylinder. The observer then aligned one of the cylinder's edges with one of the pedestrian's heels (Figure 3b). Orienting his body toward the pedestrian, the confederate aligned his own foot with the opposite edge of the cylinder, establishing a one-meter distance with the pedestrian (Figure 3c). At that point, the confederate spoke to the pedestrian (Figure 3d) performing a script (for details, see Supplementary materials: Method).

[Insert Figure 3 here]

**Figure 3: Procedure.** 3a: the pedestrian stands in front of the red light, while the confederate awaits the observer's arrival. 3b: the observer aligns one edge of the one-meter horizontal cylinder with one of the pedestrian's heels (superimposed red line). 3c: Orienting his body toward the pedestrian, the confederate aligns his own foot with the opposite edge of the cylinder. 3d: the confederate speaks to the pedestrian at a one-meter distance.

The confederate did not move until the end of the script. If the pedestrian gave a direction or sent to some other point (saying, for example, “look on the map over there”), the confederate left the scene accordingly. If the pedestrian did not offer any form of help, after uttering the last line in the script the confederate abandoned the body orientation toward the pedestrian, placed himself in front of the red light and looked down to his “crashing” phone pretending to fix the problem until the pedestrian left (which typically occurred as the light turned green).

The observer, who stood behind the interacting dyad, watched the exchange until the end of the script and then recorded the measurements on a portable tablet.

Measurements and statistical analyses (for full details, see Supplementary materials: Method)

The observer recorded pedestrians perceived gender (as assessed by experimenters), whether they were wearing a facemask during the interaction with the confederate, and whether their minimal distance from the confederate was equal or higher than one meter (complies-yes) or lower than one meter (complies-no). The data were analyzed using an Anova-like logistic regression estimated with Bayesian inference. Across and within groups defined by the other characteristics of the confederates (status, race) and by the characteristics of the pedestrian (gender, wearing a mask or not), the three models estimate, respectively, 1) the difference between the confederate’s wearing vs. not wearing a mask in June (n=1396), 2) the difference between the confederate’s wearing a mask correctly vs. exposing the nose and/or the mouth in September (n=1331), and 3) the difference between the confederate’s wearing a mask/wearing a mask correctly vs. not wearing a mask/not wearing a mask correctly taking into account the influence of the time period. To ensure that the differences between the time periods were not confounded with differences attributable to the confederates (recall that the age match was not perfect in June), the analysis is limited to the observations pertaining to the confederates who participated in both experiments, that is those who are locally categorized as Blacks (n=1366). Subsequent models performed on the full sample

confirmed that the results arising from the sub-sample restricted to the Black confederates are upheld when the total set of observations over the two periods is considered ( $n=2727$ ).

*Note on Bayesian inference.* The goal of the statistical analyses to be reported is to test the null hypothesis of no difference between the experimental conditions. The mathematical application used to this purpose is an ANOVA-like model in the framework of the Generalized Linear Model [33, 34]. Null hypothesis testing, the logic of ANOVA and the GLM are familiar enough to most readers. The unfamiliar part concerns only the mechanics of inference, which in this study is Bayesian instead of frequentist. The major advantage of using Bayesian inference (and most exactly sampling algorithms for approximating posterior distributions) in order to test null hypotheses via ANOVA-like GLMs is the flexibility and richness that it brings to the analysis. Flexibility: the analyst programs every detail in the model, notably including the mathematical form of the distribution, but also varying intercepts and slopes and possible hierarchical relations between these. Richness: the output of a GLM relying on Bayesian inference directly provides (that is, without post hoc manipulations) all main effects, simple effects, interaction effects and effect size statistics expressed as probability distributions of possible parameter values; these distributions are estimated jointly and directly incorporate uncertainty. In some simple applications, frequentist and Bayesian inference provide almost exactly the same results, and there might be no particular reason to use one or the other. The relative returns of the Bayesian method increase with complexity.

The models to be reported below, of intermediate complexity, involve the estimation of dozens of parameters. The output of interest is limited to that particular family of null-hypothesis tests that in the language of ANOVA we call main and simple effects. Main effects designate differences on the outcome between levels of a nominal predictor averaging over the levels of all the other predictors (e.g. differences in the probability of complying between mask-yes and mask-no averaging over the levels of race and status). Simple effects compute differences on the outcome between levels of a nominal predictor within a particular level of another predictor (e.g. differences

in the probability of complying between mask-yes and mask-no when the confederate conveys high status).

In the analyses that follow, null-hypothesis tests are accomplished by examining whether the “central posterior intervals” [35] estimating main and simple effects credibly differ from zero. The chosen alpha level is the standard 5%. The null is rejected if zero is excluded from the values comprised between the 2.5<sup>th</sup> and 97.5<sup>th</sup> percentiles of the posterior probability distribution of the relevant effect. In frequentist statistics, “statistically significant” is the expression used to flag differences that, according to some distribution, differ from zero with some usually high probability. The Bayesian equivalent is the adjective “credible”.

