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# **Risk compensation during COVID-19: The impact of face mask usage on social distancing.**

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## Abstract

To reduce the spread of Covid-19, governments around the world have recommended or required minimum physical distancing between individuals, as well as either mandating or recommending the use of face coverings (masks) in certain circumstances. When multiple risk reduction activities can be adopted, people may engage in risk compensation by responding to a reduced (perceived) risk exposure due to one activity by increasing risk exposure due to another. We tested for risk compensation in two online experiments that investigated whether either wearing a mask or seeing others wearing masks reduced physical distancing. We presented participants with stylized images of everyday scenarios involving themselves with or without a mask and a stranger with or without a mask. For each scenario, participants indicated the minimum distance they would keep from the stranger. In line with risk compensation, we found that participants indicated they would stand, sit or walk closer to the stranger if either of them was wearing a mask. This form of risk compensation was stronger for those who believed masks were effective at preventing catching or spreading Covid-19, and for younger (18-40 years) compared to older (over 65 years) participants.

Key Words: risk compensation, social distancing, decision making, Covid-19, mask usage

## Public Significance Statement

This study suggests that people may believe it is acceptable to reduce their compliance with Covid-related physical distancing if they are wearing a face mask or are near others wearing masks. This belief applied to both indoor and outdoor settings, and was stronger in younger people. Governments may need to counteract this belief through clear guidance about maintaining the full distance whenever possible.

During the coronavirus Sars-CoV-2 pandemic, the priorities of governments worldwide have shifted toward reducing the spread of the virus, slowing its impact so that health systems can cope and vulnerable members of society, such as the elderly, can be protected (see, e.g., Ferguson et al., 2020; Walker et al., 2020). In most cases, this has involved interventions aimed at reducing the intensity of interactions between people (broadly known as social distancing) and the recommended or mandatory use of face masks.

Although there is much diversity, both within and between countries, in how policies are implemented, the simultaneous use of masks and social distancing has been widespread. Social distancing measures include encouraging people to work from home, closing schools, pubs, restaurants, and non-essential shops, limiting travel, and mandating or encouraging minimum physical distances (often two metres, or six feet) when interacting with others outside the household. Policies around mask use have differed considerably between and even within countries (e.g., Feng et al., 2020; Howard et al., 2020). In some countries such as China, Vietnam, South Korea and Germany, face masks were widely used very early in the pandemic, due to a combination of public policy, their recent experiences with other epidemics such as SARS, and cultural norms. In the UK – where our studies were conducted – little encouragement was given initially to use face masks when engaging in permitted activities outside the home. Rather, mask use by the public was initially somewhat discouraged and the emphasis was placed on preserving the availability of higher specification masks and other personal protective equipment for “key workers” such as those in the medical profession and in care homes (for example, see Baynes, 2020). But on 15 June 2020, that changed, and face masks became a requirement when using public transport in England and, from 24 July, also when entering shops (The other devolved

administrations in the UK – Scotland, Wales and Northern Ireland – adopted similar measures with slightly different timings).

Mask effectiveness depends on various conditions, such as the type of mask (e.g., N95/FFP2 masks [aka disposable respirators], surgical masks, or cloth face coverings), the type of virus and its infectiousness (e.g., influenza or coronaviruses), compliance in mask wearing (e.g., disposable respirators are less comfortable and lead to less compliance), and the situational context (e.g., outdoors, on public transport, or in confined spaces). As highlighted in a systematic review (Mills, Rahal and Akimova, 2020), most studies on mask effectiveness focus on healthcare rather than community settings, and they often rely on observational methods rather than randomised controlled trials. These observational studies suggest that face coverings can help slow the spread of airborne viruses such as Sars-CoV-2 by preventing mask wearers from infecting other people and (to a lesser extent) protecting mask wearers themselves (e.g., CDC, 2020; Wang et al., 2020). These findings have led professionals and politicians to call for widespread mandatory mask usage.<sup>1</sup>

One concern when introducing multiple public health measures – e.g., social distancing, regular hand washing, and face masks – is how the measures will interact with one another. Multiple measures might have an additive effect, or even reinforce each other. For instance, mandatory mask wearing may encourage social distancing, leading to a greater

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<sup>1</sup> For example, more than 100 UK doctors signed an online petition on April 18<sup>th</sup>, 2020 calling for face mask use in public (<https://www.thetimes.co.uk/edition/comment/times-letters-masks-and-protection-measures-for-the-uk-t3sn5bfdx>).

than anticipated effect. Conversely, the introduction of new measures might reduce compliance with existing measures.

We are particularly interested in the latter possibility, and specifically in whether mask wearing might reduce social distancing due to *risk compensation* (Hedlund, 2000; Peltzman, 1975; Underhill, 2013, Wilde, 1982). Risk compensation occurs when individuals react to a perceived risk reduction (e.g., the safety afforded by wearing masks) by otherwise increasing their risk exposure (e.g., getting closer to others). As we shall explain, risk compensation need not imply individual irrationality. However, regardless of individual rationality, it may render policies less effective than anticipated. If everyone who wore a mask compensated fully for their risk reduction by standing closer to others, the mask policy would have no net effect on disease transmission despite the effectiveness of those masks.

We investigate these issues with two pre-registered online experiments in which participants state how close they are willing to get to strangers in several scenarios. We find clear evidence of risk compensation, in that participants indicate they are willing to be closer to a stranger if they or the stranger (or both) are wearing masks. We find the effect is stronger in younger participants and for those who believe more strongly that masks protect against catching and/or spreading Covid-19.

At the time of writing, the emerging evidence about this issue was mixed. Field studies conducted in Germany (Seres et al., 2020) and Italy (Marchiori, 2020) found that, when standing outside, people were keeping further apart from confederates wearing a mask than from confederates not wearing a mask, one key driver of this effect being the

perception that the mask wearer would prefer more distancing. Several subsequent related studies have reported conflicting findings (Cartaud et al., 2020; Jorgensen et al., 2020; Liebst et al., 2021; Yan et al., 2021). We will return to the relationship between our findings and these others in the general discussion.

We begin by outlining the theoretical arguments for risk compensation in relation to mask wearing and social distancing, before presenting our experiments.

### **Mask usage and risk compensation**

Risk compensation is a common concern when considering the interaction between multiple risk reduction interventions (Hedlund, 2000; Peltzman, 1975; Underhill, 2013, Wilde, 1982). Risk compensation occurs when people respond to a perceived reduction in risk brought about by a safety intervention (e.g., anti-lock or ABS brakes) by increasing the riskiness of related behaviours (e.g., driving faster) (Wilde, 2014). Risk compensation has been explained via both economic and psychological mechanisms. From an economic perspective, safety can be treated as a good, and thus traded for other desirable goods (Peltzman, 1975). In the case of ABS brakes, for example, people may be willing to trade some of the extra safety provided by better brakes for a quicker arrival at their destination and the pleasure of high-speed driving (Hedlund, 2000). From a psychological perspective, one theory is that people have a desired level of risk, so if an intervention is perceived to reduce overall risk, they will take other risks until they return to this tolerated risk level. This is termed risk homeostasis (Underhill, 2013, Wilde, 1982).

The risk compensation hypothesis has been studied for a vast range of health and safety interventions, including seatbelts (Evans & Graham, 1991; Peltzman, 1975; Streff & Geller,

1988), road lighting (Assum, Bjørnskau, Fosser, & Sagberg, 1999), bicycle helmets (Phillips, Fyhri, & Sagberg, 2011; Radun, Radun, Esmaeilikia, & Lajunen, 2018), ski helmets (Ruedl, Abart, Ledochowski, Burtscher, & Kopp, 2012), HPV vaccines (Marlow, Forster, Wardle, & Waller, 2009), HIV prevention (Eaton & Kalichman, 2007; Marcus et al., 2013; Pinkerton, 2001; Underhill, 2013) and more (McCarthy & Talley, 1999; Noland, 1995). It has been investigated using a variety of methods, including lab experiments (Phillips et al., 2011; Streff & Geller, 1988), observational studies or natural experiments (Assum et al., 1999; Radun et al., 2018), self-report questionnaires (Eaton & Kalichman, 2007; Marcus et al., 2013; Marlow et al., 2009; Pinkerton, 2001; Ruedl et al., 2012) and population level statistics (Evans & Graham, 1991; McCarthy & Talley, 1999; Noland, 1995). Although these studies suggest that risk compensation occurs, they also show that it is not universal and depends on the nature of the intervention and the behaviours being measured.

One factor that is particularly important for our experiments is whether risk compensation is measured through observations of behaviour (e.g., Assum et al., 1999; Phillips et al., 2011; Streff & Geller, 1988), self-reports about past behaviour, or predictions of behaviour (Holt & Murphy, 2017; Stetzer & Hofmann, 1996). Due to the restrictions in place at the time of our study, and ethical concerns around live interactions with people unmasked, we focused on measuring people's beliefs about their behaviour.

Assessing risk compensation through beliefs about behaviour has several advantages. First, it allows researchers to study risk compensation in domains where direct observation of behaviour can be difficult. For instance, studies of risk compensation in sexual health often ask people about their intended behaviour, beliefs, or self-reported past behaviour. Risk

compensation has been studied in this way by Eaton & Kalichman (2007), who found people reported they would be less likely to use a condom if an HIV vaccine existed; by Marlow et al. (2009), who found young women with low levels of education believed that the HPV vaccine would lead to an increase in risky sexual behaviours; and by Pinkerton (2001), who found increases in self-reported number of sexual partners after interventions encouraging condom use. Second, studies of behavioural intentions or beliefs also allow for the collection of information about perceptions of risk that cannot be done in field studies (Holt & Murphy, 2017). For instance, in our studies we elicit participants' beliefs about the effectiveness of masks. Third, they also allow for manipulation of variables that may not be controllable in the field. In our case, we were able to directly manipulate whether the participant is wearing a mask, and thereby separate the effect of wearing a mask from selection effects, in that those who choose to wear a mask may behave differently than those who do not. This has not been possible in previous field studies about mask use (e.g., Seres et al., 2020).

