Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Do socio-structural factors moderate the effects of health cognitions on COVID-19 protection behaviours?

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ABSTRACT

Objective: Adherence to protection behaviours remains key to curbing the spread of the SARS-CoV-2 virus that causes COVID-19, but there are substantial differences in individual adherence to recommendations according to socio-structural factors. To better understand such differences, the current research examines whether relationships between health cognitions based on the Reasoned Action Approach (RAA) and eight COVID-19 protection behaviours vary as a function of participant-level socio-structural factors.

Methods: Within-person design with behaviours nested within participants in a two-wave online survey (one week delay) conducted during the UK national lockdown in April 2020. A UK representative sample of 477 adults completed baseline measures from the RAA plus perceived susceptibility and past behaviour for eight protection behaviours, and self-reported behaviour one week later. Moderated hierarchical linear models with cross-level interactions were used to test moderation of health cognitions by socio-structural factors (sex, age, ethnicity, deprivation).

Results: Sex, ethnicity and deprivation moderated the effects of health cognitions on protection intentions and behaviour. For example, the effects of injunctive norms on intentions were stronger in men compared to women. Importantly, intention was a weaker predictor of behaviour in more compared to less deprived groups. In addition, there was evidence that perceived autonomy was a stronger predictor of behaviour in more deprived groups.

Conclusion: Socio-structural variables affect how health cognitions relate to recommended COVID-19 protection behaviours. As a result, behavioural interventions based on social-cognitive theories might be less effective in participants from disadvantaged backgrounds.

In early 2020, a novel Coronavirus (SARS-CoV-2) spread rapidly across the world, causing the global pandemic of COVID-19 with currently (July 23, 2021) more than 190 million confirmed cases and more than 4.13 million COVID-19-related fatalities (Johns Hopkins University and Medicine, 2020). The virus is highly transmissible, and spontaneous outbreaks in otherwise well-controlled areas (e.g., mid-February 2021 outbreak in Melbourne, Australia) point to the ongoing need for effective responses to the pandemic. Although effective vaccines against SARS-CoV-2 are now (July 2021) available and are being rolled out internationally, both the scarcity of vaccines and the emergence of virus variants suggest that adhering to behavioural recommendations (for example, in the UK: washing hands regularly, wearing a face mask in enclosed spaces, staying at least 2 m apart or 1 m with face masks or other precautions; HM Government, 2020) remain effective strategies to curb the transmission of the SARS-CoV-2 virus and reduce the incidence of COVID-19.

1. COVID-19 protection behaviours and health cognitions

However, to be effective, these behavioural recommendations must be adhered to by, ideally, the entire population. Current monitoring studies (e.g., COSMO study in Germany; Betsch et al., 2020) suggest

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most people are adhering to behavioural recommendations, but also that self-reported adherence to the specific behaviours varies between 57 % (avoiding public places) and 89 % (wearing face masks). One approach to understanding differences in adherence to COVID-19 protection behaviours is to focus on the social-cognitive determinants of behaviour (i.e., health cognitions) as outlined in theories such as the Reasoned Action Approach (RAA; Fishbein and Ajzen, 2010). The RAA proposes that behavioural intention, the most proximal determinant of behaviour, is based on attitude, norms, and perceived behavioural control. Attitudes, representing the overall evaluation of a behaviour, include both affective/experiential (i.e., the extent to which the behaviour is perceived as pleasant) and cognitive/instrumental (i.e., the extent to which the behaviour is perceived as beneficial) components. Norms, representing the perceived influence of others, include injunctive (i.e., perceptions of whether others would approve of them engaging in the behaviour) and descriptive (i.e., perceptions of whether others themselves engage in the behaviour) components. Perceived behavioural control, representing the level of control over the behaviour, includes capacity (i.e., perceptions of confidence that they could engage in the behaviour; similar to self-efficacy) and autonomy (i.e., perceptions that they have control over whether or not to engage in the behaviour) components.