Sample sizes are not provided in separate tables but incorporated to the Figures that present the parameter estimations in graphical form. The the reader can thus directly access the sample size underlying the estimation of every single reported main or simple effect. The used effect size statistic is the ratio between the probability of compliance in the mask condition and that probability in the control condition, at the median of the central posterior distribution.

## Results

The grand mean in the probability of complying with the one-meter rule was (estimated to lie with a 95% chance within the interval) [40%, 46%] in June and [30%, 37%] in September.

*P1a: when the confederate wears the face mask pedestrians will be more likely to comply with physical distancing recommendations.*

*P1b: when the confederate wears the face mask pedestrians will be less likely to comply with physical distancing recommendations (risk compensation hypothesis).*

Discarding both P1a and P1b, none of the periods yield a credible main effect of the (correct use of the) mask on the probability of complying with the one-meter rule.

*P2: when the confederate wears the manager costume, pedestrians will be less likely to comply with physical distancing rules.*

Neither in June nor in September does a main effect relating to the confederate's signaled status emerge, discarding P2.

*P3a: when the confederate is White, pedestrians will be less likely to comply with physical distancing rules.*

*P3b: when the confederate is Black, pedestrians will be less likely to comply with physical distancing rules.*

Both P3a and P3b are discarded, as race fails to elicit a main effect in June as well as in September.

*P4: female pedestrians will comply more with the distancing recommendation.*

A credible simple effect offers partial support for P4. Women were [5%, 16%] more likely to observe the rule in June (see Fig 4, difference between parameters "Pedestrian: male" and "P: female"), but no different from men in September 2020. In June, for every ten females who complied with the policy, only eight men did so.

*P5: when the confederate wears the face mask, male pedestrians will be less likely to comply with physical distancing recommendations than will female pedestrians.*

The simple effect of the mask on compliance differs for females and males, first in June and then again in September. Considered separately, in none of the surveyed periods did women alter their probability of observing the physical distancing recommendation as a function of the confederate's wearing the face mask (correctly). In contrast, both in June and September, men were [1%, 16%] and [2% , 20%] less likely, respectively, to comply with the one-meter rule when the confederate used the covering (see Figs 7 and 8, parameter "P: male"), with an effect slightly larger in magnitude

for September. In June (September), for every ten males who complied with the policy in the control condition, only eight (seven) did so when the confederate wore the mask. In June the 95% lower and upper bounds were seven and nine, respectively; in September, five and nine.

In both experiments the compliance-reducing effect of the mask among men was strongest when the confederate signaled high status, with an estimated decrease of [4%, 19%] in June and of [5%, 29%] in September (See Figs 7 and 8, “P: male, Confederate: corporate”), and again the effect size is slightly larger in September. When males interacted with the high-status participant in June (September), for every ten participants who complied with the policy in the control condition, only six (five) did so when the confederate wore the mask. Of a comparable strength, but restricted to September, was the simple effect of the mask among males who interacted with the Black confederates, as within this subsample the confederate’s use of the protection turned out to decrease by [1%, 26%] the probability of observing the distancing rule (See Fig 8, “P: male, C: black”). Thus, the mask decreases compliance among men but not among women, supporting the expectation of conditional risk compensation. Within each experiment regarded in isolation, risk compensation is conditional on gender.

*P6: risk compensation will be lower in June 2020 (mask use recommended in the streets of Paris) than in September 2020 (mandatory).*

The simple effect of the mask on compliance differs for females and males also when the June and September data are considered together, offering conditional support for P6. It may be recalled that the Black men that served as confederates in June and September are the same individual persons, unlike their White counterparts. When consideration is restricted to the confederates that served in both experiments, the analysis brings to light some differences in the behavior of female pedestrians between the periods that are not paralleled by corresponding changes among males. Compared to June, in September women overall observed [4%, 19%] less often the one-meter rule (see Fig 9, parameter “P: female”). Among female pedestrians, the decrease in compliance resulting from the

time period was particularly pronounced when the confederate used the manager costume (“P: female, C: corporate”, [3%, 27%]), when the woman herself wore the mask (“P: female, P: mask”, [6%, 25%]), and when the confederate wore the covering (“P: female, C: mask”, [1%, 23%]). In all these conditions, for every ten women who observed the distancing recommendation in June, the number of those who did so in September was comprised between seven and eight. In other words, when the periods are compared with one another, the decrease in compliance brought about by the mask is approximately 25% stronger in September than in June, but only among women, in support again of the expectation of conditional risk compensation

[insert Figures 4-6 here]

**Figures 4-6: main effects on compliance, June 2020 (Fig 4), September 2020 (Fig 5) and June vs. September comparison (Fig 6).** The headings on the left-hand side of the plot index levels of nominal predictors, where “C” stands for “confederate” and “P” for “pedestrian”. The quantities below the parameter names detail the number of observations on which the estimation of the corresponding parameter directly relies. On the left plot, the x-axis represents the estimated value of the parameter (averages), whereas on the right plot it estimates main effects. Within the plot area of the left plot, the blue vertical line indicates the grand mean (more exactly, the median of the grand mean’s posterior distribution). Within the plot area of the right plot the dashed vertical line indicates the location of the value 0, which signifies no difference between levels of the same factor, and consequently the absence of a main effect. The horizontal segments represent the central 95% posterior intervals of the parameters. The bolder section of the segment corresponds to the central 90% posterior interval and the solid point indicates the median of the distribution. The differences in color are only meant to facilitate reading. Graphically, when the segment representing the central posterior interval does not intersect the vertical dashed line, the null hypothesis of no difference is discarded.

