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

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Draft version 05/08/2020. This paper has not been peer reviewed

Abstract

To reduce the spread of Covid-19, governments around the world 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. They may respond to reduced risk due to one activity by increasing risk due to another. We tested for risk compensation related to mask usage during the Covid-19 pandemic 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. Consistent with risk compensation, we found that participants indicated they would stand, sit or walk closer to the stranger when 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

During the Covid-19 pandemic, the goal of many governments worldwide has been to reduce 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 coverings (masks). This raises the question of how effective individual interventions are when combined with other interventions.

One example of the implementation of multiple interventions is the use of masks and social distancing. 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 have involved encouraging people to work from home, closing schools, pubs, restaurants, and non-essential shops, limiting travel, and mandating or suggesting minimum physical distances (often 2 metres) when interacting with others outside the home. 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, the use of face masks was widespread very early in the pandemic, due to a combination of public policy, their recent experiences with other epidemics such as SARS, and/or cultural norms. In the UK – where our study was conducted – little encouragement was given initially to use face masks when engaging in permitted activities outside the home. Rather, it was argued these masks conferred little extra benefit; and the emphasis was placed on preserving the availability of higher specification masks and other personal protective equipment for essential occupations such as those in the medical profession. From 15 June 2020, face coverings became a requirement when using public transport in England and, from 24 July, also when entering shops (other devolved administrations in the UK adopted similar measures with slightly different timings).

Although we focus on the behavioural effects of mask usage on social distancing, the effectiveness of face masks in reducing virus transmission has been widely discussed and remains highly controversial. Mask effectiveness may depend on various conditions, such as the type of mask (e.g., N95/FFP2 masks [aka respirators], surgical masks, or cloth face coverings), the type of virus (e.g., influenza or coronaviruses), compliance in mask wearing (e.g., respirators are less comfortable and lead to less compliance), and the situational context (e.g., outdoors, in public transport, or in confined spaces). As highlighted in a recent systematic review (Mills, Rahal and Akimova, 2020), most existing studies on mask effectiveness focus on healthcare rather than community settings, and they often rely on observational methods rather than randomised controlled trials. For these reasons, scientists and politicians alike are split (or at least were split at the time of our study) on the wisdom of requiring face coverings in public spaces.

There is growing evidence from observational studies that face coverings can help slow the spread of viruses such as Covid-19, in terms of preventing mask wearers from infecting other people and (to a lesser extent) protecting mask wearers themselves (e.g., CDC, 2020; Wang et al., 2020). Such findings—coupled with the observation that countries with cultural norms in favour of mask wearing have fared relatively well during the pandemic—led to increasing calls by health professionals and politicians to implement mandatory mask usage in a range of settings (for example, in the UK, more than 100 doctors signed an online petition on April 18th calling for face mask use in public).

When considering the interaction between multiple risk reduction interventions, a common concern is that there may be risk compensation (Hedlund, 2000; Peltzman, 1975; Underhill, 2013, Wilde, 1982), in which decreased risk from one intervention is accompanied by increased risk from another. Risk compensation in general 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). Both economic and psychological justifications for risk compensation have been given. 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 the extra safety provided by brakes for a quicker arrival at their destination (Hedlund, 2000). From a psychological perspective, the theory is that people have an optimal level of risk, so if an intervention reduces overall risk, they will take other risks until they return to this tolerated risk level. This is termed risk homeostasis (Underhill, 2013, Wilde, 1982).

Risk compensation has been studied for health and safety interventions, such as 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 aggregate statistics (Evans & Graham, 1991; McCarthy & Talley, 1999; Noland, 1995). While these studies suggest that risk compensation occurs, they also show that it is not a universal phenomenon and may depend on the nature of the intervention and the behaviours being measured.

Hedlund (2000) outlined four criteria needed for risk compensation to occur. The first criterion is visibility, in that the intervention has to 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 some kind of effect. We might expect that masks also satisfy this criterion, either because individuals believe in their protective abilities, or, because they believe (contrary to fact) that masks "make things worse" (e.g., Griffin, 2020). The third criterion is the risk taker's motivation to change their behaviour. Given that most social distancing measures place restrictions on people's lifestyle, people may be inclined to minimise their compliance with these measures. For instance, they may be motivated to reduce their physical distancing so that they can take a seat on the train, or not step out into the road to avoid an oncoming pedestrian. The final, fourth criterion is whether the risk taker has control over their behaviour and can change it. Although some aspects of social distancing (e.g., the requirement to work from home or the accessibility of shops) are outside the control of individuals, others, such as physical distancing when in a shop, give them a lot of leeway.

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 concept of risk compensation may be more dangerous than the actual compensation itself (Mantzari, Rubin and Marteau, 2020). In contrast to our study, however, this review focuses mainly on risk compensation through hand hygiene rather than through physical distancing—and, indeed, the authors themselves call for future research to better understand the latter type of risk compensation.

There are good reasons why risk compensation associated with face masks may be more likely to occur for physical distancing than for hand washing. Although "risk" is a very general concept, it is now widely accepted that risk attitudes are highly domain and behaviour specific (e.g., Blais & Weber, 2006; Weber & Blais 2002). This suggests that risk compensation may also be more likely to occur for related behaviours. Car safety is again a useful analogy. People may compensate for the risk reduction afforded by ABS brakes by adjusting related behaviours (e.g., driving closer to the car in front, driving more quickly or on icy patches they would otherwise avoid). But they would be less likely to compensate the risk by changing unrelated behaviours (e.g., not topping up the windshield wiper fluid, playing the radio louder or driving in dangerous neighbourhoods). Similarly, if the purpose of face masks is to permit safer social interaction, it seems natural for people to respond to the wearing of face masks by engaging in social interaction in ways they would not do without face masks. This may include, among other things, getting closer to others. But face masks do not, on the other hand, keep one's hands cleaner, so we do not expect people to respond to the wearing of face masks by soiling their hands or failing to clean them.

However, it is also possible that mask usage may increase, rather than decrease, physical distancing. One reason is politeness—people may assume those wearing a mask would prefer greater distancing. This idea is supported by Seres et al. (2020), who conducted a field experiment in which experimental confederates joined a queue either wearing a mask or not, and experimenters measured the distance observed by the next person who joined the queue. They found distances were greater when the experimenter was wearing the mask. A subsequent survey suggested this was due to participants believing that masked individuals would prefer more distancing. Another reason why mask usage might increase physical distancing 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 in Seres et al., 2020) 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 it or decreasing it, we set out to investigate which of the two effects will prevail when mask wearing is manipulated exogenously.

Overview of experiments

We conducted two online experiments, the first on June 12, 2020, the second on July 7 2020. The design and analysis plan for both experiments were preregistered at OSF (https://osf.io/rs6nu). As detailed below, both experiments were conducted before mask usage in shops became mandatory in England, but during a time when it was widely discussed and legislation was in flux, and so mask wearing and its implications for risk were likely to be highly salient.

In both experiments, we tested whether wearing a mask, seeing a stranger wearing a mask, or the location of an encounter (inside or outside) might affect the distance people would keep from a stranger for three different activities (standing, sitting and walking). These activities and locations were chosen to cover the majority of situations in which people might encounter mask usage or wear a mask themselves. Because the chosen activities were associated with many differences apart from mask wearing, we planned separate analyses for each activity, and the analysis below largely adheres to that plan—although in the discussion we make some non pre-registered speculations. In experiment 1, in addition to the preregistered analysis, we performed exploratory analyses looking at how distancing varied with respect to participants' prior mask usage, their beliefs about the effectiveness of masks, and their perceived risk of hospitalization. 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.

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 in some. This second change was part of a larger relaxation of restrictions intended to stimulate the economy, including opening 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.

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. These scenarios differed in the activity the participant was performing (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). Participants indicated, on the image, the closest they would be willing to get to the other person in the shown scenario, either while sitting, standing, or walking by. Initially the image showed just the other person (with or without a mask, depending on the scenario), 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) 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).