Although widely applied across a range of health behaviours (McEachan et al., 2016), the RAA and its predecessor, the theory of planned behaviour (TPB; Ajzen, 1991), have only been used in a few studies to explain pandemic-related behaviours, including intentions (Agarwal, 2014; Yang, 2015) and uptake (Liao et al., 2011) of the H1N1 (swine flu) vaccine, willingness to self-isolate during the SARS pandemic (Zhang et al., 2019), and compliance with SARS protection behaviours (Cheng and Aik-Kwang, 2006). In the context of COVID-19, a number of studies have examined relationships between RAA predictors and protection behaviours (e.g., Barile et al., 2021; Lin et al., 2020; Margraf et al., 2020; Norman et al., 2020) or intentions to receive vaccination (Guidry et al., 2021). These studies generally find patterns of relationships consistent with the RAA in that more favourable health cognitions are associated with higher intentions and higher levels of protection behaviours.

2. Perceived susceptibility and RAA

The TPB/RAA does not include perceived susceptibility as a predictor, but in the current COVID-19 pandemic, perceived susceptibility has emerged as a key predictor of protection behaviours (Bruine de Bruin and Bennett, 2020; Dryhurst et al., 2020; Savadori and Lauriola, 2020). For example, research in South Korea during the early stages of the current pandemic found perceived susceptibility to becoming infected with COVID-19 to be significantly associated with the wearing of facial masks, but not other preventive behaviours (Lee and You, 2020). Perceived susceptibility is included as a predictor of behavioural intentions in related models such as the health action process approach (Schwarzer and Luszczynska, 2015) and protection motivation theory (Norman et al., 2015) and, as a result, might be also usefully added to the TPB/RAA to explain behavioural responses to the COVID-19 pandemic.

3. Socio-structural factors and the RAA

The utility of theories such as the RAA depends on their sufficiency in explaining variance in behaviours, and this sufficiency has been shown to vary between individuals or groups of individuals based on socio-structural factors (Conner et al., 2013; Schüz et al., 2017, 2020). Socio-structural factors include demographics and constructs such as educational attainment, individual or household income, neighbourhood factors, or, more generally, socioeconomic status (SES). These factors are also implicated in differences in COVID-19 protection behaviours. For example, the COSMO study in Germany shows that women are more likely to wear face masks and are more likely to be willing to get vaccinated; older adults are similarly more likely to be willing to get vaccinated (Betsch et al., 2020). Similarly, an eight-nation study found women and those with higher incomes to be more likely to adhere to COVID-19 recommendations (Galasso et al., 2020). In the USA, individuals with lower incomes and with less secure employment status were less adherent to social distancing recommendations (Papageorge et al., 2020), while a Canadian study found that mask wearing was more likely in those with higher educational attainment and in full-time employment (Brankston et al., 2020).

While these studies point to clear differences in COVID-19 protection behaviours by socio-structural factors, most theories of health behaviour are not particularly well suited to understand such differences because the relationship between social-structural factors, health cognitions and health behaviours is poorly specified (Schüz, 2017). For example, theories such as the TPB/RAA have little to say about how and why socio-structural factors would moderate the effects of health cognitions on behaviour. However, there is emerging evidence that the degree to which health cognitions influence behaviour varies with the levels of socio-structural variables (e.g., Conner et al., 2013; Schüz et al., 2020; Schüz et al., 2017). In these studies, higher socio-economic status was associated with stronger effects of health cognitions such as behavioural intention on behaviour, although there are other studies which observe no such moderating effects (Vasiljevic et al., 2016). However, to date, these moderating relationships have not been examined with regards to pandemic-related behaviours. Testing and exploring the boundary conditions of behavioural theories (i.e., moderation effects) can further our understanding of various behaviours, such as those that help minimize the risk of virus transmission, allowing better prediction and targeting of those who may or may not adhere. It also helps to establish whether interventions based on such theories can be expected to be effective in ideally the entire population (Michie and Prestwich, 2010) or need to be supplemented for particular sub-sections of the population, which is particularly relevant in the case of pandemic-related behaviours.