[insert Figures 7-9 here]

**Figures 7-9: Simple effects of the mask in June (Fig 7) and September (Fig 8) and simple effects of the time period (Fig 9), across levels of other factors.** The quantities on the right-hand side of the plot specify the number of observations on which the estimation of the corresponding parameter directly relies; the first number refers to the sample size of the mask group, the second number to that of the no mask group. The x-axis represents the difference between the mask and the no mask conditions.

## **Discussion**

Overall, the three studies provide conditional support to the hypothesis of risk compensation, with a gender difference in risk-compensatory behavior arising from the data. Consistently over the two surveyed time periods, men are approximately 20% less likely to comply with the one-meter rule when the confederate wears the face mask. Women, in contrast, appear to change their behavior over time, observing roughly 25% less often the one-meter rule in September than in June when they or the confederate wear the face mask. In short, men's risk-compensatory behavior with regard to these two measures is stable, whereas women's depends on the time period.

Men's risk-compensatory behavior, in turn, appears to be sensitive to the confederate's social status. In both experiments the compliance-reducing effect of the mask is of greatest magnitude, namely between 40% and 50%, when male pedestrians interact with the confederate in the high status condition. In the low status condition, the fact that the confederate wears the covering does not affect male pedestrians' probability of observing the distancing recommendation. Similarly, but restricted to the September experiment only, male pedestrians observe approximately 40% less often the one-meter rule in response to the mask when the mask-wearer is Black, but not when he is White. In the September experiment, Black and White confederates were better

matched, and one may wonder whether the same result would have been reached in June if a better match had been achieved at that point.

The results reported here are in fundamental agreement with those from an online experiment performed with a French sample during the Spring 2020 lockdown [13]. This is noteworthy for at least two important reasons. First, the population from which participants in both studies were sampled share the national context and all the characteristics that go with it. Second, to date both studies are the only ones to have examined the influence of the mask on distance in the specific context of focused (or conversation-like) interactions, and both similarly find support to the risk compensation hypothesis. In spite of significant differences in the time frame and the overall methodology, the partial overlap in the population sampled and the shared focus on conversation-like interactions bolster the validity of this common but independently reached conclusion.

It is important to note that although the population and the type of interaction overlap, the interactional setting was indoors in the online study but outdoors in the present experiment. The fact that for this population the proxemic reactions to the mask appear to be similar in indoor and outdoor interactions offers some basis to defend the clinical relevance of the present findings. In effect, it may be objected that in outdoor interactions as the ones studied here, whether participants use a face covering or not, or approach more or less, the risk of transmission remains low all the same, because exchanges are brief and the environment is well ventilated (cite paper for CER). There is no definitive, unequivocal evidence in support of this objection, but even if there were, it could be replied that, as the cumulative behavioral data from France suggest, people's proxemic responses to the face mask during Covid-19 do not seem to vary along the indoors-outdoors contrast. If so, the results reached by the present experiment may be reflecting a general tendency that extends to interactional configurations that consensually involve a high risk of viral spread, e.g. prolonged indoor face-to-face exchanges. If the present findings illustrate a general tendency, the one-fourth to one-half decrease in compliance with physical distancing recommendations that the

face masks brings about points to a clinically nonnegligible instance of risk compensation during a global health emergency.

Although not sharing the population or the exact interactional phenomenon, the conclusions of the comparison between the time periods resonate with the findings from an online experiment based on a British sample [14] and with the results from surveys representative of the population in Denmark [28] and the United States [29]. The four studies indicate that a concomitant of making the mask mandatory is to reduce compliance with physical distancing rules when the mask is worn. In other words, in Denmark, France, the UK and the US as the mask becomes mandatory, risk compensation appears to increase.

An important limitation is that the confederates in the experiments reported were all male. It remains to be tested if the observed gender differences in risk compensation would hold if pedestrians were approached by female confederates. In the present state of knowledge, it is impossible to decide whether the observed contrast results from the gender of the pedestrian or rather from the gender composition of the dyad that the pedestrian forms along with the confederate. A related limitation has to do with the measurement of gender. Pedestrians were categorized as *homme* (man), *femme* (woman) or neither not on the basis of their self-reported gender identity but relying on experimenters' commonsensical perceptions. The bigger the disagreement between experimenters' perceptions and the gender identity that pedestrians would have reported had they been asked, the bigger the bias introduced by this measurement technique, which will have to remain undetermined. Other limitations, bearing more on precision than generalizability or bias, concern the facts that neither the actual/perceived risk of infection incurred by pedestrians nor the interaction length were measured and used as controls in the statistical analyses. Also, knowledge of a baseline "pre-outbreak" distance in the type of situation studied and using the same measurement technique would have been instructive to better put the results in perspective.