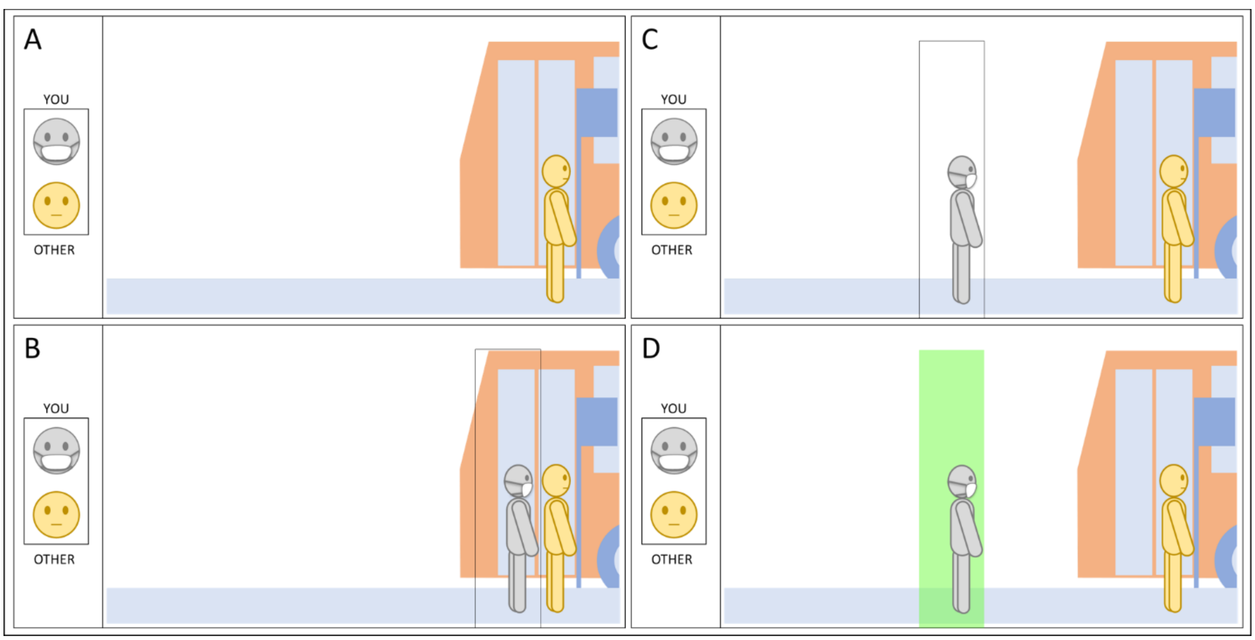

Figure 1: Four example images from the outside standing scenario with the participant wearing a mask (Self-yes) and the stranger not wearing a mask (Other-no). Panel A shows the start of the trial. Panels B and C show the appearance of the trial when the participant hovers the mouse over distance 1 (0m) and distance 9 (2m) respectively. Panel D shows distance 9 selected before submission.

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 4 blocks of six scenarios, 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) were counterbalanced across participants. Within each block, the location (inside or outside) and the activity (sitting, standing, or walking) were crossed to produce six trials. 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, the full details of which are provided in the supplementary materials. These questions asked participants about: their mask usage; their beliefs about how protective masks are; the perceived health risks of Covid-19 to them, both realised and predicted; their employment both now and in February; social norms regarding mask usage; and their thoughts when seeing others wearing masks. Prolific provided us with information about the age, sex, ethnicity, household income and education level of each participant. In experiment 2, we included two additional survey 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, aged from 18 to 82 with a median age of 29. All participants completed the study 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 in the approximately 10 minute study.

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 preferences 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)

Figure 3 depicts mean distance preferences. The top row shows distance preferences for standing (the closest the participant would stand to another person in a queue), the middle row for sitting (the closest they would sit to another person on a bench), and the bottom row for walking (the closest they would walk to another person when passing them). 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) or not (blue) and whether the stranger was wearing a mask (solid bar) or not (shaded bar).

The headline results are easily seen from Figure 3. Distance preferences were always reduced by mask usage, with separate main effects for masks worn by the self and by the other. There was no interaction between self mask and other mask, so physical distancing was maximized when there were no masks, and minimized when there were two. Surprisingly, there were no consistent differences between distance preferences inside or outside. In short, for all three behaviours we see behaviour consistent with the risk compensation hypothesis, in that people engage in riskier behaviour (less social distancing) when masks are used than when they are not. This pattern was replicated across the three activities.

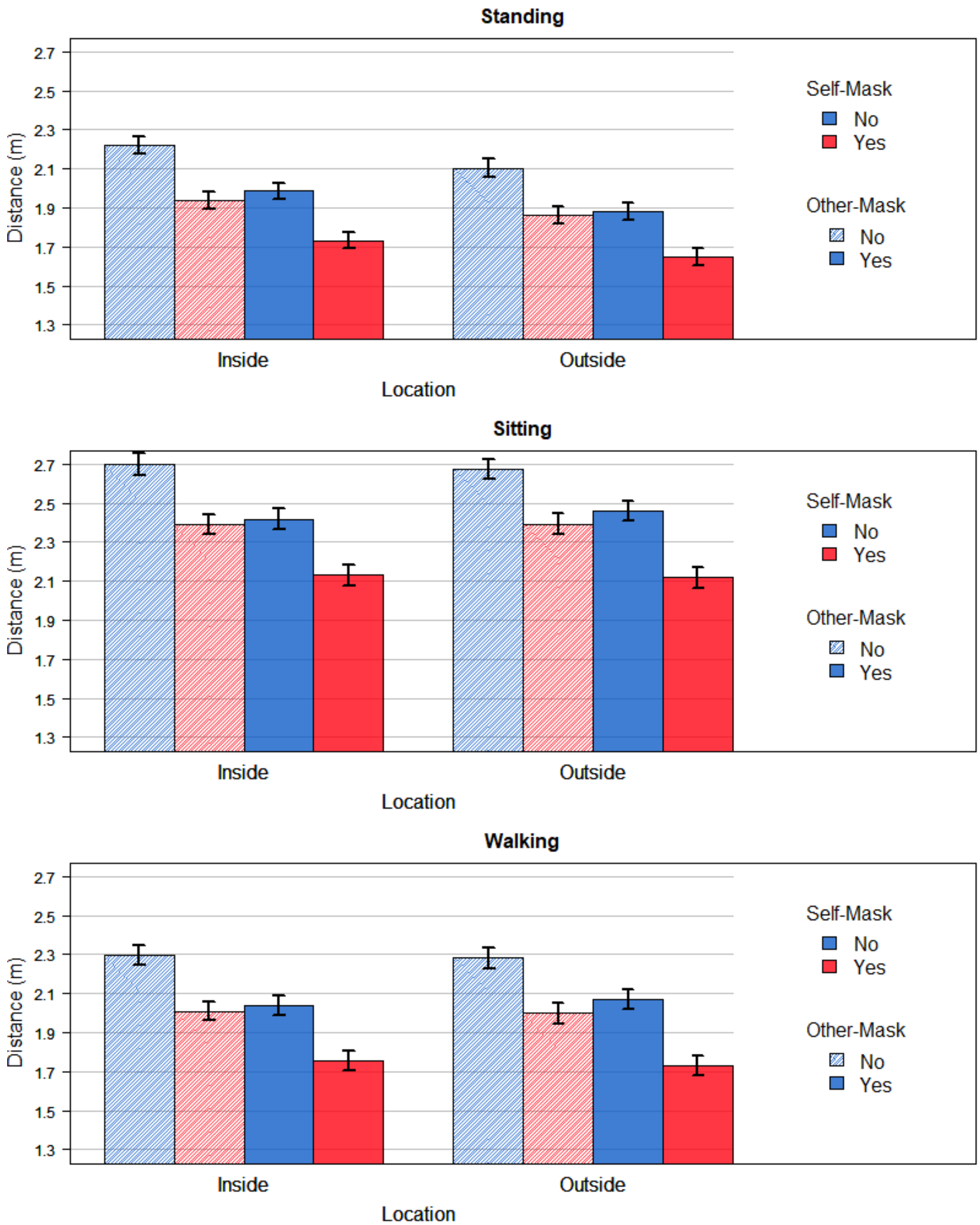

Figure 3: Mean distance preferences, in metres, for standing, sitting and walking in experiment 1, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the location was inside or outside. The top row shows distances when standing, the middle row distances when sitting and the bottom row distances when walking.. Error bars show standard errors.

Standing. The 2x2x2 ANOVA revealed a main effect of self mask ($F(1, 372) = 157.16$, $p < .001$, $\eta_p^2 = 0.297$), other mask ($F(1, 372) = 120.72$, $p < .001$, $\eta_p^2 = 0.245$), and location ($F(1, 372) = 32.86$, $p < .001$, $\eta_p^2 = 0.081$). There were no interactions.

Details: When the participant was wearing a mask they indicated they would stand closer to the stranger (m = 1.8, sd = 0.78) than when they were not (m = 2.05, sd = 0.8). Similarly participants would stand closer to a stranger wearing a mask (m = 1.81, sd = 0.77), than one who was not (m = 2.03, sd = 0.81). Finally, participants would stand closer to the stranger, on average, when they were outside (m= 1.87, sd= 0.79), compared to inside (m= 1.97, sd= 0.77).

Sitting. Results were much the same as for standing, except there was no effect of location. The 2x2x2 ANOVA revealed a main effect of both self mask ($F(1, 372) = 168.45$, $p < .001$, $\eta_p^2 = 0.312$), and other mask ($F(1, 372) = 115.34$, $p < .001$, $\eta_p^2 = 0.237$), but no other significant main effects nor interactions.