4. Current study

Here, we aimed to identify the factors that predict COVID-19 protection intentions and behaviours, and test whether these associations vary as a function of participant-level socio-structural factors in a UK representative sample. We considered health cognitions as described by the RAA, plus perceived susceptibility and socio-structural factors (sex, age, ethnicity, and area-level deprivation), as predictors of eight COVID-19 protection behaviours in the UK population in April 2020, around one month after the World Health Organization identified the COVID-19 outbreak as a global pandemic on March 11, 2020. In the case of pandemics, by definition the entire population is the target group for potential interventions. Thus, examining which socio-structural variables interact with potentially modifiable determinants of behaviour is crucial.

As the particular behaviours recommended and evidenced to affect SARS-CoV-2 transmission might change over the course of the pandemic, we assessed relationships across a group of protection behaviours within individuals (Conner et al., 2016; Schüz et al., 2020) to account for the likely within-person clustering of such behaviours (e.g., Betsch et al., 2020). Exploring the correlates of such clusters of behaviours could further point to a better generalisability of the findings to additional protection behaviours.

A within-person approach is more appropriate if multiple behaviours are studied compared to the more commonly used between-person approaches which essentially examine rank congruence, that is, whether those with highest levels in health cognitions are also those with the highest levels of the corresponding behaviour and the highest levels of socio-structural factors. Thus, for between-person designs, interaction effects between socio-structural factors and health cognitions on behaviour indicate congruent ranks, rather than testing whether the

strength and direction of relationships between health cognitions and behaviour vary as a function of socio-structural factors. The within-person design employed in this study examines the relationship between multiple health cognitions (level-1) and protective behaviours (level-1) within persons, and then tests whether these relationships vary between individuals as a function of socio-structural factors (level 2). In principle, this is similar to examining repeated within-person associations of health cognitions and behaviour across different time points (e.g., Inauen et al., 2016), but extends this perspective to associations within participants across different behaviours (Conner et al., 2016; Schüz et al., 2020).

5. Method

5.1. Participants and procedure

Participants were recruited via Prolific (prolific.com) and completed an online survey hosted on Qualtrics at two time points separated by one week in April 2020. Quota sampling was used to recruit participants from the pool of individuals signed up to Prolific who were roughly representative of the UK adult population in terms of age (18–24: 12.0 % (UK)/12.4 % (study sample), 25–34: 17.0 % (UK)/17.0 % (study sample), 35–44: 17.7 % (UK)/17.4 % (study sample), 45–54: 17.6 % (UK)/18.0 % (study sample), 55+: 35.7 % (UK)/35.2 % (study sample); Office for National Statistics, 2020b), sex (females: 50.6 % (UK)/51 % (study sample); Office for National Statistics, 2020b) and ethnicity (non-white:15 % (UK)/18 % (study sample); gov.uk, 2020). Participants read an information sheet and indicated consent before accessing the survey. The University of Sheffield Research Ethics Committee granted ethical approval for the study (ref. 034149). A total of 500 participants began the study, with 477 completing all measures and being analyzed. The retained sample were older than those omitted ($M = 34.52$, $SD = 15.54$ vs. $M = 24.22$, $SD = 15.20$, $t(498) = 3.60$, $p < .001$) but otherwise similar on measured variables. The current data has been previously partly reported in Norman et al. (2020), who examined five of the eight behaviours individually using a between-person approach without considering moderation effects. In contrast, the current study focuses on moderation effects of socio-structural factors in a hierarchical model examining all behaviours simultaneously using a within-participants approach.