*Gender differences in risk compensation*

One possible interpretation for the contrast observed in the experiments reported above is to invoke gender differences in the perception of the threat posed by the new coronavirus. Two independent survey studies based on data collected in March and April 2020 across different sets of countries converge in the finding of gender differences with regard to the pandemic: compared to men, women perceive more risk [36] and consider Covid-19 as a more serious health problem [24]. Related to their perception of higher risk, women also report greater compliance with measures such as the one-meter rule or the use of a face mask, and the difference is stable over time [24, 34]. Assuming that these measures are effective in reducing the risk of catching the disease, men's lower compliance with preventive rules in June and September implies that they take higher risks with regard to Covid-19. Such an outcome would be confirming the repeatedly observed and widely echoed result that men, on average, are more likely to take risks, or take higher risks, than women [26].

But this cannot be the full story, because women too engage in risk compensation. There is evidence that, in some tasks for which risk assessments are highly relevant, gender differences may depend on the context. One such task is competition. When solving computerized mazes, compared to solitary play, women increased performance in a single-sex tournament but not in a mixed-sex tournament [38]. Negotiation represents another task in which risk perceptions are crucial, and there too gender differences seem to be context-dependent. In a word game, male participants, compared to their female counterparts, were more likely to initiate a discussion with the experimenter for greater compensation when participants were told that they could "negotiate for more", but gender differences disappeared when the instruction was that they could "ask for more" [39]. In a simulated computerized negotiation of a starting salary, women negotiated for a lower sum than men when the salary was for themselves (self-advocacy), but the sums bargained by women and men did not differ when the salary under negotiation was that of a friend (other-advocacy, [40]). A convenient way of summarizing these findings is to point out that men's responses in situations involving risk assessments tend to be stable, whereas the responses of women vary depending on

the specifics of the context. In this reading, on average women appear to be more “sensitive to the particulars of the situation” [41].

If women’s risk-taking behavior depends on the particulars of the situation, the explanation for women’s increase in risk compensation in September compared to June must be sought in perceived differences between the situations associated to these two time periods. An important variable that plausibly affects mask use, physical distancing and their combination is the perceived probability of being affected by Covid-19 and the perceived magnitude of the pandemic. Survey data shows that these subjective assessments are not totally arbitrary but tend to reflect the actual magnitude of the pandemic at a given point in time [24, 34]. In the 30 days preceding the June experiment, in France the number of intensive care admissions and deaths due to Covid-19 were four to five times higher than in the 30 days preceding the September experiment [42]. The corresponding statistics, translated into smoothed barplots, were routinely used by the French government and mainstream media to depict the situation in terms of rising and declining “curves” and “waves”. If women, compared to men, are more sensitive to this (perceived) decrease in the probability of being affected and in the magnitude of the pandemic from one period to the other, that could explain why female pedestrians are more likely to engage in risk compensation in September than in June, whereas among male pedestrians the probability of risk compensation remains stable over time.

In sum, male pedestrians engage in risk compensation to the same extent in June and September possibly because, compared to women, they underestimate the severity of Covid-19. In contrast, female pedestrians show more risk-compensatory behavior in September than in June possibly because, compared to men, they are more sensitive to the (perceived) decline in hazard from one period to the other.

*Risk compensation conditional on the status of the interaction partner*

Drawing on the immediacy hypothesis [15], it was predicted that pedestrians would comply less often with the one-meter rule when the confederate signalled high status. The results disconfirm the expectation but indicate that male pedestrians in particular are less likely to observe this rule when the high-status confederate wears the face mask. Why does the mask decrease compliance with distancing recommendations when the mask-wearer is high-status? Here is one possible *post hoc* speculation.

A number of personal, experiential, and relational-situational pre-interaction factors shape the understanding that a person has of what the “right” distance to another person might be on a given occasion [17]. In the context of the Covid-19 crisis, these may be thought to include the specific influence of the pandemic. If the influence of the pandemic is factored out, the sense of the “right” distance that remains is the one that the person had before the outbreak. For convenience, this sense will be called “pre-outbreak distance”. In contrast, the term “post-outbreak distance” will be used to designate the sense of the “right” distance when the influence of the pandemic is factored in. The “proxemic effect of the pandemic” makes reference to the difference between the post- and the pre-outbreak distance.

As a simplification, we posit that the influence of the pandemic as a pre-interaction factor, for a given actor and type of situation, is to put all possible interaction partners on an equal footing as potential sources or targets of infection, setting a universal post-outbreak distance. It follows that, for a given actor, interaction partner and type of situation, the proxemic effect of the pandemic will depend on the baseline pre-outbreak distance. Assuming that in pre-outbreak times actors preferred to interact closer to high-status vs. low-status partners, this implies that the proxemic effect of the pandemic will be larger when the interaction partner is high- compared to low-status.