Details: When participants were wearing a mask they sat closer to the stranger (m = 2.26, sd = 0.96), compared to when they were not (m = 2.56, sd = 0.96). They were also willing to sit closer if the stranger was wearing a mask (m = 2.28, sd = 0.96), compared to when they were not (m = 2.54, sd = 0.95). Differing from the standing scenario, there was no difference between inside and outside locations.

Walking. For walking the 2x2x2 ANOVA also revealed main effects of self ($F(1, 372) = 163.21$, $p < .001$, $\eta_p^2 = 0.305$) and other ($F(1, 372) = 141.79$, $p < .001$, $\eta_p^2 = 0.276$) mask, but no other significant main effects or interactions.

Details: Distance preferences were reduced when the participant wore a mask (m = 1.87, sd = 0.91), than when they did not (m = 2.17, sd = 0.93). They were similarly reduced when the stranger was wearing a mask (m = 1.9, sd = 0.89), than when they were not (m = 2.15, sd = 0.93). As with the sitting results participants behaved similarly inside and outside.

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 responding for each participant.

Exploratory Analyses

In a series of exploratory analyses, we investigate 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 consistent, we average across the three activities- sitting, standing and walking- and the two locations- inside and outside. Results are similar if we look at the three activities separately, as in the main analyses.

Mask Usage and beliefs. Those who are used to wearing a mask will be aware of the contrast between wearing and not wearing a mask, and so might be particularly sensitive to the difference. Moreover, choosing to wear a mask may indicate a stronger belief in mask effectiveness. Both effects would predict that those who have worn a mask might show greater risk compensation. This is consistent with Phillips (2011) finding that only those who usually wear a helmet show risk compensation when cycling. In our survey 184 participants had previously worn a mask in public and 189 had not.

In Figure 4 we plot separately the distance preferences for those who had worn a mask previously (left side) and those who had not (right side). We do not see an overall change in distancing caused by prior mask usage, but we find an interaction between prior mask usage and the self-mask manipulation. Participants who had previously worn a mask in public showed a greater difference between their self masked (red) and self unmasked (blue) responses (m_d = -0.38, sd_d = 0.41) than those who had not worn a mask (m_d = -0.19, sd_d = 0.32; F(1, 365) = 9.86, p = 0.002, η_p^2 = 0.026).[1] That is, similar to the findings for helmet use and cycling speed, participants who had voluntarily worn a mask showed greater risk compensation.

In Figure 4 the other-mask effect also appears greater for those who had previously worn a mask (m_d = -0.29, sd_d = 0.38), than those who had not worn a mask (m_d = -0.19, sd_d = 0.33). However, this interaction was not statistically significant (F(1, 365) = 1.96, p = 0.162, η_p^2 = 0.005).

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[1] All exploratory inferential statistics reported in this section are based on a 2 (prior usage) x 2 (spread beliefs) x 2 (catch beliefs) x 2 (self mask) x2 (other mask) mixed ANOVA on distancing. 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. No other main effects or interactions are significant, apart from those reported in text.

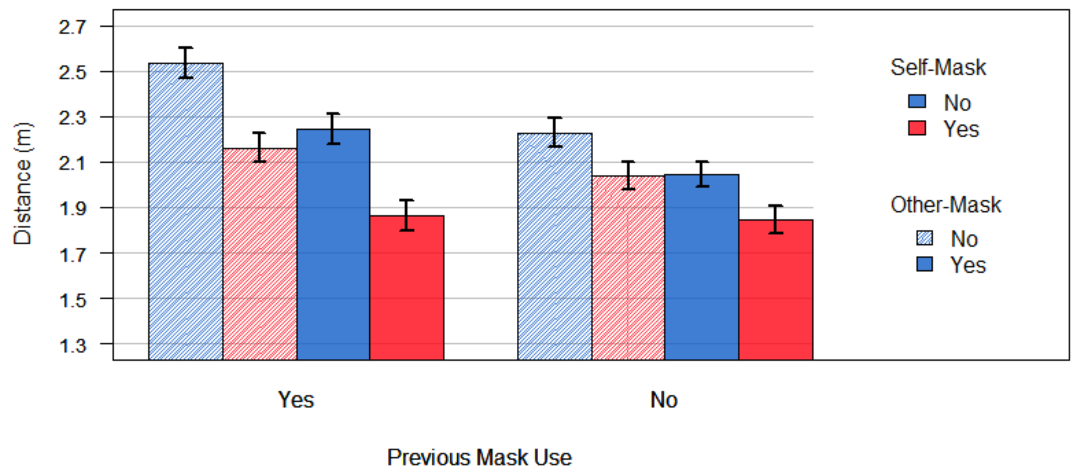

Figure 4: Mean distance preferences, in metres, from experiment 1, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the participant had previously worn a mask in public. Error bars show standard errors.

Participants also rated, 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 high and low on the catching prevention and the spreading prevention questions to create two mask belief variables. Figure 5 shows distance preferences broken down into those who believe masks prevent the wearer from catching covid-19 (left) and those who do not (right). Figure 6 similarly separates distance preferences into participants who believe wearing a mask prevents the wearer from spreading Covid-19 (left) and those who do not (right).

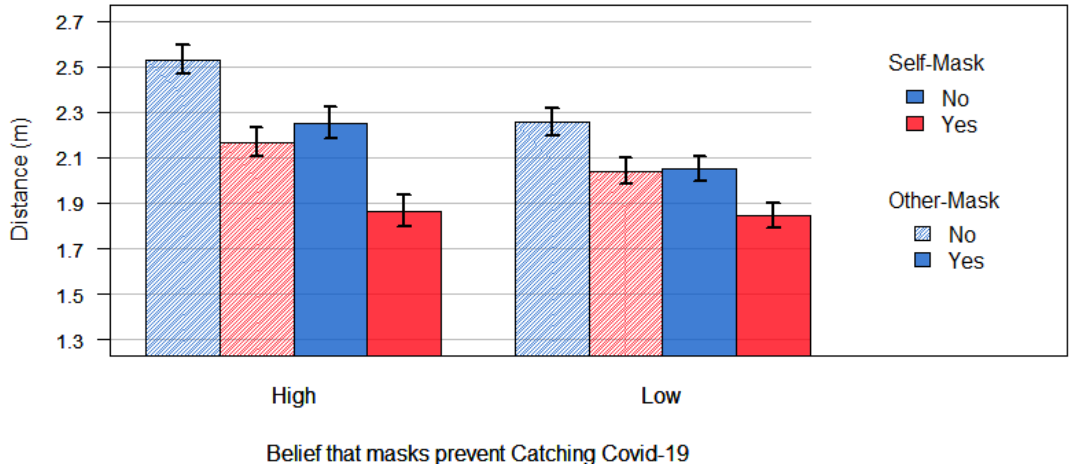

Figure 5: Mean distance preferences, in metres, from experiment 1, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the participant believed masks were effective at preventing the wearer from Catching Covid-19. Error bars show standard errors.

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, η_p^2 = 0.019). Participants who believed that wearing a mask prevents them from catching 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 behaviour 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, η_p^2 = 0.003).

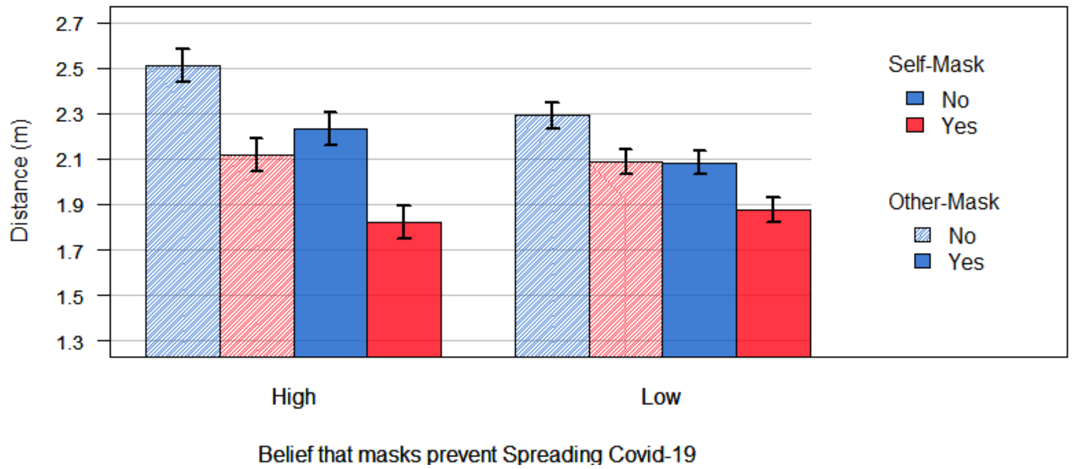

Figure 6: Mean distance preferences, in metres, from experiment 1, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the participant believed masks were effective at preventing the wearer from Spreading Covid-19. Error bars show standard errors.