Under what circumstances can risk compensation occur? First, actors must believe they are engaging in a risky action. In addition, as summarised by Hedlund (2000), four criteria appear necessary for risk compensation to occur. The first criterion is visibility, in that the intervention must be noticeable to the risk taker. For face masks, this requirement is clearly met, both when one is wearing a mask, and when observing others wearing a mask. The second criterion is whether the risk taker believes the intervention to have an effect. We might expect that masks also satisfy this criterion, either because individuals believe in their protective abilities, or, because they believe that masks "make things worse" (e.g., Griffin, 2020). This criterion suggests that the *perceived* change in risk associated with

mask usage matters for risk compensation. The third criterion is the risk taker's motivation to change their behaviour. Given that social distancing limits people's ability to physically engage in social interaction, one of the strongest predictors of individual well-being (e.g., Powdthavee, 2008), it is reasonable to expect that people may be motivated to lower their compliance with social distancing guidelines. In a similar vein, complying with social distancing typically requires individuals to exert constant cognitive efforts to monitor their distancing from others, and creates many minor inconveniences which they may be motivated to reduce. For instance, they may be motivated to reduce their physical distancing to take a seat on the train, or to not step out into the road to avoid an oncoming pedestrian. The fourth criterion is whether the risk taker has control over their behaviour. Although some aspects of social distancing (e.g., the requirement to work from home or the accessibility of shops) are not controllable, others, such as physical distancing when inside a shop, give individuals a lot of leeway.

Risk compensation may also depend upon whether public policy measures relate to the same or different "transmission channels" or domains of risk. For example, mask wearing and social distancing concern the same channel of airborne virus transmission, whereas hand washing relates to a different channel (i.e., transmission through smear deposits). In the case of Covid-19 and mask usage, a recent literature review suggests that risk compensation is unlikely to be a major problem, and even that, due to its potential to delay beneficial interventions such as mask wearing, the debate about risk compensation may be more dangerous than the actual compensation itself (Mantzari, Rubin and Marteau, 2020). In contrast to our study, however, that review focuses mainly on risk compensation through hand hygiene rather than through physical distancing. Considering the highly

domain-specific nature of risk attitudes (e.g., Blais & Weber, 2006; Weber, Blais & Betz 2002), it seems reasonable to assume that risk compensation might be more likely for the related behaviours of mask usage and social distancing, than for the less related mask usage and hand washing.

While we have good reasons to expect risk compensation for mask usage and physical distancing, it is also possible that mask usage may increase, rather than decrease, physical distancing. One reason is politeness—people may assume that those wearing a mask would prefer greater distancing (e.g., Seres et al., 2020). Another reason is that people may perceive mask users as more likely to pose a risk—a belief compatible with the possibility that mask users are infected. These two reasons suggest that masks worn *by others* would increase social distancing as opposed to masks worn by individuals themselves. Regardless of who is wearing them, masks may also act as a salient reminder of the need for physical distancing, again increasing physical distancing.

Given that mask usage may interact with physical distancing by either increasing or decreasing it, we investigated which of the two effects would prevail when mask wearing is manipulated exogenously in a range of common daily scenarios.

### **Overview of experiments**

We conducted two online experiments, the first on June 12, 2020, the second on July 6, 2020. The design and analysis plan for both experiments were preregistered at OSF

(<https://osf.io/rs6nu>).<sup>2</sup> As detailed below, both experiments were conducted when mask usage was being widely discussed and legislation was in flux, but before mask usage in shops became mandatory in England. At that time, mask wearing and its implications for risk were likely to be highly salient.

In both experiments, we considered a series of potential encounters between the participant and a stranger, and tested whether the participant wearing a mask, seeing the stranger wearing a mask, or the location of an encounter (inside or outside) might affect social distancing in three different activities (standing, sitting, and walking). We chose these three activities to cover the most common situations in which people might encounter mask usage or wear a mask themselves. We tested each activity in both an indoor and outdoor location, since globally guidelines for both mask usage and physical distancing frequently differ between indoors and outdoors. Testing six broad situations also lessens the risk that we just happen to pick the one activity where risk compensation does, or does not, occur. Because the chosen activities were associated with many differences apart from mask wearing, we planned separate analyses for each activity. To simplify the presentation of results, however, we present our findings pooled across activities, with the separate analysis of each activity reported in the supplement.<sup>3</sup>

In experiment 1, we also performed exploratory analyses looking at how distancing varied with respect to participants' prior mask usage, their beliefs about the effectiveness of

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<sup>2</sup> The data from both experiments, and copies of the images used to create our scenarios, can also be accessed at this repository.

<sup>3</sup> We thank the reviewers for this suggestion.

masks, and their perceived risk of hospitalisation. These measures were particularly interesting as they relate to whether the participant is likely to perceive wearing a mask (or a stranger wearing a mask) as reducing their risk, a key requirement for risk compensation to occur. In experiment 2, we preregistered a confirmatory study of these exploratory analyses, and tested whether age influenced distancing preferences by recruiting participants from two separate age groups. As older people face a substantially higher fatality risk from Covid-19 (Banerjee et al, 2020), it would be particularly concerning if they engaged in less physical distancing, or greater risk compensation behaviour. Due to the extensive media coverage and government messaging on the relation between Covid-19 health risks and age (e.g., Department of Health and Social Care & Public Health England, 2020; Walker & Pidd, 2020), it is also likely that older people correctly perceive their risk as much higher, which may lead to less risk compensation, or greater distancing in general.

Because these experiments were conducted when the UK government was progressively releasing lockdown restrictions, there were also changes in the UK guidelines on social distancing between the two experiments. Firstly, it became mandatory to wear masks on public transport from June 15, 2020. Secondly, the guidelines on physical distancing were relaxed on July 4, 2020, from requiring 2 metres in all circumstances to allowing 1 metre if necessary when other mitigating measures are taken. This second change was part of a larger relaxation of restrictions intended to stimulate the economy, including reopening pubs, restaurants, and shops, with adequate distancing in place. As a result, experiment 1 was conducted before masks were made mandatory, and experiment 2 after the guidelines were relaxed. We investigate the possible implications of these changes for our findings by comparing the preferences of younger participants (18-40-year-olds) across experiments.

To preview our main results, we found that:

1. People engaged in risk compensation for all three activities in both experiments, indicating they would sit/stand/walk closer to a stranger when either they were wearing a mask, or the stranger was.
2. Risk compensation was greater for those who believed masks are more effective at either preventing them transmitting Covid-19 to others or catching Covid-19 from others.
3. Older participants behaved in ways consistent with more caution or greater risk perception. For sitting and walking, older participants engaged in less risk compensation than younger participants, while for standing, they preferred greater distances overall.

### **Distancing Preference task**

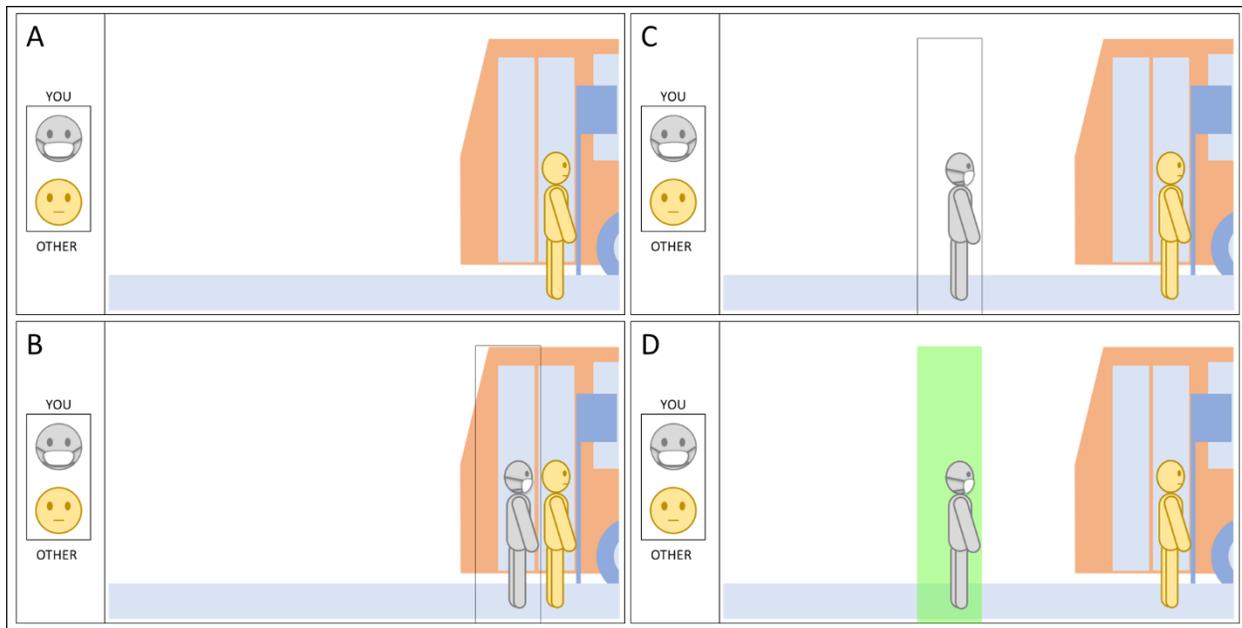
The primary task participants completed was a *distancing preference task*.

Participants indicated the closest distance they would keep from another person (described as a stranger) in 24 different scenarios. By asking participants to specify the “closest” distance, we conveyed the idea that there may be situations in which they would not be able to stand as far as they would ideally like to. The hypothetical nature of the task means that participants indicate their desired distance based on introspection about what they would do in the specific situation. We would still expect Hedlund’s (2000) four criteria to apply to this task due to the visibility of masks, the likelihood that participants attribute

some effects to mask wearing (which we measured in our survey – see later), and their motivation and ability to decide where to stand in relation to somebody else.