We posit that the effect of the mask is to bring the post-outbreak distance back to the the baseline pre-outbreak distance when these turn out to differ. In this interpretation, the observed fact that men comply less with the one-meter rule in response to the mask when the protection is worn by a high-status confederate would originate in a substantial positive gap between men’s preferred

post- and pre-outbreak distances from high-status interaction partners. By the same logic, the absence of a mask effect among men when the confederate signals low status would follow from a null difference between those distances. *Mutatis mutandis*, the same reasoning applies to Blacks vs. Whites.

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**Figure 1: confederates' appearance in Experiment 1 (June 2020).** 1a: worker look, no mask. 1b: manager look, no mask. 1c: worker look, mask. 1d: manager look, mask.

1a



1b



1c



1d



**Figure 2: confederates' appearance in Experiment 2 (September 2020).** 2a: worker, mask. 2b: manager, mask. 2c: worker, nose. 2d: manager, nose. 2e: worker, mouth. 2f: manager, mouth.

2a



2b



2c



2d



2e



2f



**Figure 3: Procedure.** 3a: the pedestrian stands in front of the red light, while the confederate awaits the observer's arrival. 3b: the observer aligns one edge of the one-meter horizontal cylinder with one of the pedestrian's heels (superimposed red line). 3c: Orienting his body toward the pedestrian, the confederate aligns his own foot with the opposite edge of the cylinder. 3d: the confederate speaks to the pedestrian at a one-meter distance.

3a



3b



3c



3d



Figures 4-6: Main effects on compliance.

Fig 4

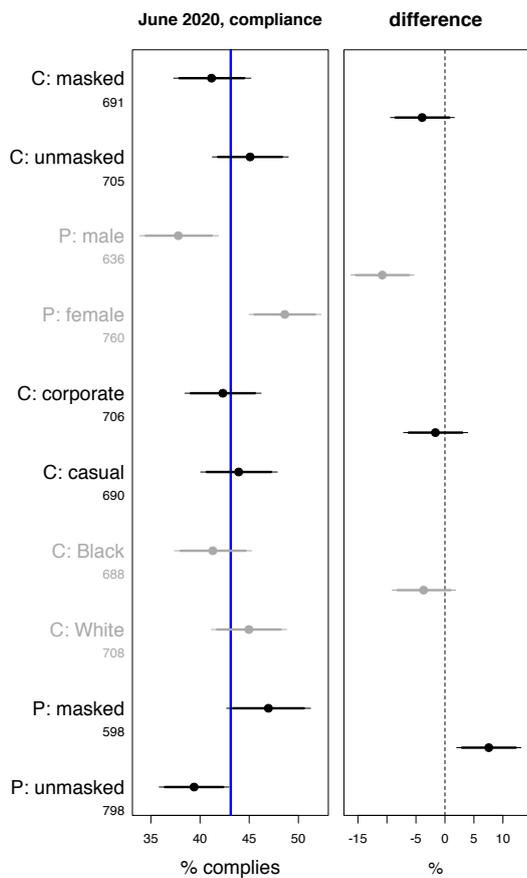


Fig 5

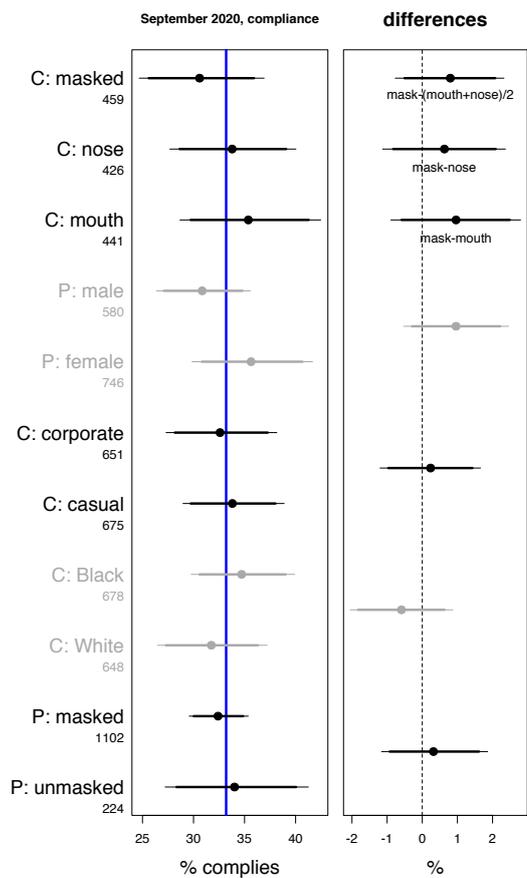
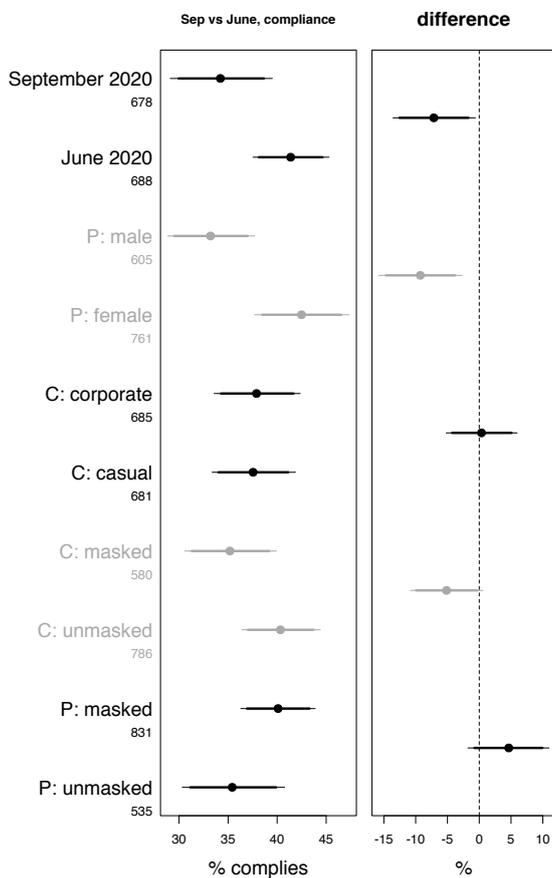