Turning to spread prevention beliefs, our speculation is not supported as there is no significant interaction between spread beliefs and the other mask manipulation $F(1, 365) = 0.29$, $p = 0.593$, $\eta_p^2 = 0.001$). 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 high spread prevention beliefs did respond differently to the self-mask manipulation. As with catch prevention beliefs, those with high spread prevention beliefs decreased their physical distancing by more when wearing a mask (m_d = -0.4, sd_d = 0.44), than those with low 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 are considering the risk they pose to others as well and compensating for the lower risk they pose to others when wearing a mask, by moving closer.

Risk of Covid-19. As the risk of Covid-19 varies greatly amongst the population (Ferguson et al., 2020), we expect an individual's attitudes to distancing will differ depending upon their real or perceived risk of illness. We proxied real risks with the participant's age, 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 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 judgements.

To test whether age or perceived 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 7 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 themself and the stranger (β = 0.0069, $F(1, 369) = 15.89$, $p < .001$). This does not interact with either the self mask (β = 0.0003, ,$F(1, 369) = 0.17$, $p = 0.682$), or other mask (β = 0.0002, ,F(1, 369) = 0.06, p = 0.805) manipulations. No higher order interactions with hopsitalisation chance are present.

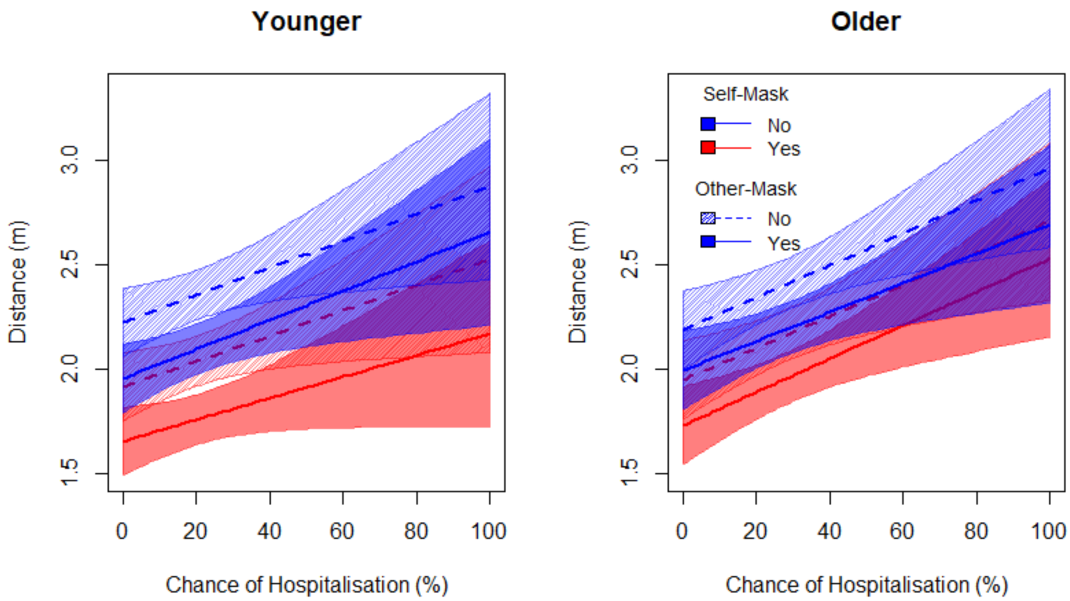

Figure 7: Regression model fit for hospitalisation chance for all four mask conditions and young, verse older participants. The dependent variable is mean distance preference, in metres. The left panel shows the best fitting line for younger respondents and the right panel for older respondents. Around the line is the 95% confidence interval. Separate lines are mask conditions. Red is self masked, blue is self without mask. Solid colour is other masked, shaded is other without mask.

Comparing across the panels it appears that the effects of both mask manipulations decrease with age, however only the interaction with self-mask is significant (β = -0.0913, F(1, 369) = 5.32, p = 0.022), other-mask is not (β = -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 judgements (β = 0.0613, F(1, 369) = 0.56, p = 0.456).

Experiment 2

Results

Participants and Exclusions

400 adult residents of the UK took part: 200 between the ages of 18 and 40 years, and 200 aged 65 years or above (with 143 of this group 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.

Main Analysis

In experiment 1 we found evidence for risk compensation both when wearing a mask yourself, and when the other person was wearing a mask for all three activities. The primary goal of experiment 2 is to replicate these results, while also testing 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 a 2x2x2x(2) mixed ANOVA performed using the Afex package in R, with age a between-subjects factor and the other factors within-subjects, as in experiment 1.

Figures 8 to 10 are similar to Figure 3, except that the three activities are shown in separate figures. Each figure plots the results separately for younger (left) and older (right) participants with the results for inside and outside locations plotted on separate rows. The headline result is similar to experiment 1, with participants decreasing their distance preferences when either the participant, 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 stranger were wearing a mask, and weakest when both were wearing a mask, the effect of the participant wearing a mask was greater if the stranger was also wearing a mask. These results were consistent across all 3 activities. The conclusions regarding age are less clear. For standing older participants seemed to have greater distancing preferences, while for the other two activities age instead moderated our mask effects, generally suggesting that older participant engaged in less risk compensation.

Standing. The 2x2x2x(2) ANOVA revealed a successful replication of the self-mask ($F(1, 355) = 161.31$, $p < .001$, $\eta_p^2 = 0.312$), other-mask ($F(1, 355) = 146.33$, $p < .001$, $\eta_p^2 = 0.292$) and location effects found in experiment 1 for standing ($F(1, 355) = 9.86$, $p = 0.002$, $\eta_p^2 = 0.027$). In addition it revealed a main effect of age ($F(1, 355) = 6.07$, $p = 0.014$, $\eta_p^2 = 0.017$), and interactions between self and other-mask ($F(1, 355) = 4.93$, $p = 0.027$, $\eta_p^2 = 0.014$) and between age and location ($F(1, 355) = 8.73$, $p = 0.003$, $\eta_p^2 = 0.024$). Age did not significantly interact with either the self- ($F(1, 355) = 1.96$, $p = 0.162$, $\eta_p^2 = 0.006$) or other-mask ($F(1, 355) = 0.72$, $p = 0.398$, $\eta_p^2 = 0.002$) manipulations.

Details: Similar to experiment 1 standing distances were shorter when the participants was wearing a mask, compared to not, when the stranger was wearing a mask compared to not and when the queue was outside compared to inside. Figure 8 plots these results. Unlike experiment 1 the significant self-mask by other-mask interaction suggests the effect of wearing a mask yourself was bigger when the stranger was also wearing a mask.

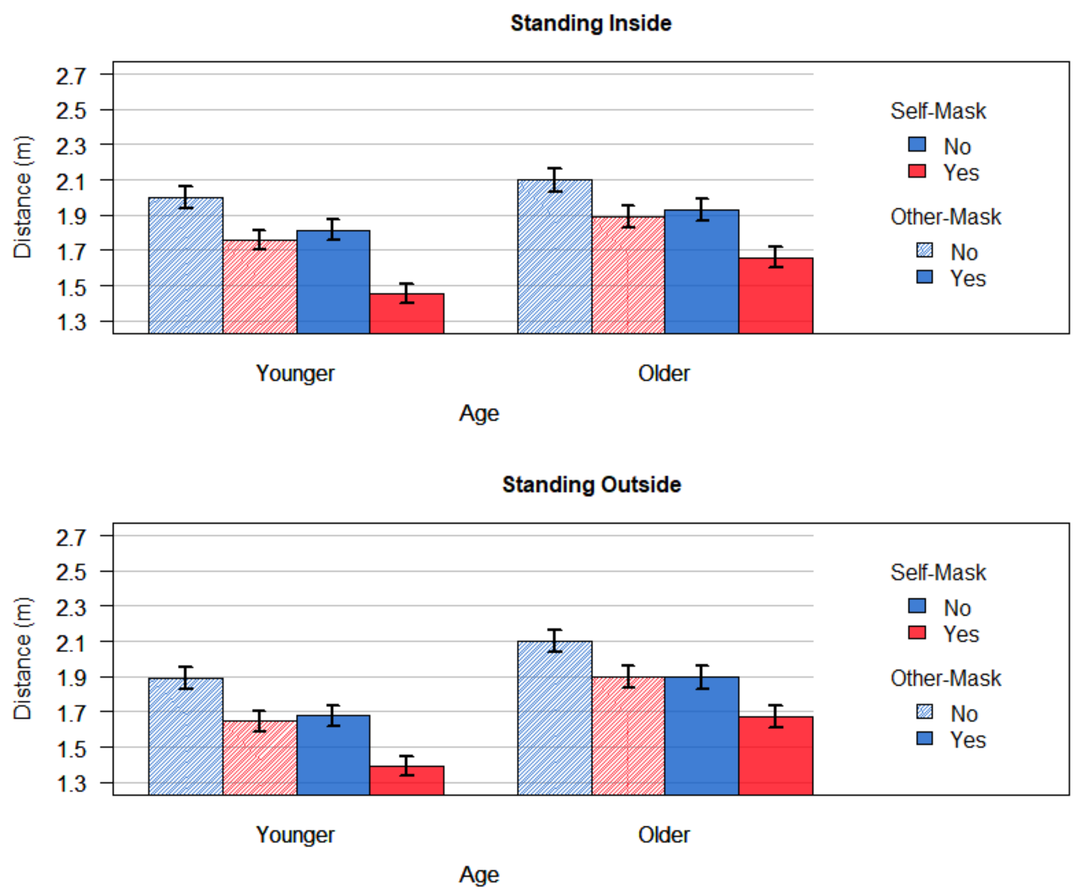

Figure 8: Mean standing distance preferences, in metres, from experiment 2, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask. The left set of bars shows responses for younger participants and the right set older participants. The top row shows the responses for inside locations and the bottom row outside locations. Error bars show standard errors.