These scenarios differed in the activity (standing, sitting or walking), the location of the activity (inside or outside), whether the participant was wearing a mask (yes or no) and whether the stranger was wearing a mask (yes or no). Each participant saw all possible combinations of the 3 (activity) x 2 (location) x 2 (self-mask) x 2 (other-mask) variations.

Each scenario was presented on a separate trial, with a written description and a stylized image of the scenario (see Figure 1 and Appendix for examples). Initially, the image showed just the other person (with or without a mask, depending on the scenario, as depicted on the panel to the left of the image), represented by a yellow figure (Figure 1 panel A). As the participant moved their mouse over the image, a grey figure representing the participant (with or without a mask as appropriate) would appear in the scene and could be placed closer or farther from the other person (Figure 1 panels B and C). When the participant clicked on the image, a green box would appear indicating their chosen distance preference (Figure 1 panel D), which could be submitted by clicking the 'Next' arrow button or changed by removing the previous selection and clicking elsewhere. In each scenario, there were 17 different distances at which the grey figure could be placed. During the instructions and prior to the first scenario, participants were told that the figures represented adults 1.7m tall. Using this scaling, the 17 distances corresponded roughly to a range of 0 to 4 metres between the two figures, in increments of 25 cm (participants were not told this).



**Figure 1: Four example images from the outside standing scenario with the participant wearing a mask (Self-yes) and the stranger not wearing a mask (Other-no). Panel A shows the start of the trial. Panels B and C show the appearance of the trial when the participant hovers the mouse over the first increment (0m) and the ninth (2m) respectively – the ninth interval being half of the maximum distance possible. Panel D shows the ninth interval selected before submission. Note that the shaded areas/boxes overlapped so that the placement of the front of the figure increased by 25cm with each increment.**

The instructions also showed the type of mask (a simple surgical mask) that the figures were wearing (Figure 2).



**Figure 2: Participants were shown this image of the type of masks depicted in the distance preference task.**

To control for potential order effects, the 24 scenarios were split into four blocks of six scenarios each, in which the level of the two mask factors were held constant. The order of these four blocks (both masked, neither masked, self-masked only or other-masked only) was counterbalanced across participants. Within each block, the location (inside or outside) and the activity (sitting, standing, or walking) were crossed to produce six trials presented in random order. Following the completion of all scenarios, as a check question, participants identified, from a list of four options, what they had been asked to judge on the previous trials (i.e., the closest distance).

## **Survey**

Following the check question, participants answered several survey questions about: their prior mask usage; their beliefs about how protective masks are; the perceived health risks of Covid-19 to them; their employment both at the time of the survey and in February; social norms regarding mask usage; and their thoughts when seeing others wearing masks. Information about age, sex, ethnicity, household income and education level was obtained through the recruitment platform. In experiment 2, we included two additional questions about people's awareness of the UK guidelines. The exact wording for all survey items is provided in the supplementary materials.

## Experiment 1

### *Participants and Exclusions*

Participants were 401 UK residents recruited from Prolific, who completed the experiment implemented on Qualtrics. 66% of participants were female, their ages ranged from 18 to 82 with a median of 29. All participants completed the experiment on June 12, 2020. In line with our preregistered criteria, 28 participants were excluded from the analysis for failing the check question, leaving 373 for our analyses. Including these 28 participants does not change our conclusions. All participants were paid £1.50 for participation, which took approximately 10 minutes.

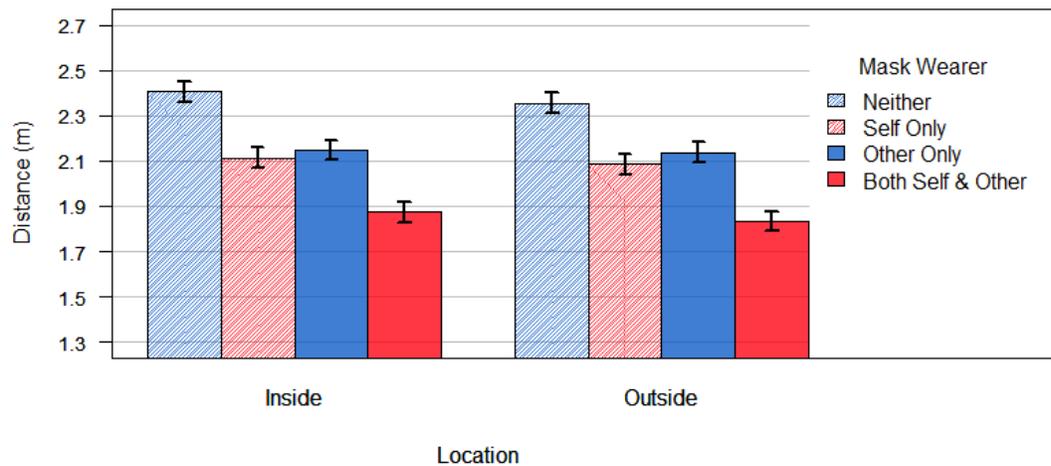
### **Results**

We use the term “distance preference” for the closest the participant would get to another person, measured in metres. In our main analysis, we look at how distance preference is affected by self-mask usage (yes or no), other-mask usage (yes or no) and location (inside or outside). As preregistered, we conducted three 2x2x2 within-subjects ANOVAs (using the Afex package in R), one for each activity (standing, sitting, walking). However, as results were very similar for each activity, here we present simplified results where we average across the three activities for the analysis. The full results for each activity can be found in the supplementary materials. We also note where the results differ notably between activities.

Figure 3 depicts mean distance preference, averaged across the three activities. The left set of bars show distance preferences when the activity was inside (e.g., in a supermarket) and the right set when it was outside (e.g., at a bus stop). Separate bars indicate whether the participant was wearing a mask (red bars) or not (blue bars) and whether the stranger was wearing a mask (solid bars) or not (shaded bars).

The headline results are easily seen from Figure 3. Distance preferences were reduced by mask usage, with separate main effects for masks worn by the self and by the other. When the participant was wearing a mask, they indicated they would stay closer to the stranger ( $m = 1.98$ ,  $sd = 0.81$ ) than when they were not ( $m = 2.26$ ,  $sd = 0.83$ ). Similarly, participants were comfortable closer to a stranger who was wearing a mask ( $m = 2.00$ ,  $sd = 0.81$ ) than one who was not ( $m = 2.24$ ,  $sd = 0.83$ ). There was no interaction between self-mask and other-mask, so physical distancing was maximized when there were no masks (shaded blue bar) and minimized when there were two (solid red bar). In short, we see behaviour consistent with the risk compensation hypothesis, in that people think it is acceptable to engage in riskier behaviour (less social distancing) when masks are used than when they are not. This pattern was replicated across the three activities.

Surprisingly, considering the greater risk of transmission in enclosed spaces, there were no consistent differences between distance preferences inside or outside. While overall distances were marginally shorter when outside ( $m = 2.10$ ,  $sd = 0.81$ ) than inside ( $m = 2.14$ ,  $sd = 0.80$ ), this was driven by differences in the standing condition (inside:  $m = 1.97$ ,  $sd = 0.77$ ; outside:  $m = 1.87$ ,  $sd = 0.79$ ).



**Figure 3: Mean distance preferences, in metres, averaging across standing, sitting and walking in experiment 1, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the location was inside or outside. Error bars show standard errors.**

*Statistics.* The 2x2x2 ANOVA, averaging across the three activities, revealed a main effect of self-mask ( $F(1, 372) = 211.28, p < .001, \eta_p^2 = 0.362$ ), other-mask ( $F(1, 372) = 166.55, p < .001, \eta_p^2 = 0.309$ ), and location ( $F(1, 372) = 9.77, p = 0.002, \eta_p^2 = 0.026$ ). No two-way interactions were significant.<sup>4</sup>

The ANOVA results for individual activities differed from the overall results only for the location effect. The location effect was only significant for standing ( $F(1, 372) = 32.86, p < .001, \eta_p^2 = 0.081$ ), not sitting ( $F(1, 372) = 0.01, p = 0.905, \eta_p^2 = 0$ ), nor walking ( $F(1, 372) = 0.08, p = 0.773, \eta_p^2 = 0$ ).

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<sup>4</sup> We did not have any predictions regarding higher order interactions. However, for completeness, we included them in our models for readers who may be interested or have predictions of their own. We found a significant three-way interaction ( $F(1, 372) = 5.08, p = .025, \eta_p^2 = 0.013$ ) overall. However, this interaction was not significant for any of the 3 activities when analysed separately.

To test the robustness of our results, in the supplemental materials we report additional analyses where the self- and other-mask manipulations are treated as between-subjects factors by looking just at the first block of responses for each participant.

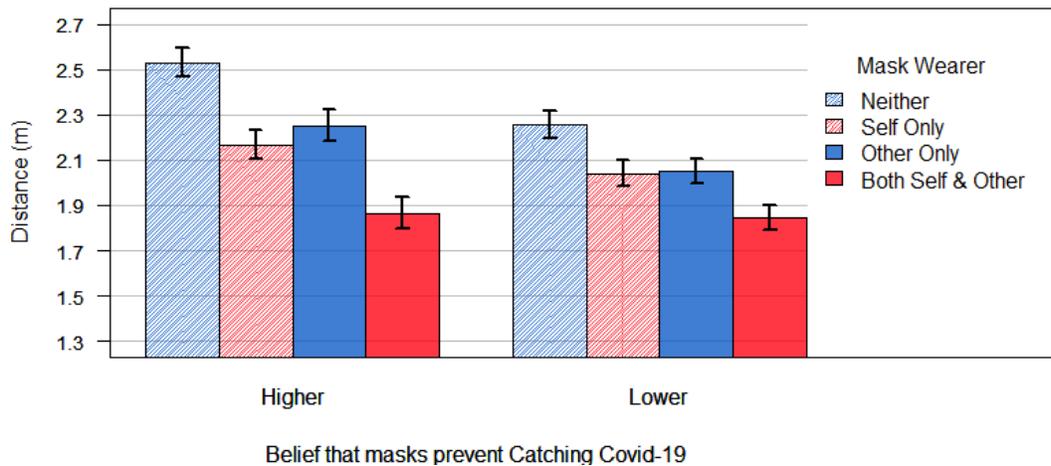
### ***Exploratory Analyses***

In a series of exploratory analyses, we investigated how distance preferences with and without masks interacted with key survey measures. To simplify these analyses, and because the pattern of results observed in the main analyses were mostly consistent, in addition to averaging across the three activities – sitting, standing, and walking – we also averaged across the two locations – inside and outside. Results are similar if we look at the three activities separately.