Fig 6



Figures 7-9. Simple effects of the mask across levels of other factors.

Fig 7

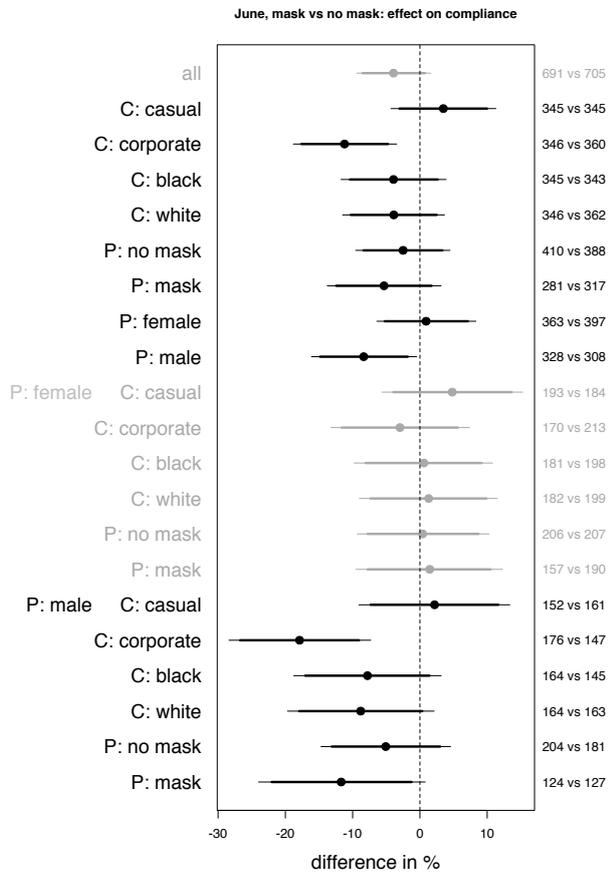


Fig 8

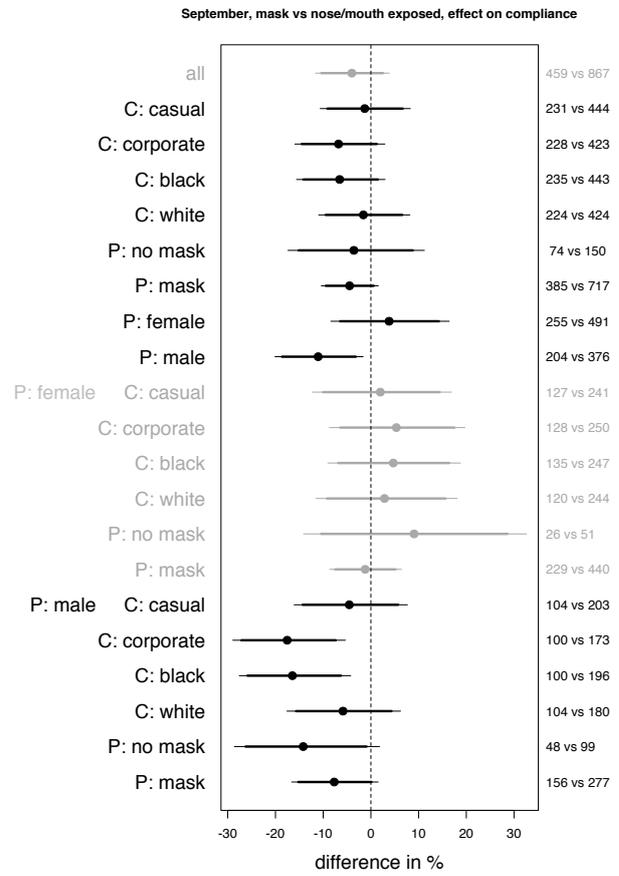
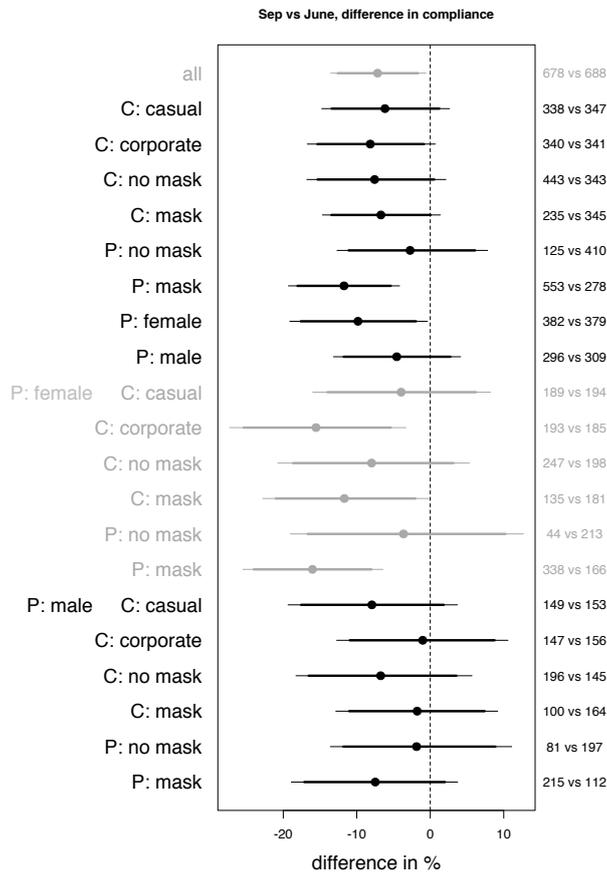


Fig 9



Supplementary materials: Method

### **Ethical considerations**

Acting as an Institutional Review Board, the DPD division of Centre National de la Recherche Scientifique approved the procedure. The latter mimics an ordinary interaction that could have occurred without the intervention of the researcher, that does not entail any form of harm for the participant and, as far as the experimenter's behavior is concerned, is in full conformity with preventive measures against Covid-19. Further, the collected data are fully anonymous as the procedure does not involve identifying information.

### **Confederates' script**

Excusez-moi de vous déranger. Bonjour.

Excuse me. Hello.

*Je cherche [...]*

*I'm looking for [name of street; République: rue Turbigo, Stalingrad: avenue Secrétan, place de Clichy: rue Biot, Saint-Lazare: rue de Rome]*

If pedestrian gives a direction:

*Merci beaucoup, au revoir.*

*Thank you very much, goodbye [end of script]*

If pedestrian does not give any directions:

*Parce que mon téléphone plante, j'arrive pas à la trouver.*

*Because my mobile crashes, I'm not able to find it.*

If pedestrian helps in some way.

*Merci beaucoup, au revoir.*

*Thank you very much, goodbye. [end]*

If pedestrian does not help in any way:

*C'est pas grave, je vais me débrouiller. Merci en tout cas.*

*No worries, I'll cope. Thank you anyway. [end]*

## **Measurements**

### *Pedestrian characteristics*

The observer recorded his perception of the pedestrian's gender and whether he or she was wearing a face mask during the interaction with the confederate. Using their commonsensical understanding of gender and whatever cues were available to them, experimenters assigned pedestrians to the category *femme* (n=1622, 54.8%) or *homme* (n=1328, 44.9%), or left the variable undetermined if neither seemed apt (n=9, 0.3%).