We also find that age affects standing distance in the expected direction. Older participants, who are at higher risk of Covid-19, indicated they would stand further from the other person than younger participants. From the exploratory analyses of experiment 1 we might have expected age to interact with our self- or other-mask effects, with older participants showing less risk compensation. However we find no evidence of this in standing distance, as neither interaction is significant. However older participants did show less of an effect of the location, as indicated by the significant age by location interaction.

We were also interested in whether the change in guidelines between experiments 1 and 2 may have impacted distancing. To test this, we calculate the average standing distance for all participants in both experiments, by averaging across self, other and location factors. As there are very few participants over the age of 65 in experiment 1, we limit this analysis to just 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 that standing distance is significantly greater in experiment 1 (m = 1.87, sd = 0.75), than in experiment 2 (m = 1.7, sd = 0.69; t(473) = 2.48, p = 0.014).

Sitting. As with standing, the 2x2x2x(2) ANOVA replicates the main sitting effects from experiment 1. We find a main effect of self -mask (F(1, 355) = 173.67, p < .001, η_p^2 = 0.328), other-mask (F(1, 355) = 151.92, p < .001, η_p^2 = 0.3), and no location effect (F(1, 355) = 0.82, p = 0.367, η_p^2 = 0.002). Also like the standing results, we find an unexpected interaction between the self-mask and other-mask effects that was not present in experiment 1 (F(1, 355) = 6.67, p = 0.01, η_p^2 = 0.018). Unlike standing results there was no main effect of age (F(1, 355) = 0.32, p = 0.573, η_p^2 = 0.001), but were significant interactions between age and both the self-mask effect (F(1, 355) = 4.98, p = 0.026, η_p^2 = 0.014), and the other-mask effect (F(1, 355) = 4.18, p = 0.042, η_p^2 = 0.012). We also find unexpected interactions between age and location (F(1, 355) = 4.4, p = 0.037, η_p^2 = 0.012), self and location (F(1, 355) = 4.5, p = 0.035, η_p^2 = 0.013), and a four way interaction (F(1, 355) = 6.85, p = 0.009, η_p^2 = 0.019).

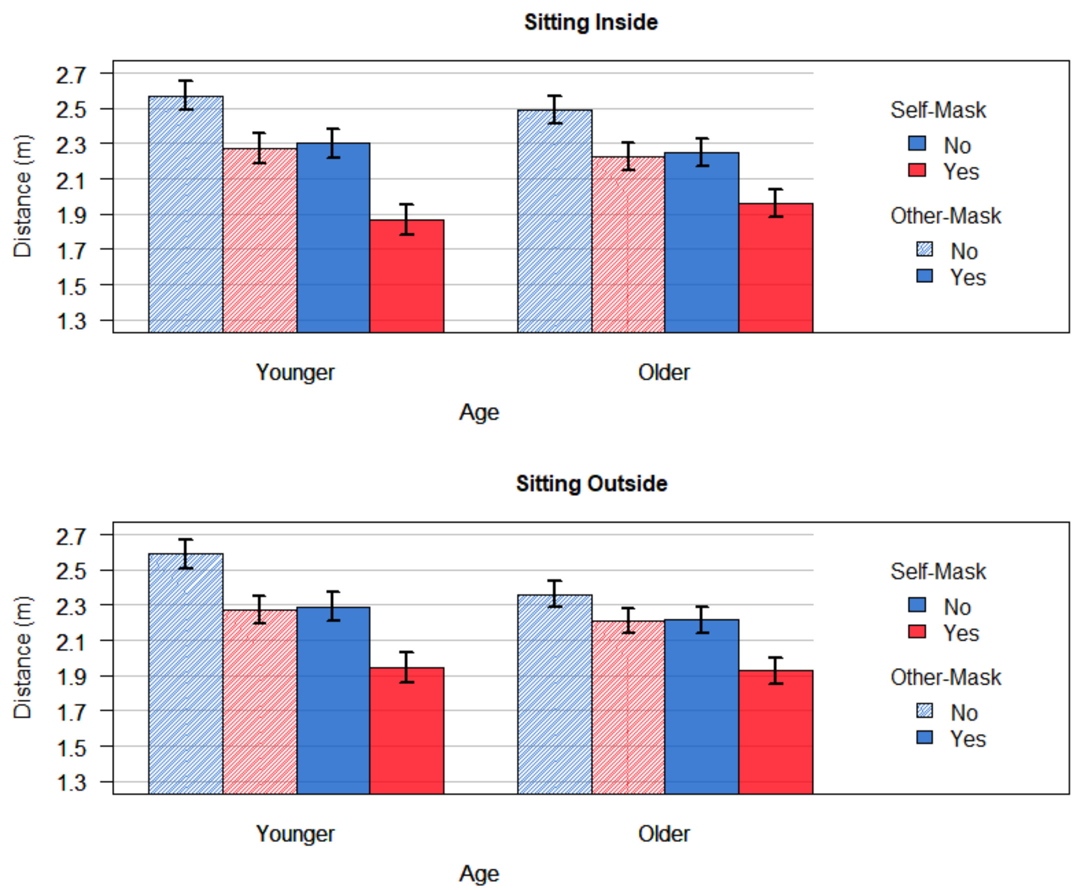

Figure 9: Mean sitting distance preferences, in metres, from experiment 2, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask. The left set of bars shows responses for younger participants and the right set older participants. The top row shows the responses for inside locations and the bottom row outside locations. Error bars show standard errors.

Details: As in experiment 1, participants indicated they would sit closer to the stranger if either the stranger or they themselves were wearing a mask (Figure 9). As with standing the significant interaction revealed that the effect of the participant wearing a mask was greater if the stranger was also wearing a mask. Unlike for standing, when sitting we did not find that older participants kept greater distances overall than younger participants.

However we do see that the effect of either wearing a mask yourself, or the stranger wearing a mask, is greater for younger people. Alone this would suggest that older participants are engaging in less risk compensation. However interpretation of these results is complicated by the significant four-way interaction.

Comparing across the two experiments, as we did for the standing scenario, we find no effect of guidelines. There was no significant difference between sitting distance in experiment 1 (m = 2.4, sd = 0.94) and experiment 2 (m = 2.26, sd = 1.01; t(473) = 1.42, p = 0.155).

Walking. For walking the 2x2x2x(2) ANOVA also revealed significant main effects of self-mask (F(1, 355) = 168.29, p < .001, η_p^2 = 0.322) and other-mask (F(1, 355) = 187.39, p < .001, η_p^2 = 0.345) and an interaction between the two (F(1, 355) = 5.15, p = 0.024, η_p^2 = 0.014). The age by self-mask interaction was also significant (F(1, 355) = 4.24, p = 0.04, η_p^2 = 0.012), but the age by other-mask interaction, and main effect of age were not (F(1, 355) = 1.28, p = 0.26, η_p^2 = 0.004). was not (F(1, 355) = 2.88, p = 0.091, η_p^2 = 0.008). No other main effects or interactions were significant.

Details: Similar to sitting, passing distances were shorter when the participant was wearing a mask compared to not (Figure 10) The difference between the masked and unmasked distances was also greater for younger than older participants, and when the stranger was wearing a mask. Passing distances were also shorter when the stranger was wearing a mask, but this did not differ by age.

Comparing walking distances across experiments, we find no significant difference in walking distance between experiment 1(m = 2, sd = 0.89) and experiment 2 (m = 1.86, sd = 0.88; t(473) = 1.65, p = 0.099).