5.2. Measures

Age (in years), sex (0 = male, 1 = female) and ethnicity (0 = non-white, 1 = white) were obtained from Prolific records. Participants provided a UK postcode that was then linked to Index of Multiple Deprivation (IMD) decile scores using lookup tables (lower scores represent higher levels of relative deprivation). The IMD represents an area-level measure of relative deprivation based on National Statistics on income, employment, health and disability, education, skills and training, crime, access to services, housing and the living environment. It thus consists of validated National Statistics indicators and has itself been validated against multiple indicators of deprivation (UK Ministry of Housing, Communities and Local Government, 2019).

The baseline questionnaire included measures in relation to each of eight COVID-19 protection behaviours: Only leave home for food shopping, exercise, medical needs or travelling to work (if you cannot work from home); Keep at least 2 m (6 feet) away from other people when outside away from home; Keep at least 2 m (6 feet) away from other people when inside shops; Not visit or meet friends or other family members that you don't live with; Wash your hands as soon as you return home; Limit yourself to one session of exercise (e.g. walk, run, cycle) close to home each day; Limit the number of times you leave home each week to shop for food; Wear a mask when away from home. Items to assess health cognitions were constructed in line with current recommendations (e.g., Conner and Sparks, 2015). The full list of items is available in online supplementary material 1. Participants completed single-item measures for each protection behaviour to assess *affective attitudes* (e.g., 'To what extent would you doing each of the behaviours listed below over the next week be unpleasant or pleasant? Unpleasant–Pleasant'), *cognitive attitudes* (e.g., 'To what extent would you doing each of the behaviours listed below over the next week be harmful or beneficial? Harmful–Beneficial'), *injunctive norms* (e.g., 'To what extent would other people disapprove or approve of you doing each of the behaviours listed below over the next week? Would disapprove–Would approve'), *descriptive norms* (e.g., 'To what extent do you think other people will do each of the behaviours listed below over the next week? None–All'), *capability* (e.g., 'How confident are you that you could do each of the behaviours listed below over the next week? Not at all confident–Very confident'), *autonomy* (e.g., 'How much control do you have over whether or not you do each of the behaviours listed below over the next week? No control–Complete control'), *behavioural intention* (e.g., 'Do you intend to do each of the behaviours listed below over the next week? Definitely don't–Definitely do'), *perceived susceptibility* (e.g., 'If you don't do each of these behaviours, how likely is it that you would get coronavirus? Not at all likely–Very likely') and *past behaviour* (e.g., 'To what extent have you done each of the behaviours listed below over the past month? Not at all–All the time). All items were responded to on 7-point scales.

In the follow-up questionnaire (one week after baseline), participants reported performance of each of the 8 protection behaviours over the previous week ('To what extent have you done each of the behaviours listed below over the past week? Not at all–All the time'; e.g., 'To what extent have you … kept at least 2 m (6 feet) away from other people when inside shops? Not at all–All the time') and performance of the corresponding risk behaviour ('To what extent have you done each of the behaviours listed below over the past week? Not at all–All the time'; e.g., 'To what extent have you … been within 2 m (6 feet) of other people when inside shops? Not at all–All the time'). The two items were combined into a dichotomous measure of behaviour (scored 1 for full compliance for those who scored 7 on the first item and 1 on the second item and scored 0 for non-full compliance for all other patterns of responses).

5.3. Analyses

Data were analyzed in SPSS (version 24, SPSS Inc.) and HLM (version 7, SSI). Participants who had missing data for the demographic variables or at least one variable missing for each behaviour were excluded. A total of 3952 person-behaviour data points spread across 477 individuals were used in the analysis. To examine clustering, variance components were examined by computing the intra-class correlation coefficient. To formally test moderation of the effects of health cognitions on COVID-19 protection behaviours by socio-structural variables, we tested whether person-level socio-structural variables could explain between-person variation in the within-person associations of the health cognitions (affective attitude, cognitive attitude, injunctive norms, descriptive norms, capability, autonomy, perceived susceptibility) with behavioural intention and (plus behavioural intention) with behaviour (see conceptual figure in online supplementary material 2). This analysis used Hierarchical Linear Modeling using HLM7 (Raudenbush and Bryk, 2002). Given that the data were hierarchically clustered under persons, we assumed a maximal random effects structure, which is accounted for by including random intercepts and random slopes in the model (Barr et al., 2013).