### *Outcomes*

**Helping.** The observer assigned the pedestrian's answer to one of the following categories: Gives a direction (pedestrian is sure), Gives a direction (pedestrian is not sure), Does not know: searches on the phone, Does not know: sends to something or somebody else, Does not know: neither searches

nor sends to something or somebody else, Refuses to interact, Third party intervenes (i.e. a non solicited pedestrian addresses the confederate's request in place of the solicited pedestrian).

The analysis of the helping measurements is not included in the present report.

**Distance (June Experiment).** The observer attributed one of the following codes (in increasing order of proximity): Moves Away, Does not move, Moves but neither approaches nor moves away (mostly to orient the body toward the confederate), Approach 1 (below 100 cm and above or equal to 80 cm), Approach 2 (below 80 cm).

To select the code, the observer paid attention to the position of the pedestrian's heels using the following decision rules. The observation period goes from the beginning to the end of the confederate's script. The default code is *Does not move*; in this case, neither heel changes position during the observation period.

If one or both heels do change position, but it is not fully clear if the pedestrian is approaching or moving away, the default is *Moves but neither approaches nor moves away*. Most of the times, this category describes a situation in which the pedestrian orients his or her body toward the confederate, increasing the exposure of the face and communicating greater involvement or openness compared to *Does not move*.