**Mask Beliefs.** In the survey section, participants were asked to rate, on a 0 to 10 scale, how much they thought wearing a mask prevented them from catching and spreading Covid-19, where 0 was “not at all,” and 10 was “completely.” We speculated that those who believe masks prevent the wearer from *catching* Covid-19 will be willing to stand closer to others in the *self-mask* conditions, as they believe wearing a mask is reducing their risk.

Conversely, those who believe masks prevent the wearer from *spreading* Covid-19 will be willing to stand closer to others in the *other-mask* conditions, as they believe that the stranger wearing a mask is reducing the participant’s risk. We divided participants via median splits into ‘Higher’ and ‘Lower’ on the catching prevention and the spreading prevention questions to create two mask belief variables. Figure 4 shows distance

preferences broken down into those who believe masks prevent the wearer from catching Covid-19 (Higher) and those who do not (Lower). Figure 5 similarly separates distance preferences into participants who believe wearing a mask prevents the wearer from spreading Covid-19 (Higher) and those who do not (Lower).



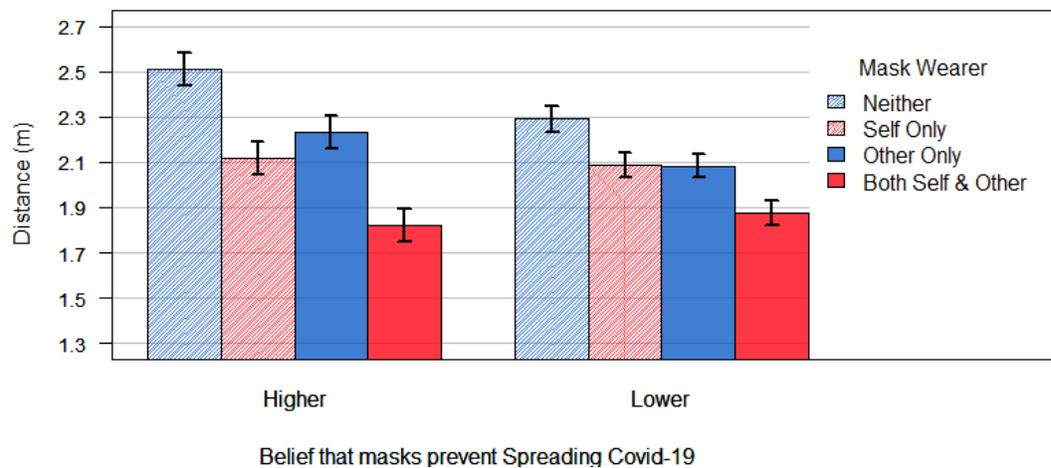
**Figure 4: Mean distance preferences, in metres, from experiment 1, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the participant believed masks were effective at preventing the wearer from Catching Covid-19 (Higher) or not (Lower). Error bars show standard errors.**

Looking first at catch prevention beliefs, consistent with our speculation, we found an interaction between beliefs and the self-mask manipulation ( $F(1, 365) = 7.1, p = 0.008, \eta_p^2 = 0.019$ ).<sup>5</sup> Participants who believed that wearing a mask prevents them from catching

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<sup>5</sup> All exploratory inferential statistics reported in this section are based on a 2 (prior mask usage) x 2 (spread beliefs) x 2 (catch beliefs) x 2 (self mask) x 2 (other mask) mixed ANOVA on distance preference. In addition to the effects reported in the text, there are significant main effects of the self-mask and other-mask manipulation, as in the main analyses. Prior mask usage tested whether those who had previously worn a mask in public responded differently to our mask treatments. Similar to the belief questions, we found that those who had worn a mask in public showed a

Covid-19 (left side) showed a greater decrease in distancing when wearing a mask themselves ( $m_d = -0.38, sd_d = 0.4$ ) than those who did not believe masks prevented catching Covid-19 ( $m_d = -0.21, sd_d = 0.34$ ). That is, those who thought wearing a mask was protecting them changed their distance preference more than those who did not. No interaction was observed between catching beliefs and the other-mask manipulation ( $F(1, 365) = 0.93, p = 0.335, \eta_p^2 = 0.003$ ).



**Figure 5: Mean distance preferences, in metres, from experiment 1, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the participant believed masks were effective at preventing the wearer from Spreading Covid-19 (Higher) or not (Lower). Error bars show standard errors.**

Turning to spread prevention beliefs, our speculation is not supported as there is no significant interaction between spread beliefs and the other-mask manipulation  $F(1, 365) =$

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greater self-mask effect ( $F(1, 365) = 9.86, p = 0.002, \eta_p^2 = 0.026$ ; see supplementary materials for more details). No other main effects or interactions are statistically significant.

0.29,  $p = 0.593$ ,  $\eta_p^2 = 0.001$ ). Participants decreased their distancing by similar amounts when the stranger was wearing a mask, regardless of how effective they thought masks were at preventing the spread of Covid-19. Surprisingly, however, those with higher spread prevention beliefs did respond differently to the self-mask manipulation. As with catch prevention beliefs, those with higher spread prevention beliefs decreased their physical distancing by more when wearing a mask ( $m_d = -0.40$ ,  $sd_d = 0.44$ ) than those with lower catch prevention beliefs ( $m_d = -0.21$ ,  $sd_d = 0.31$ ;  $F(1, 365) = 10.89$ ,  $p = 0.001$ ,  $\eta_p^2 = 0.029$ ). One interpretation of this result is that participants consider the risk they pose to others, and so think they should keep further away when they are not wearing a mask.

**Risk from Covid-19.** Because the health risks from catching Covid-19 vary greatly amongst the population (Banerjee et al., 2020; Ferguson et al., 2020), we expect attitudes to distancing will differ depending upon the real or perceived risk of serious illness. We proxied real risks with the participant's age, and with whether they were in a group advised to shield by the UK government. We also asked them to estimate the chance (in %) they would be hospitalised if they caught Covid-19, as a measure of perceived health risk. Only 24 participants thought they were in a group who had been advised to shield by the government, so we focus on age and hospitalisation judgments.

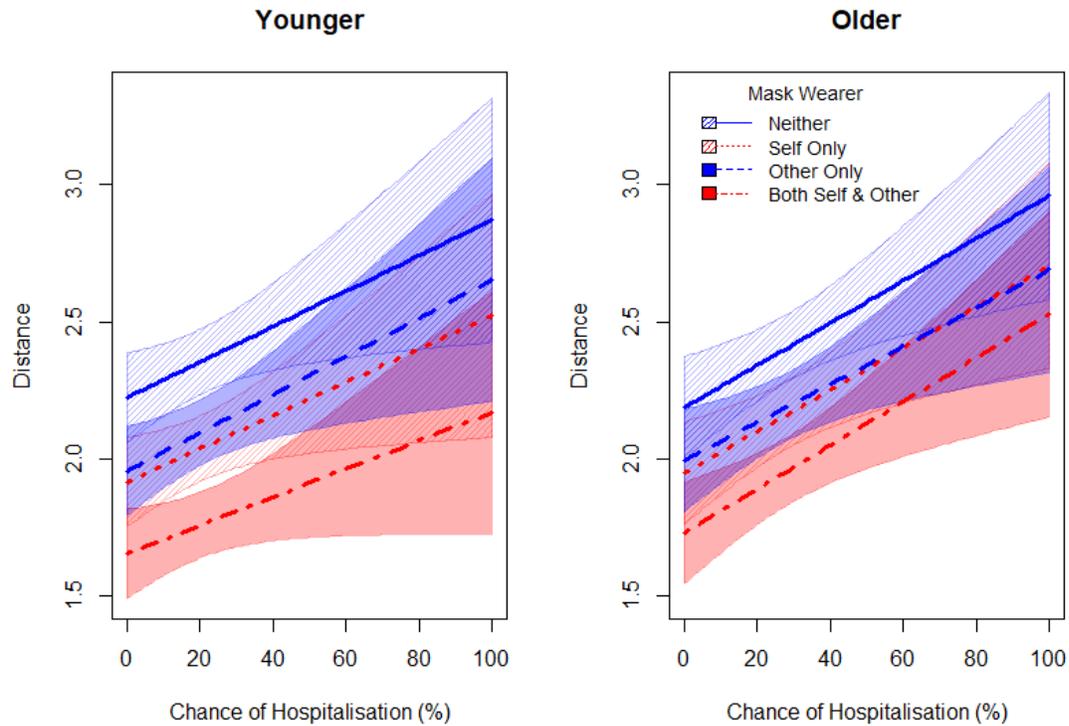
To test whether age or perceived hospitalisation risk impacts distancing, we conducted a mixed effects linear regression, with distance preference as the dependent measure, and fixed effects (predictors) of age, hospitalisation chance, self-mask and other-mask conditions, plus all interactions. Random effects were participants' level intercepts and

slopes for both self- and other-mask conditions. Inferential statistics were calculated using the KR method employed by the Afex package in R. As the age distribution was highly skewed, with many younger participants, we treated age as categorical variable by means of a median split into younger (18-29-year-olds) and older (over 30-year-olds).