Intention (Table 2) or behaviour (Table 3) were regressed on the level-1 variables (affective attitude, cognitive attitude, injunctive norms, descriptive norms, capability, autonomy, perceived susceptibility; plus behavioural intention when predicting behaviour), the level-2 variables (age, sex, ethnicity, IMD) and the cross-level interaction between the two. Model 1 included only the level 2 demographic variables, model 2 added the level 1 RAA variables (and cross-level interactions),

model 3 added perceived susceptibility (and cross-level interactions), and model 4 added past behaviour as a control variable. For each model we report model fit (deviance statistic for the linear regressions predicting intention; −2 log likelihood for the Bernoulli regressions predicting behaviour). For predictions of behavioural intention we report unstandardized coefficients and standard errors, standardized coefficients and significance (all based on the population-average model with robust standard errors) for all predictors. For predictions of behaviour we report unstandardized coefficients, odds ratios, 95%CI and significance (all based on the population-average model with robust standard errors) for all predictors. Where a cross-level interaction was significant ($p < .05$) we explored the direction of effect with simple slopes using the free software provided by Preacher (Model 3 for cross-level interactions) at http://www.quantpsy.org/interact/hlm2.htm.

6. Results

The variables had reasonable variance (Table 1) although intentions, injunctive norms, capability and autonomy were skewed. The intraclass correlation coefficients suggest that non-trivial proportions of the variance in the dependent variables (ICC intention = 0.09; ICC behaviour at follow-up = 0.19) are due to person-level clustering, thereby indicating that failure to take into account the hierarchical structure of the data could inflate the Type I error rate (Musca et al., 2011). Across behaviours, approximately 41 % of respondents fully complied with the protection behaviours at follow-up ($M = 0.41$, $SD = 0.27$).

6.1. Direct effects

Of the demographic variables, only sex was significantly correlated with behavioural intention (intention was higher in women compared to men), and only age and sex were significantly correlated with behaviour (behaviour was higher in older respondents and in women compared to men) (Table 1). Considering the behaviour-specific measures, all RAA variables, as well as perceived susceptibility and past behaviour, were significantly positively correlated with behavioural intention and behaviour (Table 1).

Regressions predicting behavioural intention (Table 2) showed that sex, affective attitude, cognitive attitude, injunctive norms, descriptive norms, and capability were each significant independent predictors of behavioural intention (Model 2). Perceived susceptibility (Model 3) and past behaviour (Model 4) were also significant independent predictors of intentions when added to the model. Capability and injunctive norms were the strongest predictors of behavioural intentions. Regressions predicting behaviour (Table 3) showed that behavioural intention (Model 2) plus affective attitude, descriptive norms, capability, autonomy (Model 3) and perceived susceptibility (Model 4) were each significant independent predictors of behaviour. The predictors also remained significant when controlling for past behaviour (Model 5). Sex, intention, and capability were the strongest predictors of behaviour.