If the change in position clearly leads the pedestrian to place his or her heel within the area demarcated by the horizontal cylinder, the observer uses the marks on the cylinder to decide if the heel is at a distance comprised between 99-80 cm (*Approach 1*) or below 80 cm (*Approach 2*). If the pedestrian makes several steps, the observer records the one that brings his or her heel closest to the confederate.

If the change in position clearly leads the pedestrian to place one or both heels farther away than the point at which the farthest heel was placed at the time the interaction began, the observer codes *Moves away*. If the pedestrian moves away and then approaches, the observer records the approach.

On the outcome distance the assay was considered not valid if the pedestrian's heel changed position after the luggage had been placed but before the confederate begun the script.

To evaluate intercoder agreement, in one session the four experimenters were present at the same site. Two of them conducted a regular session, alternating between the roles of observer and confederate, whereas the other two acted only as observers. As a result, 97 interactions were simultaneously coded by three independent observers. Intercoder reliability was assessed by computing the Krippendorff's alpha for ordinal data, yielding a coefficient of 0.83.

The distance measurements are not analyzed in their original scale in the present report.

**Distance (September Experiment).** The observer attributed one of the following codes (in increasing order of proximity): Moves Away, Does not move, Moves but neither approaches nor moves away (mostly to orient the body toward the confederate), Approach 1 (below 100 cm and above or equal to 80 cm), Approach 2 (below 80 cm and above or equal to 60 cm), Approach 3 (below 60 cm and above or equal 40 cm), and Approach 4 (below 40 cm). The coding rules are the same as in the previous experiment.

**Compliance.** To assess compliance with the one-meter recommendation, the distance measurements were dichotomized. Approach 1 and Approach 2 indicate noncompliance, whereas the other levels indicate compliance. To ensure that the dichotomous coding was not misrepresenting the data, the vector of parameters specified below (i.e.  $X_i\beta$ ) was reused in a Bayesian thresholded cumulative-normal or *probit* model on the raw ordinal values (Kruschke, 2015). For all models, the probit regressions on the ordered data yield the same qualitative results as the logistic models on the dichotomized outcome.

## **Statistical analyses**

The compliance data were analyzed by estimating logistic regressions using Bayesian inference in the framework of the Generalized Linear Model (Kruschke, 2015). The model's unit of analysis are unique confederate-pedestrian interactions denoted  $i$ . The dichotomous compliance codings, denoted  $y_i$ , were given a Bernoulli distribution equal to the average probability of observing a 1 (compliance yes) instead of a 0 (compliance no). More formally,

if  $y_i$  is the  $i^{\text{th}}$  compliance dichotomous coding (0 or 1), then  $y_i \sim \text{Bernoulli}(\text{Pr}(y_i = 1))$ , for  $i = 1 \dots, n$ , where  $\text{Pr}(y_i = 1) = \text{logit}^{-1}(X_i\beta)$ .

The inputs in the vector of parameters  $X_i\beta$  are the experimental condition  $j$ , the sex of the pedestrian  $k$ , the clothing of the confederate  $l$ , the locally perceived race of the confederate  $m$ , whether the pedestrian wears a mask  $o$ , and the site where the interaction took place  $p$ . Formally,

$$\begin{aligned} X_i\beta = & \beta_0 + \beta_1 \text{condition}_{j[i]} + \beta_2 \text{sex}_{k[i]} + \beta_3 \text{clothing}_{l[i]} + \beta_4 \text{race}_{m[i]} + \beta_5 \text{pedMasked}_{o[i]} + \beta_6 \text{site}_{p[i]} + \\ & \beta_7 \text{condition.sex}_{j[i], k[i]} + \beta_8 \text{condition.clothing}_{j[i], l[i]} + \beta_9 \text{condition.race}_{j[i], m[i]} + \\ & \beta_{10} \text{condition.pedMasked}_{j[i], o[i]} + \beta_{11} \text{sex.clothing}_{k[i], l[i]} + \beta_{12} \text{sex.race}_{k[i], m[i]} + \\ & \beta_{13} \text{sex.pedMasked}_{k[i], o[i]} + \beta_{14} \text{clothing.race}_{l[i], m[i]} + \beta_{15} \text{clothing.pedMasked}_{l[i], o[i]} + \\ & \beta_{16} \text{race.pedMasked}_{m[i], o[i]} + \beta_{17} \text{condition.sex.clothing}_{j[i], k[i], l[i]} + \beta_{18} \text{condition.sex.race}_{j[i], k[i], m[i]} + \\ & \beta_{19} \text{condition.sex.pedMasked}_{j[i], k[i], o[i]}, \text{ for } i=1 \dots, n. \end{aligned}$$

*Prior distribution.* All the priors set in the model are noninformative. Visual examination of trace plots and density plots, on the one hand, and consideration of the Gelman-Rubin statistic of convergence suggested that the sample was representative of the posterior distribution. To ensure accuracy and stability, the estimates of all the parameters reported below rest on effective sample sizes of at least 10,000.