Figure 6 plots best fitting regression lines from this analysis. In the left panel, we plot hospitalisation chance against distance for younger participants (with 95% CIs) for each mask condition. In the right panel, we do the same for older participants. As shown by the regression lines, there is a positive relationship between perceived hospitalisation chance and distancing, with those who think they are likely to be hospitalised leaving greater distances between themselves and the stranger ( $\beta = 0.0069$ ,  $F(1, 369) = 15.89$ ,  $p < .001$ ). This does not interact with either the self-mask ( $\beta = 0.0003$ ,  $F(1, 369) = 0.17$ ,  $p = 0.682$ ), or other-mask ( $\beta = 0.0002$ ,  $F(1, 369) = 0.06$ ,  $p = 0.805$ ) manipulations. No higher-order interactions with hospitalisation chance are present.

Comparing across the panels, it appears that the effects of both mask manipulations decrease with age (the fitted lines are closer for the Older than the Younger group). However, only the interaction with self-mask is significant ( $\beta = -0.0913$ ,  $F(1, 369) = 5.32$ ,  $p = 0.022$ ), other-mask is not ( $\beta = -0.0601$ ,  $F(1, 369) = 2.51$ ,  $p = 0.114$ ). This could be interpreted as older people engaging in less risk compensation when wearing a mask, but not when a stranger is wearing a mask. Age group alone is also not a significant predictor of distance judgments ( $\beta = 0.0613$ ,  $F(1, 369) = 0.56$ ,  $p = 0.456$ ). However, as over 84% of our older participants were under 55 years of age, and therefore still relatively low risk, in

experiment 2 we specifically recruited a subsample of participants over 65 years of age, for whom the risk of adverse consequences from Covid-19 was considerably higher.



**Figure 6: Regression model fit for hospitalisation chance for all four mask conditions and younger versus older participants. The dependent variable is mean distance preference, in metres. The left panel shows the best fitting lines for younger respondents and the right panel for older respondents. Around each line is the 95% confidence interval. Separate lines are mask conditions. Red is self-masked, blue is self without mask. Solid colour area is other-masked, shaded is other without mask.**

## Experiment 2

### *Participants and Exclusions*

400 UK residents took part: 200 between the ages of 18 and 40, and 200 aged 65 or above (143 of them 70 or above). All participants completed the study on July 6, 2020. In line with our preregistered criteria, 21 participants from the younger age group and 22 from the

older age group were excluded from the analysis for failing the check question. This leaves 179 participants in the 18-40 group and 178 in the 65+ group. Participants came from the Prolific pool and were paid £1.50 for participating.

## **Results**

### ***Main Analysis***

In experiment 1, we found consistent evidence that participants were willing to engage in risk compensation both when wearing a mask themselves, and when near others wearing a mask. The primary goals of experiment 2 are to replicate these results, and to test whether behaviour differs for older and younger participants. To this end, we look at the effects of self-mask usage (yes or no), other-mask usage (yes or no), location (inside or outside) and age (younger; 18-40 years; or older: over 65 years) on distance preferences for each activity (standing, sitting, walking) separately. As with experiment 1, all distance preferences have been converted to metres; all inferential statistics are based on  $2 \times 2 \times 2 \times (2)$  mixed ANOVAs performed using the Afex package in R, with age a between-subjects factor and the other factors within-subjects.

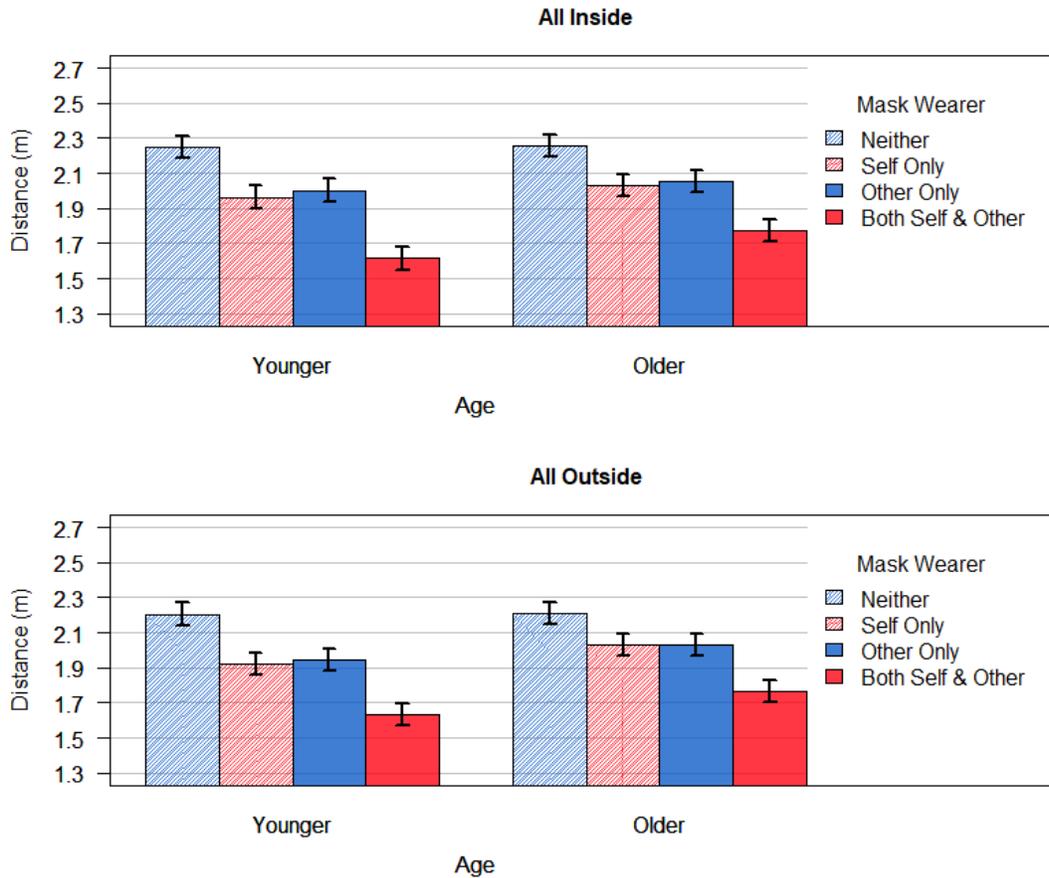
As in experiment 1, we present a simplified version of the results, averaging across the three activities. The separate preregistered analyses of each activity can be found in the supplementary materials. Figure 7 plots the distance preferences averaged across the 3 activities, as in Figure 3, but with separate panels for the inside (top row) and outside (bottom row) locations. Each panel plots the results separately for younger (left) and older

(right) participants. The headline result is similar to that for experiment 1, with participants decreasing their distance preferences when either themselves, or the stranger is wearing a mask, suggesting risk compensation for both types of mask usage. Unlike experiment 1, the self- and other-mask effects interacted with each other, so while distancing was still greatest when neither the participant nor the stranger were wearing a mask, and weakest when both were, the effect of the participant wearing a mask was greater if the stranger was also wearing a mask. These results were consistent across all three activities.

The conclusions regarding age are less clear. Overall, age moderated our self-mask effect, suggesting that older participant engaged in less risk compensation when wearing a mask, but did not moderate our other-mask effect. This is consistent with the exploratory analyses of experiment 1. We also expected older participants, who are at higher risk from Covid-19, to maintain greater distances from others. Overall, we did not find this. However, the exact pattern of age results varied across activities (see supplementary materials for more details).

*Statistics.* The 2x2x2x(2) ANOVA, averaging across activities, revealed a successful replication of the self-mask ( $F(1, 355) = 215.08, p < .001, \eta_p^2 = 0.377$ ) and other-mask effects ( $F(1, 355) = 211.11, p < .001, \eta_p^2 = 0.373$ ), as well as a self-mask by other-mask interaction not observed in experiment 1 ( $F(1, 355) = 9.07, p = 0.003, \eta_p^2 = 0.025$ ). There was no main effect of age ( $F(1, 355) = 0.87, p = 0.352, \eta_p^2 = 0.002$ ), nor age by other-mask interaction ( $F(1, 355) = 3.22, p = 0.074, \eta_p^2 = 0.009$ ). However, there was a significant interaction between the self-mask effect and age ( $F(1, 355) = 4.69, p = 0.031, \eta_p^2 = 0.013$ ).

The location effect (i.e. greater distancing inside) found in experiment 1 was also replicated ( $F(1, 355) = 6.23, p = 0.013, \eta_p^2 = 0.017$ ), although moderated by an unexpected self-mask by location interaction ( $F(1, 355) = 8.42, p = 0.004, \eta_p^2 = 0.023$ ).<sup>6</sup>



**Figure 7: Mean distance preferences, in metres, averaging across standing, sitting and walking from experiment 2, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask. The left set of bars shows responses for younger participants and the right set for older participants. The top row shows the responses for inside locations and the bottom row for outside locations. Error bars show standard errors.**

<sup>6</sup> As with experiment 1, we included higher order interactions (three- and four-way) in our models for readers who may be interested. We had no predictions regarding these interactions, nor did we try to interpret them. We found a significant four-way interaction ( $F(1, 355) = 5.12, p = 0.024, \eta_p^2 = 0.014$ ). At the individual activity level, this effect was only significant for sitting ( $F(1, 355) = 6.85, p = 0.009, \eta_p^2 = 0.019$ ). No three-way interactions were significant for any model.