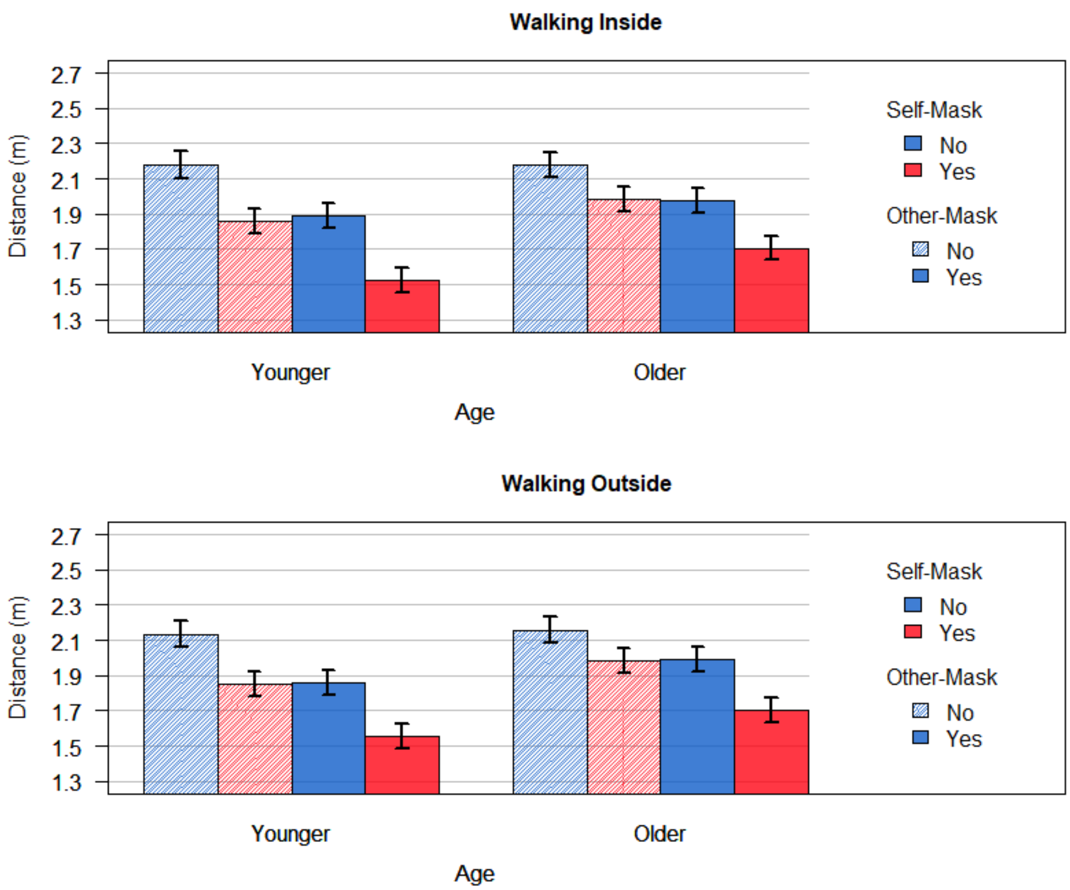

Figure 10: Mean walking distance preferences, in metres, from experiment 2, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask. The left set of bars shows responses for younger participants and the right set older participants. The top row shows the responses for inside locations and the bottom row outside locations. Error bars show standard errors.

Confirmatory Analysis

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

Mask Usage and beliefs. In experiment 1 we found that participants who had previously worn a mask showed a greater self-mask effect, i.e. they reduced their distancing by more when they were wearing a mask. We do not replicate this significant interaction in experiment 2 ($F(1, 349) = 1.38$, $p = 0.242$, $\eta_p^2 = 0.004$). This was not entirely surprising, as in experiment 1 prior mask usage was essentially a measure of voluntary usage, as mask usage was not mandatory in public, while in experiment 2 participants who had a caught public transport in the previous month would have been required to wear a mask. While we did not ask who had worn a mask voluntarily, mask usage was slightly higher in experiment 2, with 217 participants having worn a mask, split evenly across the age groups. Complicating this interpretation, we do however find an interaction between the other-mask manipulation and prior mask usage ($F(1, 349) = 4.6$, $p = 0.033$, $\eta_p^2 = 0.013$), which was not significant in experiment 1. Considering both experiments together we cannot draw any clear conclusions about whether people who already wear masks show more risk compensation than those who do not. Figure 11 plots distance preferences separated by prior mask usage (left panels) and no prior mask usage (right panels).

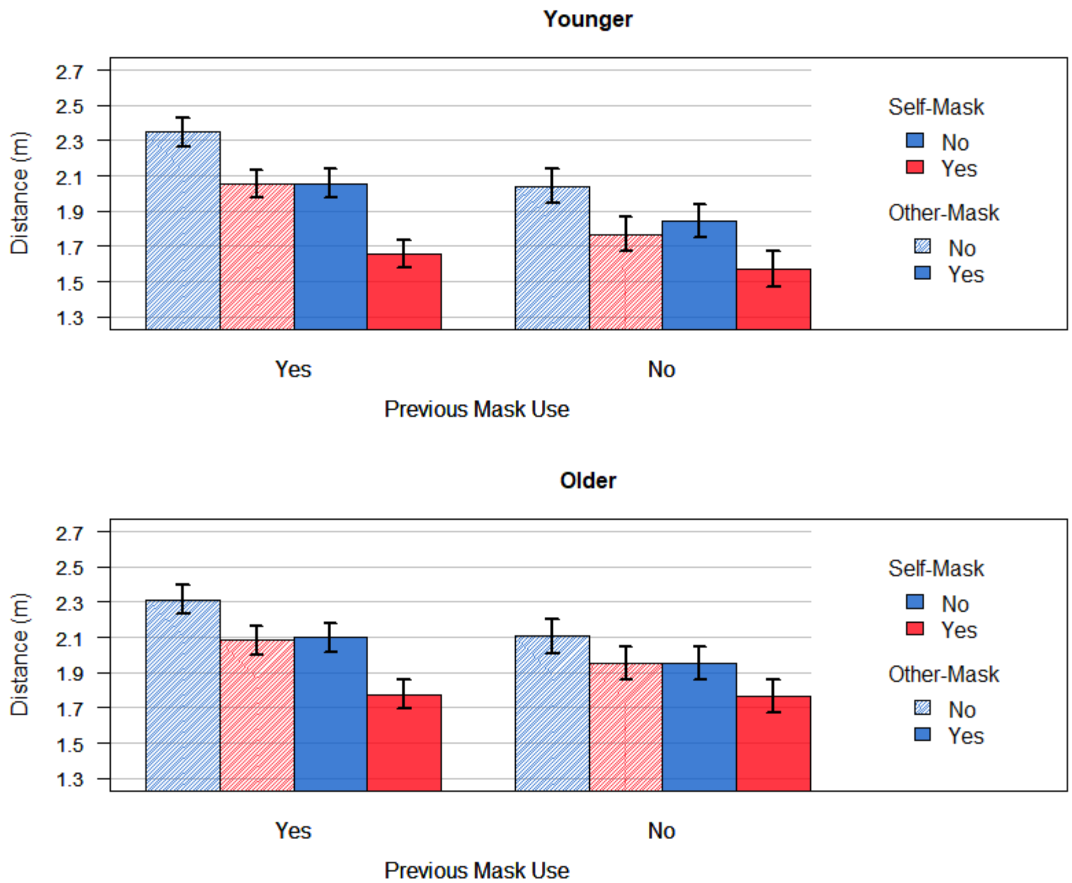

Figure 11: Mean distance preferences, in metres, from experiment 2, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the participant had previously worn a mask in public. The top row shows the responses of younger participants and the bottom row older participants. Error bars show standard errors.

As in experiment 1 we also had participants rate how effective they believed masks were at preventing spreading or catching Covid-19, and 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 themself. We replicate this interaction in experiment 2 ($F(1, 349) = 5.78$, $p = 0.017$, $\eta_p^2 = 0.016$). 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 ($F(1, 349) = 10.21$, $p = 0.002$, $\eta_p^2 = 0.028$). Figure 12 plots the relations between distancing and catching beliefs. In experiment 1 we also expected, but did not find, a similar interaction between high spread prevention beliefs and the other-mask effect. In experiment 2 we do find this interaction, with participants who gave high ratings having a greater decrease in distancing when the stranger is wearing a mask ($F(1, 349) = 15.63$, $p < .001$, $\eta_p^2 = 0.043$).[2] Figure 12 plots distancing broken down by spread prevention beliefs. In both Figures 11 and 12 the top panel plots the results for younger participants and the bottom panel older participants.

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[2] 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. Besides the results reported above, the only other significant effects in this analysis were the main effects of the self, and other mask manipulations, and an unexpected 4-way interaction between self-mask, other-mask, age and spread prevention beliefs ($F(1, 349) = 4.64$, $p = 0.032$, $\eta_p^2 = 0.013$).