6.2. Socio-structural variables as moderators of predictors of intentions

In relation to testing moderation effects, Table 2 shows that there were four significant ($p < .05$) cross-level interactions for predictions of behavioural intention. First and second, the effect of injunctive norms on behavioural intention was moderated by ethnicity, whereas the effect of descriptive norms on behavioural intention was moderated by sex (Table 2, Model 2). Both these effects remained when also controlling for perceived susceptibility (Table 2, Model 3) and past behaviour (Table 2, Model 4). Simple slopes analyses (figures in online supplementary material 3) showed that, although significant in both white and non-white groups, the impact of injunctive norms on behavioural intention was stronger in the white ($B = 1.324$, $SE = 0.129$, $p < .001$) compared to the non-white ($B = 0.935$, $SE = 0.049$, $p < .001$) sub-sample. Simple slopes analyses (figures in online supplementary material 3) also showed that, although significant in both men and women, the impact of descriptive norms on behavioural intention was stronger in men ($B = 0.630$, $SE = 0.029$, $p < .001$) compared to women ($B = 0.554$, $SE = 0.069$, $p < .001$). Third and fourth, the impact of perceived susceptibility on behavioural intention was moderated by both sex and ethnicity (Table 2, Model 3), although the latter effect became non-significant when also controlling for past behaviour (Table 2, Model 4). Simple slopes analyses (figures in online supplementary material 3) showed that, although significant in both men and women, the effect of perceived susceptibility on intention was stronger in men ($B = 0.353$, $SE = 0.024$, $p < .001$) compared to women ($B = 0.293$, $SE = 0.050$, $p < .001$). Simple slopes analyses (figures in online supplemental materials 3) also showed that, although significant in both white and non-white groups, the impact of perceived susceptibility on behavioural intention was stronger in the white ($B = 0.561$, $SE = 0.023$, $p < .001$) compared to the non-white ($B = 0.354$, $SE = 0.023$, $p < .001$) sub-sample.

6.3. Socio-structural variables as moderators of predictors of behaviours

Table 3 shows that there were three significant ($p < .05$) cross-level interactions for predictions of behaviour. First, the effect of behavioural intention on behaviour was significantly moderated by IMD (Table 3, Model 2), an effect that remained when also controlling for RAA

Table 1
Means, standard deviations, intercorrelations among RAA variables, perceived susceptibility, past behaviour, and socio-structural variables (N participants = 477).

	B	BI	AA	CA	IN	DN	Cap	Aut	Sus	PB	Age	Sex	Eth	IMD
Behaviour (B)	–	.331	.159	.180	.185	.186	.342	.214	.132	.446	.079	.074	.040	.034
Behavioural Intention(BI)		–	.294	.347	.375	.364	.722	.261	.245	.482	.005	.071	-.033	.026
Affective Attitude (AA)			–	.355	.221	.210	.306	.121	.132	.222	-.010	.035	-.057	-.040
Cognitive Attitude (CA)				–	.392	.175	.308	.105	.299	.189	.002	.150	-.049	-.008
Injunctive Norms (IN)					–	.283	.331	.124	.144	.206	.049	.111	.010	.025
Descriptive Norms (DN)						–	.339	.162	.058	.228	.163	.012	.025	.057
Capability (Cap)							–	.385	.178	.458	-.007	.076	-.051	.016
Autonomy (Aut)								–	-.021	.202	.108	.060	-.010	.023
Perceived Susceptibility (Sus)					–			–		.240	-.011	.098	-.010	-.007
Past Behaviour (PB)										–	.002	.056	.003	-.010
Age											–	.018	.177	.029
Sex												–	-.012	-.021
Ethnicity (Eth)													–	.165
Index of Multiple Deprivation (IMD)														–
Mean	0.41	6.18	3.85	5.82	6.15	4.44	6.18	6.14	4.31	4.80	46.22	0.51	0.82	5.70
SD	0.49	1.62	1.98	1.48	1.32	1.45	1.48	1.47	1.72	2.33	15.20	0.50	0.38	2.71

Note. *All* $rs > .032$ $p < .05$; $rs > .041$, $p < .01$; $rs > .053$, $p < .001$; except for correlations with socio-structural variables where $rs > .089$ $p < .05$; $rs > .118$, $p < .01$; $rs > .150$, $p < .001$.

Table 2
Hierarchical multi-level regressions of behavioural intention on RAA variables, perceived susceptibility, past behaviour, socio-structural variables and Interactions (Nparticipants = 477; Nobservations = 3952).