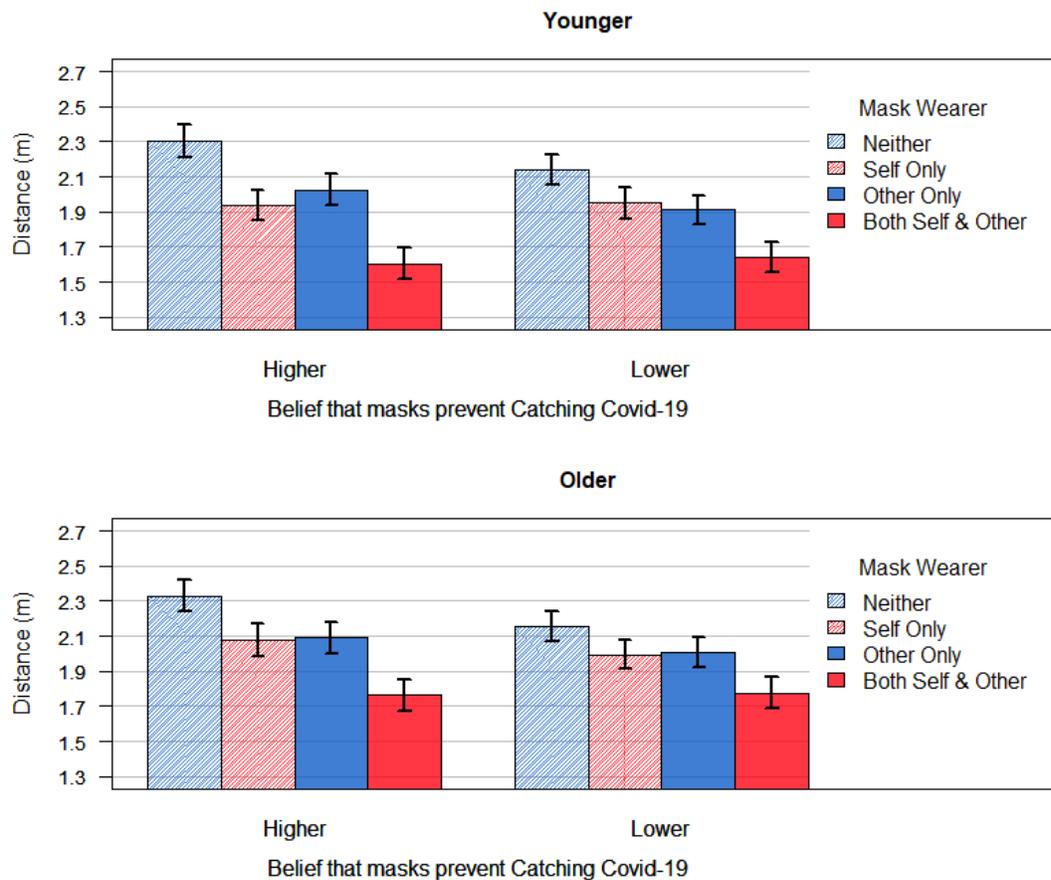
**The effect of changing guidelines.** We were also interested in whether the change in guidelines between experiments 1 and 2 may have impacted distancing. To test this, we calculated the average distance for all participants in both experiments, by averaging across self, other, activity and location factors. As there were very few participants over the age of 65 in experiment 1, we limit this analysis to those aged 18-40 in both experiments. Comparing the 297 18–40-year-old participants in experiment 1 to the 179 in experiment 2, we find no significant differences between distances in experiment 1 ( $m = 2.09$ ,  $sd = 0.79$ ) and experiment 2 ( $m = 1.94$ ,  $sd = 0.79$ ;  $t(473) = 1.96$ ,  $p = 0.051$ ).

### ***Confirmatory Analysis***

In experiment 1, we conducted exploratory analyses that suggested effects of prior mask usage (reported in supplement), beliefs about masks and perceived hospitalisation chance on physical distancing. The secondary goal of experiment 2 was to confirm these results through a preregistered analysis. As with experiment 1, in these additional analyses we average across the three activities and the two locations. Unlike experiment 1, we have added age as a factor in all analyses.

**Mask Beliefs.** As in experiment 1 participants rated how effective they believed masks were at preventing spreading or catching Covid-19, and we created two binary mask belief variables by median split on these ratings. In experiment 1 we found that those who believed masks were effective at preventing the wearer from catching Covid-19, also showed greater risk compensation when wearing a mask themselves. We replicate this

interaction in experiment 2 ( $F(1, 349) = 5.78, p = 0.017, \eta_p^2 = 0.016$ ). Figure 8 plots the relations between distance preference and catching prevention beliefs.



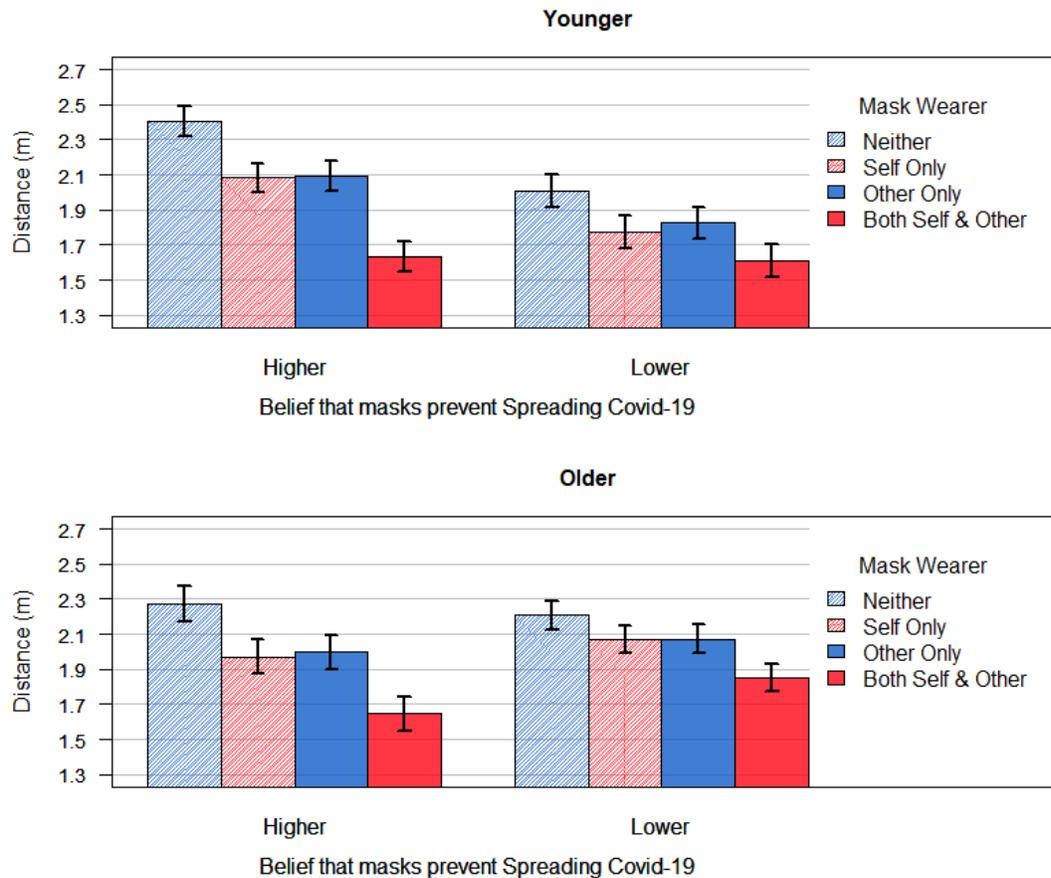
**Figure 8: Mean distance preferences, in metres, from experiment 2, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask, and whether the participant believed masks were effective at preventing the wearer from Catching Covid-19 (Higher) or not (Lower). The top row shows the responses of younger participants and the bottom row older participants. Error bars show standard errors.**

Unexpectedly, in experiment 1 we also found that those who rated masks highly for preventing spreading Covid-19 also showed more risk compensation when wearing a mask. This interaction was also replicated in experiment 2 ( $F(1, 349) = 10.21, p = 0.002, \eta_p^2 = 0.028$ ). In experiment 1, we also expected, but did not find, a similar interaction between

higher spread prevention beliefs and the other-mask effect. In experiment 2 we do find this interaction, with participants who gave higher ratings having a greater decrease in distance preference when the stranger is wearing a mask ( $F(1, 349) = 15.63, p < .001, \eta_p^2 = 0.043$ ).<sup>7</sup> Figure 9 plots distance preference broken down by spreading prevention beliefs. In both Figures 8 and 9, the top panel plots the results for younger participants and the bottom panel older participants.

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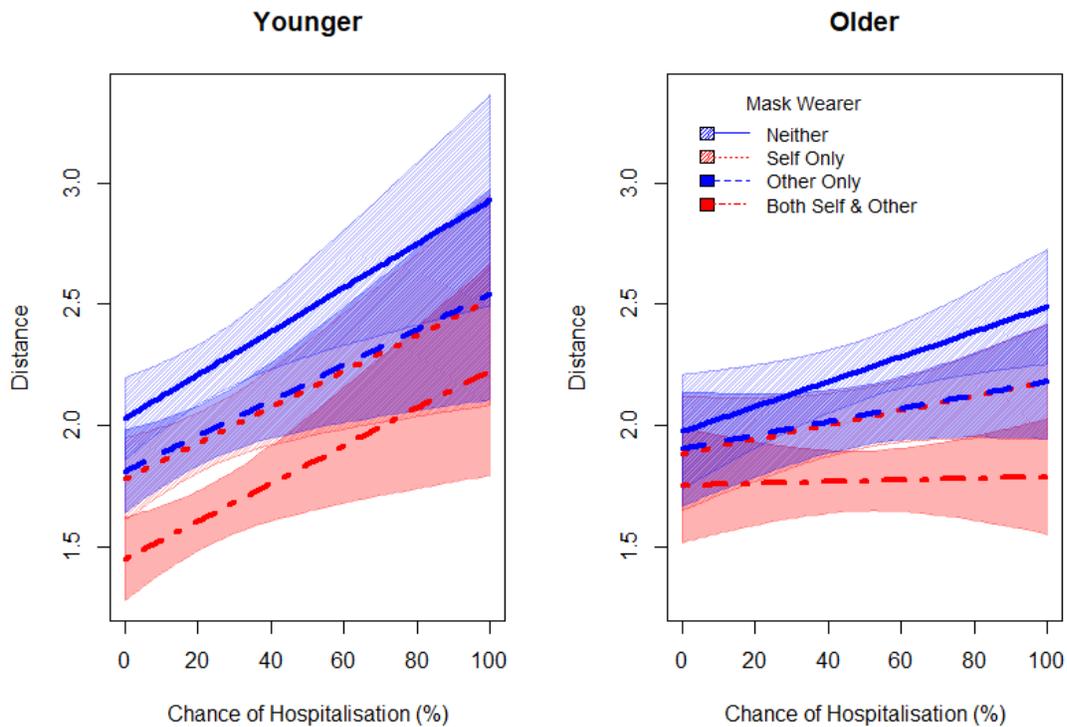
<sup>7</sup> Similar to experiment 1, all inferential statistics are based on a mixed effects ANOVA with all 5 variables, prior mask usage, spread beliefs, catching beliefs, self-mask, other-mask and age included. As we found no interactions between the mask usage and beliefs variables in experiment 1, we excluded any interactions between these variables from the model in experiment 2, to reduce the number of comparisons. We did not replicate the interaction between prior mask usage and the self-mask effect found in experiment 1 ( $F(1, 349) = 1.38, p = 0.242, \eta_p^2 = 0.004$ ). The full prior usage results are reported in the online supplement. Besides the results reported above, and in the supplement, the only other significant effects in this analysis were the main effects of the self, and other-mask manipulations, and an unexpected four-way interaction between self-mask, other-mask, age and spread prevention beliefs ( $F(1, 349) = 4.64, p = 0.032, \eta_p^2 = 0.013$ ).