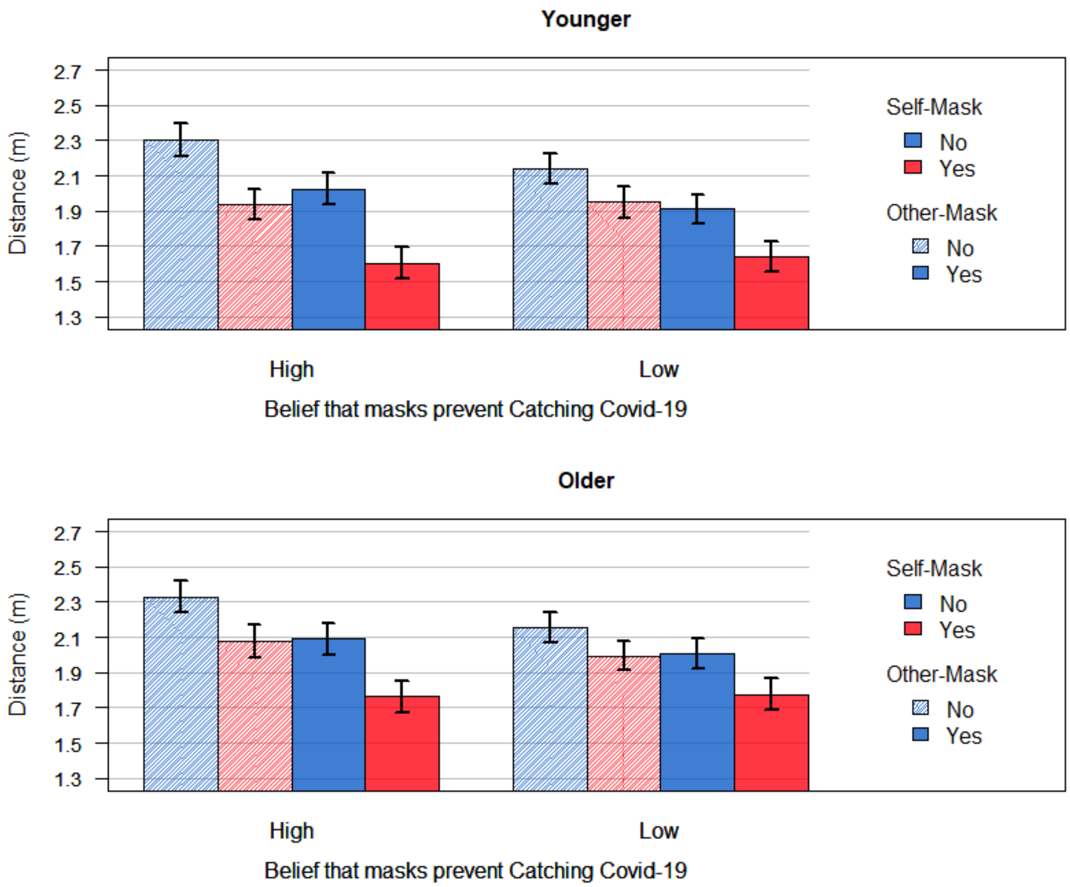

Figure 12: Mean distance preferences, in metres, from experiment 2, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the participant believed masks were effective at preventing the wearer from Catching Covid-19. The top row shows the responses of younger participants and the bottom row older participants. Error bars show standard errors.

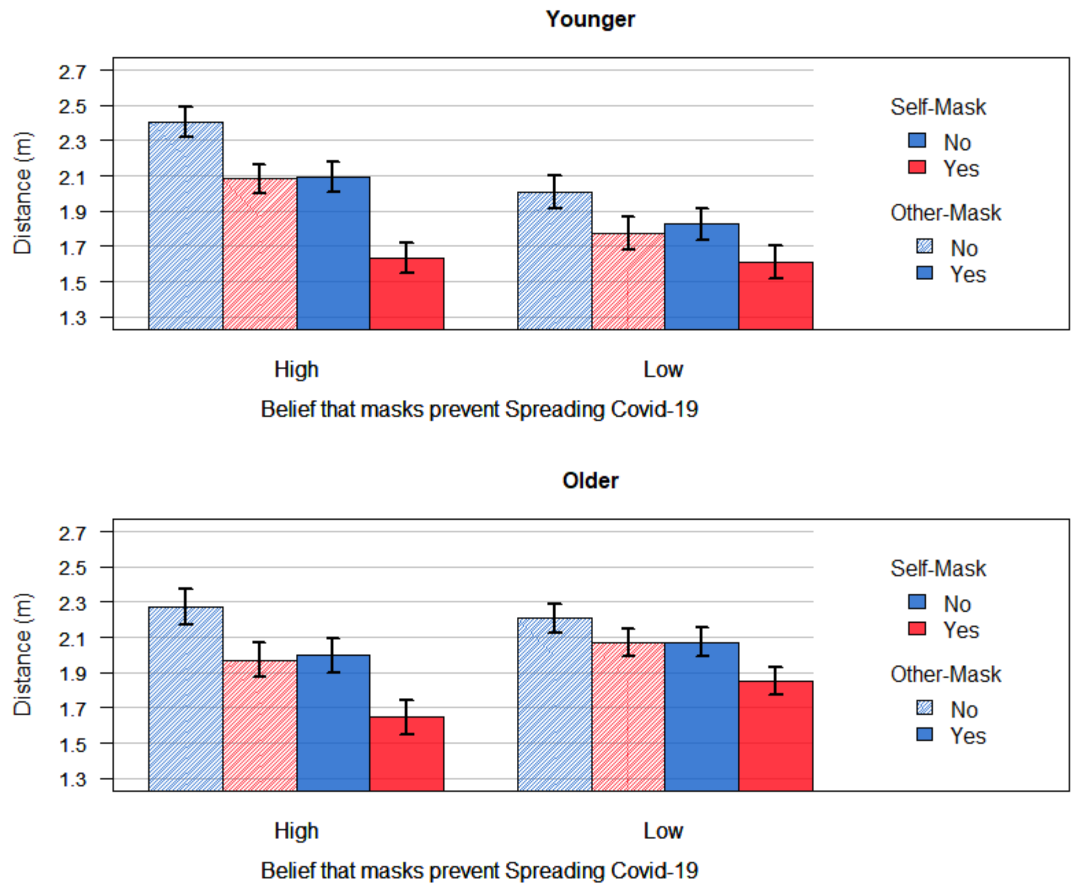

Figure 13: Mean distance preferences, in metres, from experiment 2, conditional on whether the participant (Self-Mask) or the stranger (Other-Mask) was wearing a mask and whether the participant believed masks were effective at preventing the wearer from Spreading Covid-19. The top row shows the responses of younger participants and the bottom row older participants. Error bars show standard errors.

Risk of Covid-19. We also sought to confirm the hospitalisation risk results from experiment 1 with a pre-registered confirmatory analysis in experiment 2. As we had split our sample by age during data collection, we used this categorical age variable as a predictor, rather than the median split used in experiment 1.

In experiment 1 we found that distances increased with perceived hospitalization chance. In experiment 2 we find a similar main effect of perceived hospitalization chance (β =

0.0053, ,F(1, 353) = 11.35, p < .001), but also find it interacts with our mask manipulations, both self (β = 0.0014, ,F(1, 353) = 3.98, p = 0.047), and other (β = 0.0016, ,F(1, 353) = 5.41, p = 0.021). Figure 14 shows the estimated regression line for each mask condition, and for the two age groups. In addition to the significant self-mask, other-mask and self- by other-interaction found in all analyses, we also find significant self by age (β = -0.1213,F(1, 353) = 8.21, p = 0.004) and other by age interactions (β = -0.1065, ,F(1, 353) = 7.27, p = 0.007), similar to some of the main analyses.