**Figure 9: Mean distance preferences, in metres, from experiment 2, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask, and whether the participant believed masks were effective at preventing the wearer from Spreading Covid-19 (Higher) or not (Lower). The top row shows the responses of younger participants and the bottom row older participants. Error bars show standard errors.**

**Risk from Covid-19.** In experiment 1, we found that participants' distance preferences increased with their perceived chance of being hospitalised. In experiment 2, we confirmed this result with a preregistered analysis, finding a main effect of perceived hospitalisation chance ( $\beta = 0.0053$ ,  $F(1, 353) = 11.35$ ,  $p < .001$ ). This effect interacted with our mask manipulations, both self ( $\beta = 0.0014$ ,  $F(1, 353) = 3.98$ ,  $p = 0.047$ ), and other ( $\beta = 0.0016$ ,  $F(1, 353) = 5.41$ ,  $p = 0.021$ ). In both cases the mask effect increased as perceived hospitalisation risk increased, i.e., people who believed themselves to be more at risk from

Covid-19 had greater differences between their masked and unmasked distance preferences. Figure 10 shows the estimated regression line for each mask condition, and for the two age groups. In addition to the above effects, we also found significant self-mask, other-mask, self- by other- interaction and self- by age interactions, as we did in the main analysis. We also found a significant other-mask by age interaction ( $\beta = -0.1065$ ,  $F(1, 353) = 7.27$ ,  $p = 0.007$ ), which was in the same direction as the other-mask by age interaction we observed for sitting (see supplementary materials).



**Figure 10: Regression model fit for hospitalisation chance for all four mask conditions and younger versus older participants in experiment 2. The left panel shows the best fitting lines for 18-40 year-olds and the right panel over 65 year-olds. Around each line is the 95% confidence interval. Separate lines are mask conditions. Red areas are self-masked, blue are self without mask. Solid colour areas are other-masked, shaded are other without mask.**

## Discussion

### Results and theory

We found that participants preferred to keep greater distances from strangers when either the strangers, or themselves, were not wearing a mask. The effect was cumulative, meaning they wanted to keep the greatest distance when neither were wearing masks, and the least when both were. This is consistent with *risk compensation* (Hedlund, 2000), which holds that if a new behaviour or intervention reduces risk, people will compensate by reducing related risk mitigating behaviours. Here the new intervention is mask wearing and physical distancing is the related behaviour which is reduced. An increase in mask wearing (going from no mask to a mask) is accompanied by a reduction in physical distance.

In relation to the theoretical interpretation of risk compensation, it is worth saying more about what it involves. We do not hold that it is necessarily irrational on the part of the agent to compensate for risk reduction by consuming more of a (now less) risky activity. If you have seatbelts fitted in your car and you exchange some of that increased safety for a faster ride, this may be quite rational at the individual level. We are not proposing, as some authors have, a “risk homeostasis” story, in which people have a desired level of risk and adjust for perceived risk reductions by increasing other risky actions to restore their overall risk to its original level – there is little evidence for such a strong version of the concept (Mantzari, Rubin & Marteau, 2020). However, the (partial) risk compensation we observe is nonetheless important from a policy perspective. Imagine that regulations are put in place to reduce risk – requiring seatbelts, vaccinations, or in this case the use of face

masks. The intervention may indeed reduce risk, but part of the potential reduction will be consumed because now people, feeling safer, will do more of the things made safer by the intervention, such as standing closer to others. The collective effect of the intervention on risky behaviour will not, therefore, be predictable from a mechanical computation that applies a risk reduction coefficient to current behaviour. Moreover, when individual outcomes are interdependent and hence subject to externalities, risk compensation may lead to socially suboptimal outcomes, and even sometimes increase overall risk. For instance, people who choose to violate physical distancing guidelines when wearing a face mask may have reduced their individual risk of transmission, compared to maintaining physical distancing without a mask. However, at a societal level, compliance with both physical distancing and mask usage guidelines may be required to keep the spread of the virus to a level where the health system of the country is not overwhelmed. If the capacity of the health system is exceeded, due to higher-than-expected virus transmission, this will greatly increase mortality risk among vulnerable populations, who are likely to require hospitalisation and intensive care.

### **Is it *risk compensation*?**

As we noted, risk perceptions are key to risk compensation. In both our experiments, we found that those who believed masks were effective at preventing either the spread of Covid-19 to others, or their own susceptibility to infection, showed a greater decrease in distance preferences when wearing a mask. In experiment 2, we also found that those who believed masks prevented the spread of Covid-19 decreased their distance judgments by

more when others were wearing a mask, compared to those who did not believe this. These interactions are consistent with risk compensation, as the participants who perceive the greatest reduction in risk because they believe masks provide protection also engage in the greatest extent of risk compensation behaviour (Underhill, 2013).

Risk compensating *behaviour* can also occur for reasons unrelated to risk or risk perception. A car fitted with safety features such as anti-lock brakes and premium tyres might be more fun to drive, leading people to increase their risk exposure by driving more and pushing a bit harder on the accelerator. Similarly, there are non-risk reasons for people to come closer to another (or move further away) depending on whether they or their counterpart is wearing a face mask. It might be harder to communicate while wearing a mask, because the voice is muffled and facial expressions partly hidden, so mask wearers may get closer to overcome these handicaps. People are also judged as more attractive when wearing face masks (Patel et al., 2020), and this may motivate them to move a bit closer. Such influences can undoubtedly come into play in some circumstances, but are unlikely to have done so in our experiments, which were expressly designed to abstract away from such concerns by obtaining responses to stylized situations involving people depicted with minimal individuality and described as strangers to one another. These concerns are also unlikely to be related to people's beliefs about the effectiveness of face masks at preventing catching or spreading the virus, which we found associated with distance reduction.

## **Recent related research**

Given its potentially important policy implications, it is natural that the possibility of risk compensation due to mask wearing has attracted widespread attention in the behavioural science community. Here, we relate our work with recent research on the topic that has been conducted in parallel to ours (some of which is still to undergo peer review) by teams located in a variety of different countries. Some of these studies obtained results that differ from ours. Although some of these differences could be due to the timing of the research or to where it was conducted, here we will focus on more theoretical issues. A full, comprehensive account of all studies that have been reported (and are yet to be) and the conclusions to be drawn from them will no doubt comprise an important future project.

Liebst et al. (2021) used CCT footage of pedestrians in Dutch cities (Amsterdam and Rotterdam), and checked for social distancing violations among mask wearers and non-wearers. Their test did not allow for comparisons between situations where both are wearing a mask, versus only one person or neither. While they found considerable violations of social distancing rules, the propensity to violate those rules did not differ between mask wearers and non-wearers. One important difference between this study and ours is that the participants in Liebst et al. (2021) self-selected into wearing a mask or not. We cannot know the effect of this, but we cannot rule out the possibility that those who choose to wear a mask are generally more risk sensitive than those who do not, and so the failure to find risk compensation is consistent with masks making the risk averse mask wearers act like the risk seeking non-wearers.

Seres et al. (2020) conducted a clever field experiment in Berlin, when face masks were not in widespread use. An experimenter, masked or unmasked, joined a queue in a shop and

then surreptitiously measured the distance taken by the next entrant to the queue. They found that when the experimenter was wearing a mask the next customer chose to keep a greater distance. Marchiori (2020) similarly found that people wanted to keep a greater distance from a masked than an unmasked person. He tested this by walking the street, masked or unmasked, and recording the distances between himself and passers-by. Seres et al. (2020) conducted a follow-up study to measure beliefs around mask wearing and found that people believed someone voluntarily wearing a mask would prefer others to keep a greater distance than someone not wearing a mask. Their results contrast with ours, and we suggest that a key question concerns what people will believe or do when they view mask use as an active decision on the part of an agent, versus an obligation. That is, when the link between mask wearing and the wearer's preferences is broken, as in our experiment, or as mask usage becomes the rule rather than the exception, wearing a mask may no longer be seen as a clear signal of the wearer's desire for greater distance.<sup>8</sup>

Several studies found results broadly consistent with our own. Yan et al. (2021) used location data from smart devices to track people's behaviour after the introduction of face mask mandates in several U.S. states. They found people spent less time at home and visited commercial locations more often after the introduction of face mask mandates, in

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<sup>8</sup> Another factor that may contribute to the different results is Seres et al.'s (2020) use of FFP2 disposable respiratory protection masks. Most of the media attention and marketing around masks suggest that these types of masks are more effective for protecting yourself from catching Covid-19, while the simple masks we show to participants (Figure 2) are more appropriate for preventing the wearer from spreading Covid-19 (for example, see Public Health England (2020) guidance). It is possible that the participants, being aware of this difference, inferred that the confederate in Seres et al.'s (2020) study was particularly trying to shield themselves from catching Covid-19, and therefore would also desire more space.

line with risk compensation. Jorgensen et al. (2020) compared self-reported attention to distancing and mask usage in Denmark before and after the introduction of mandatory mask usage in public. Consistently with risk compensation, they found a negative relationship between mask use and attention to distancing, measured through self-reported compliance with various guidelines. Finally, in an online study similar to ours, Cartaud et al. (2020) showed participants images of computer-generated people at various distances either wearing or not wearing masks. They found that the minimum acceptable distance was shorter for masked than unmasked images. They also found that the people in masked images were judged as more trustworthy.

### **Intentions vs. Behaviour**

A potential limitation of our study is its focus on participants' expectations of how they would behave under different scenarios (rather than real-life behaviour). Existing social and health psychology literature has found varying relationships between individuals' behavioural intentions and their actual behaviour. In a meta-analysis, Webb and Sheeran (2006) discuss three conceptual factors that moderate this relationship. The first one, volitional control, is clearly present in the case of wearing face masks and social distancing. Individuals control when and where they wear masks, and under most real-life circumstances (except, e.g., inside a narrow lift) they can control their distance to other people. The second factor implies that intentions will better translate into health-protective rather than health-risk behaviours that are carried out in social contexts. Mask wearing and social distancing have elements of both: health-protective (in that they help the individual

avoid virus infections) and health-risk in a social context (as bystanders may frown or murmur disapproval if they dislike a person's behaviour). The third factor suggests that intentions may have little impact on behaviour in the case of habitual control. Fortunately, our study took place at a time when the government had announced, but not yet implemented, stricter anti-pandemic measures (especially mandatory mask wearing in certain circumstances, which was enforced after our experiment 1 and just before our experiment 2). So, for many people, wearing a mask, and reacting to situations where their counterpart may or may not wear a mask, were not yet habitually controlled decisions.

How then do we reconcile our findings with those of the field studies which did not find evidence of risk compensation in actual behaviour? We have already discussed key factors that may explain these differences. More broadly, our results, and those of Cartaud et al. (2020), can be characterized as reflecting people's cool and reflective judgments about social distancing when using masks or not. In essence, we found that people's underlying belief is that it is acceptable to reduce adherence to physical distancing guidelines if either they are wearing a mask or are around others wearing a mask. In daily life, however, there may be specific contextual factors that can override this belief. For instance, as suggested by Seres et al. (2020) and discussed previously, in an environment where masks are voluntary and rare, people may draw inferences about others who choose to wear masks that encourage greater physical distancing. As mask usage becomes more common, or is made compulsory, these inferences will become less accurate and may play less of a role in distancing decisions. Instead, as people become increasingly used to planning their actions around the use of masks, as they currently are in most countries, we suspect that their more considered beliefs will play a greater role in their decisions around social distancing.

## **Policy implications**

Our main result can be framed as “bad news”, in that there is the possibility of risk compensation, which may undermine policy around mask usage. But perhaps the most important news is good. By being willing to get closer to a stranger when masks are being worn (either by the stranger or the participant), participants indicated a degree of belief in mask effectiveness. Indeed, the more strongly participants believed in mask effectiveness, the closer they were willing to get. In this section, we consider some ways policy makers could use our results.

The implications of our findings for government advice on social distancing depend upon the goals of government. For instance, in the UK there are industries, such as education or healthcare, where physical distancing is difficult but continued lockdown may have significant long-term negative impacts. If the goal of government is to get children back into schools, or people back to their healthcare providers for non-Covid reasons, then our results suggest that encouraging or mandating mask usage in these environments may help people feel safe in attending, while also lowering their risk of catching or spreading the virus. However, it is also important that policymakers are aware that people may engage in risk compensation and make efforts to ensure that social distancing requirements (e.g., the two-metre rule) are just as salient as mask wearing.

Alternatively, if a government’s goal is purely to control the transmission rate of the virus, then people’s belief that it is acceptable to trade off physical distancing and mask usage is more problematic. For instance, if the difference between masks-plus-2-metre distancing and masks-plus-1.5-metre distancing is significant for transmission rates, our results

would suggest that governments should take this into account when modelling the impacts of different sets of guidelines or when communicating those guidelines to the public. It may be important to explicitly emphasise that masks are not an alternative to physical distancing, but rather a complement; and maybe also stress the fact that people engage in risk compensation, which might make the public more careful, self-aware and less prone to get closer to others when wearing a mask. Future research should be testing behaviour change interventions (e.g., Bavel et al., 2020; West, Michie, Rubin, & Amlôt, 2020) that could make risk compensation less likely.

While our experiments focused on the UK, it is likely that similar results would be found in countries with similar histories of mask usage. Our results could be particularly relevant for countries where mask usage is now high, but physical distancing guidelines had been relaxed prior to a second/third wave of infections: they may suggest that compliance with stricter physical distancing guidelines may be lower now than it was at the start of the pandemic, when mask usage was low. Our results also contribute to a broader understanding of how people trade off risks during the coronavirus pandemic. With recent research suggesting that people may be liable to reduce adherence to physical distancing guidelines in anticipation of the vaccine (Anderson et al., 2020), understanding these trade-offs may be particularly important as vaccination programs are rolled out worldwide.

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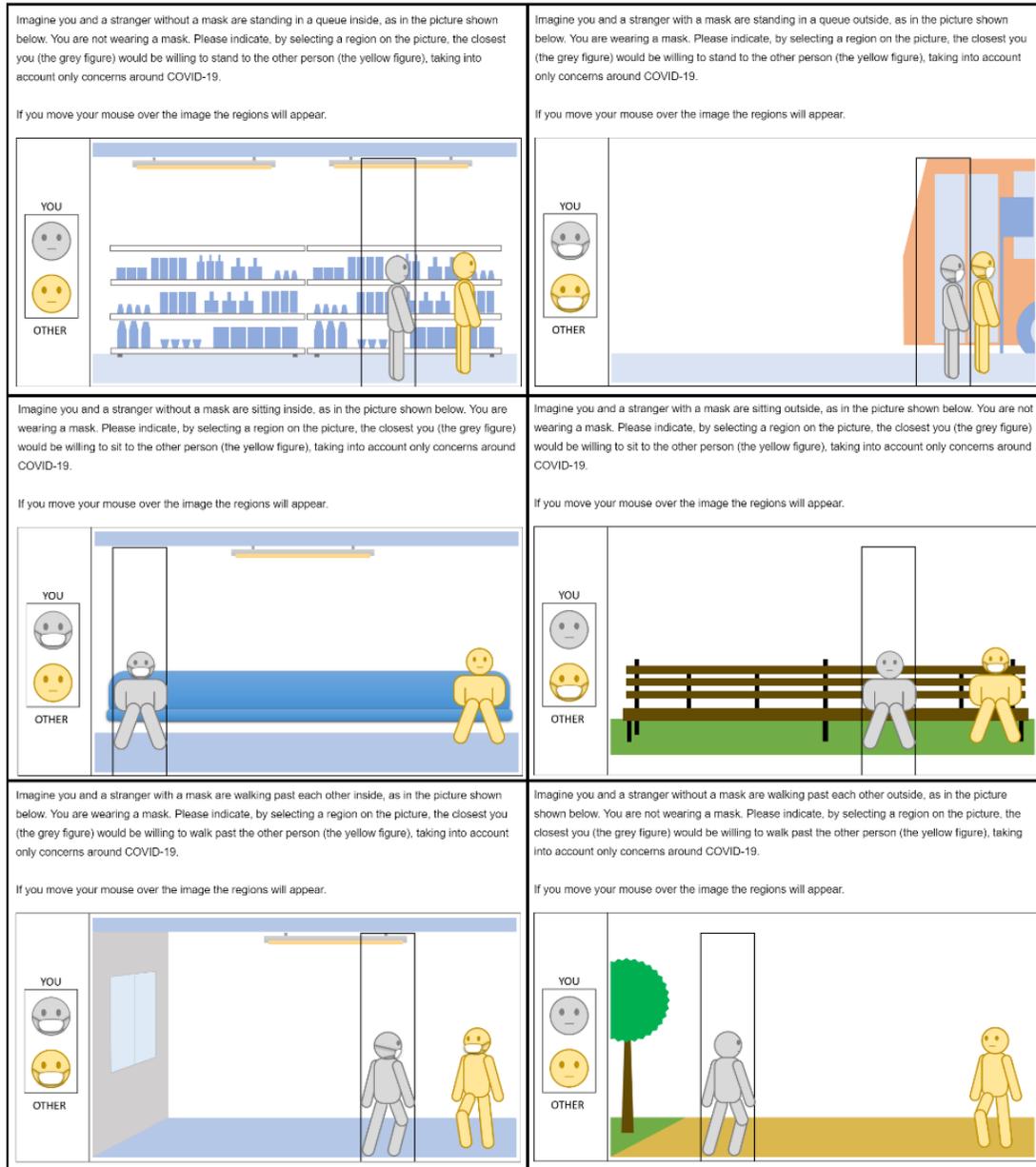
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## Appendix

Figure A1 shows 6 example stimuli from the experiment. These show all combinations of location and activity, and vary in self and other mask usage. The top and bottom rows show examples of either both, or neither figures wearing masks, while the middle row shows one wearing a mask and the other not.



**Figure A1: Example of the descriptive text and image for each combination of Activity and Location. Top row shows Standing, middle Sitting and bottom Walking activities. Left column is indoor location and right column outdoor location. Different combinations of masks are used in each example so that all four mask combinations are shown, and both masked and unmasked examples of each figure are shown for each activity. All images are before the participant has made their selection. Different distances are shown for the participant (grey) figure to illustrate the range of responses possible.**