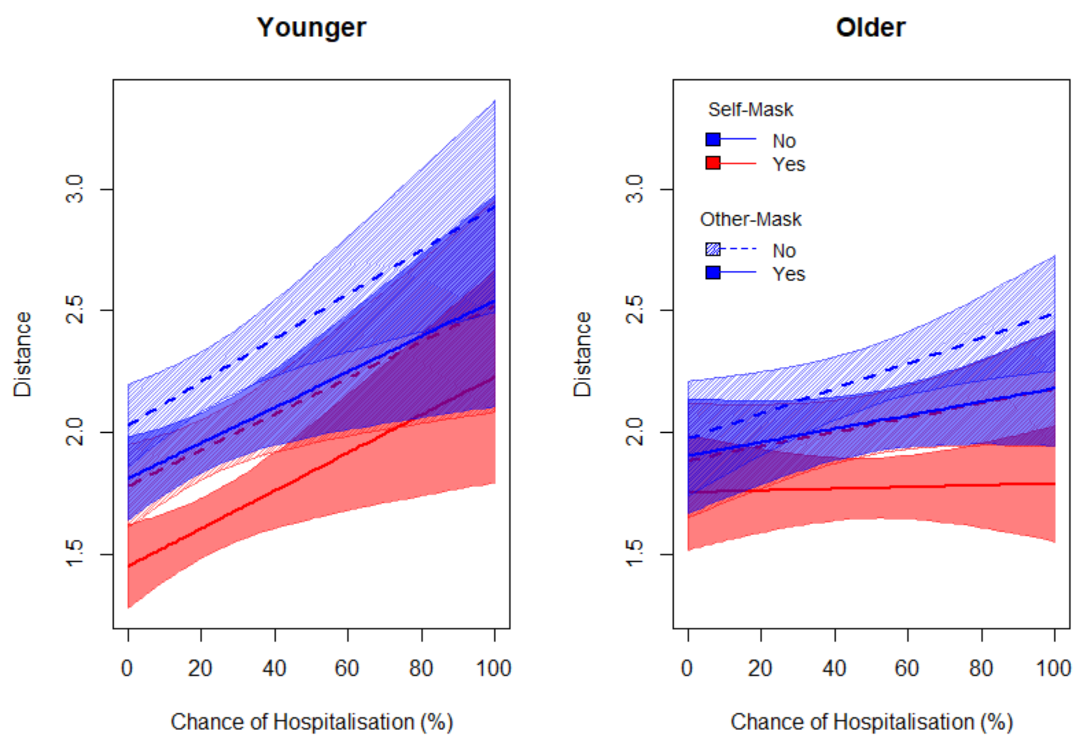

Figure 14: Regression model fit for hospitalization chance for all four mask conditions and young, verse older participants in experiment 2. The left panel shows the best fitting line for 18-40 year olds and the right panel over 65 year olds. Around the line is the 95% confidence interval. Separate lines are mask conditions. Red is self-masked, blue is self without mask. Solid colour is other-masked, shaded is other without mask.

Discussion

We found that participants wanted to keep greater distances from strangers when either the strangers, or themselves, were not wearing a mask. This is consistent with the *risk compensation hypothesis* (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. This was true both when the participant was wearing the mask, or when the stranger was.

This second result conflicts with findings of Seres et al. (2020), who found greater distancing when others were shown to be wearing a mask. An important difference between the two studies, which may account for the differing results, is the types of masks used. In Seres et al. (2020), the experimenter wore a FFP2 respiratory protection mask. 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, rather than catching Covid-19. For example, Public Health England (2020) produced guidance on when to use the different kinds of mask. It is quite possible that participants, in general, are aware of this difference and so in Seres et al. (2020) perceived the respiratory mask wearers as particularly trying to shield themselves from catching Covid-19, while the participants in our studies did not read this intentionality into the behaviour of simple-mask wearers. If they did not infer that the other person was particularly trying to protect themselves from Covid-19, then there is also less reason for them to assume that the other person desires more space. Future studies should address this question.

In addition to our main finding of risk compensation in both cases, our results suggest that beliefs about the effectiveness of masks may also play a role in the strength of risk compensation. In both experiments, we found that those who believed masks were effective at preventing either the spread of Covid-19, or them catching Covid-19, showed a greater decrease in distancing when wearing a mask. In experiment 2, we also found that those who believed masks prevented the spread of Covid-19 decreased their distancing 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).

The implications of our findings for government advice on social distancing depend upon the current 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 long-term negative impacts. If the goal of government is to get children back into schools, or people back to their local doctor, 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 policymakers are aware that people may engage in risk compensation, and that such policy may have a perverse effect by actually increasing the absolute risk of transmitting the virus

(Pinkerton, 2001). We have found evidence of the risk compensation, but to identify whether masks have a perverse effect more information is needed on how transmission of the virus is impacted by mask usage compared to changes in physical distances. Future research should replicate our findings in field settings and also measure some proxy for the actual risk of transmitting the virus, such as counting the number of times people violate the distancing rules i.e. getting closer than they should (e.g. 2m or 1m depending on local guidelines).

If the government's goal is to minimise the transmission rate of the virus, then people's willingness to trade-off physical distancing and mask usage is problematic. Given the effectiveness of masks in preventing spread, our results would instead suggest that the guidelines for mask usage need to be clear enough to prevent this trade-off. For instance, by explicitly emphasising that masks are not an alternative to physical distancing, but rather a complement; and maybe also stressing 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. Hence, future research should also be testing behaviour change interventions aiming to reduce such violations (Bavel et al., 2020; West, Michie, Rubin, & Amlôt, 2020).

While our experiments focused on the UK, it is likely that similar results would be found in countries with similar histories of mask usage, such as Australia (which is undergoing a minor resurgence in cases as we write), the US, or much of Europe. Our results could be particularly relevant for countries where mask usage is now high, but physical distancing guidelines have been relaxed: they may suggest that if these countries need to return to greater levels of physical distancing, for instance due to a second wave of infections, that may be harder to implement than it was when mask usage was low at the start of the pandemic.

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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 trials where one was wearing a mask and the other not.

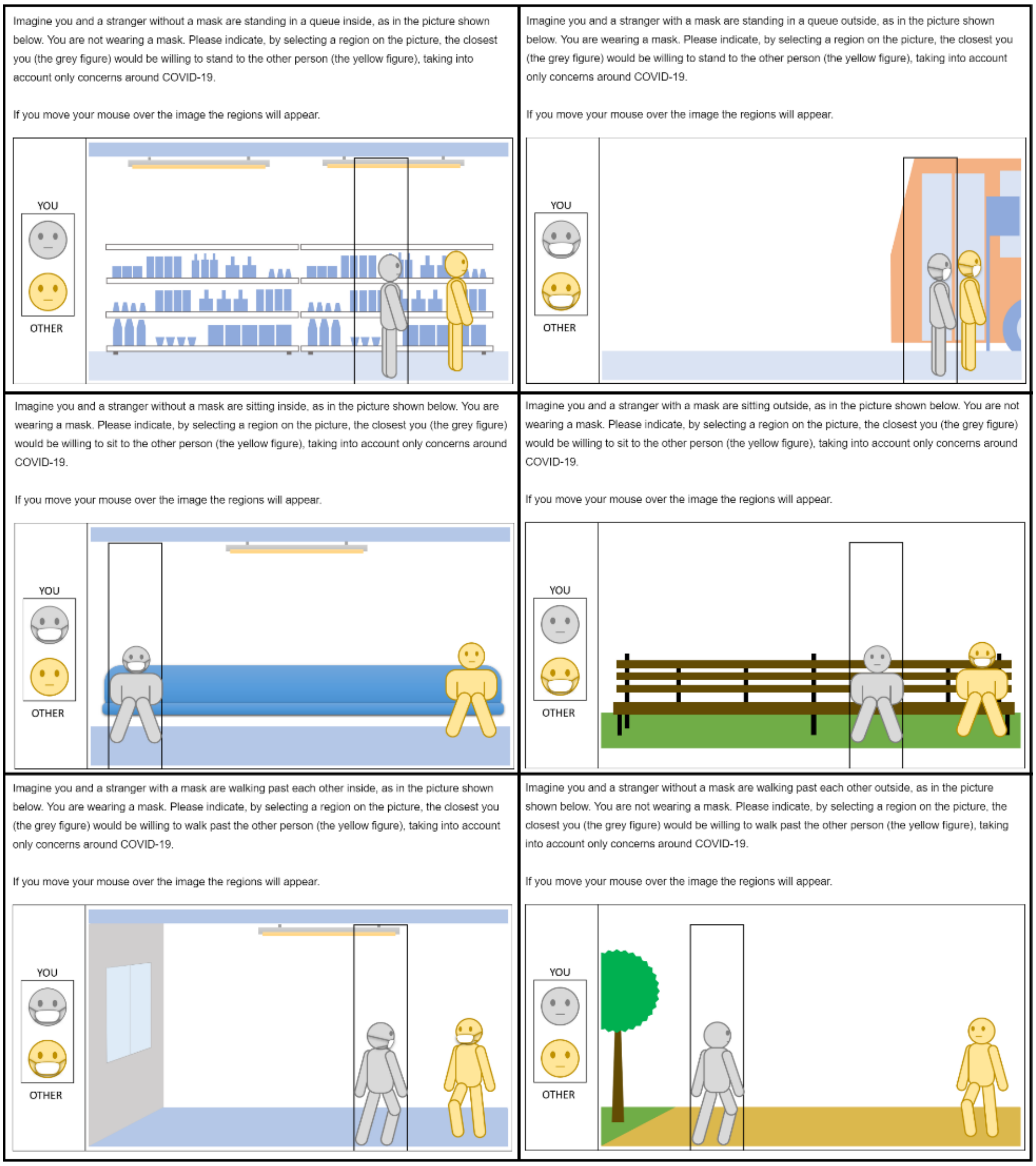

Figure A1: Example of the descriptive text and image for each combination of Activity and Location. Top row shows Standing, middle Sitting and bottom Walking activities. Left column is indoor location and right column outdoor location. Different combinations of masks are used in each example so that 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.