Predictor	Model 1			Model 2			Model 3			Model 4		
	B	SE	Beta	B	SE	Beta	B	SE	Beta	B	SE	Beta
Intercept (γ_{00})	6.178	.032		6.178	.032		6.178	.032		6.178	.032	
Age (γ_{01})	0.000	.002	.000	0.000	.002	.000	0.000	.002	.000	0.000	.002	.000
Sex (γ_{02})	0.229	.064	.071***	0.244	.062	.075***	0.239	.063	.074***	0.238	.063	.073***
Ethnicity (γ_{03})	−0.127	.103	-.030	−0.083	.099	-.019	−0.084	.099	-.020	−0.085	.099	-.020
IMD (γ_{04})	0.017	.011	.028	0.016	.011	.027	0.017	.011	.028	0.016	.011	.027
Affective Attitude (γ_{10})				0.034	.010	.042***	0.033	.009	.040***	0.021	.010	.026*
Cognitive Attitude (γ_{20})				0.057	.018	.052***	0.034	.018	.031	0.024	.017	.022
Injunctive Norms (γ_{30})				0.309	.035	.250***	0.291	.034	.235***	0.284	.034	.230***
Descriptive Norms (γ_{40})				0.124	.019	.111***	0.120	.019	.107***	0.118	.019	.106***
Capability (γ_{50})				0.707	.024	.650***	0.700	.023	.644***	0.701	.023	.645***
Autonomy (γ_{60})				−0.030	.018	-.027	−0.017	.018	-.015	−0.022	.018	-.020
Perceived Susceptibility (γ_{70})							0.080	.013	.084***	0.075	.013	.079***
Past Behaviour (γ_{80})										0.035	.008	.051***
Injunctive Norms x Ethnicity (γ_{33})				0.153	.065	.124*	0.140	.065	.113*	0.142	.065	.115*
Descriptive Norms x Sex (γ_{42})				−0.094	.035	-.084**	−0.082	.034	-.073*	−0.086	.034	-.077*
Perceived Susceptibility x Sex (γ_{72})							−0.071	.024	-.074**	−0.076	.024	-.080**
Perceived Susceptibility x Ethnicity (γ_{73})							0.045	.021	.047*	0.041	.022	.043

Note. B = unstandardized coefficient; SE = standard error; Beta = standardized coefficient. Model 1, Deviance = 14,980.1; Model 2, Deviance = 11,019.2; Model 3, Deviance = 10,976.7; Model 4, Deviance = 10,955.2; *$p < .05$; **$p < .01$; ***$p < .001$.

variables (Table 3, Model 3), perceived susceptibility (Table 3, Model 4) and past behaviour (Table 3, Model 5). Simple slopes analyses showed that as IMD scores increased from low (M – 1SD) to moderate (M) to high (M + 1SD), the positive impact of behavioural intention ($B = 0.701$, $SE = 0.053$, $p < .001$; $B = 0.788$, $SE = 0.083$, $p < .001$; $B = 0.875$, $SE = 0.114$, $p < .001$ for low, moderate and high levels of IMD respectively) on behaviour increased, although it remained significant at all levels of IMD (Fig. 1, left panel). Given that lower IMD scores indicate higher levels of relative deprivation, these results show that the strength of the intention-behaviour relationship increased as levels of relative deprivation decreased. Second, the effect of autonomy on behaviour was also significantly moderated by IMD (Table 3, Model 3), an effect that remained when also controlling for perceived susceptibility (Table 3, Model 4) and past behaviour (Table 3, Model 5). Simple slopes analyses showed that as IMD scores increased from low (M – 1SD) to moderate (M) to high (M + 1SD) the positive impact of autonomy ($B = 0.210$, $SE = 0.027$, $p < .001$; $B = 0.152$, $SE = 0.049$, $p = .002$; $B = 0.093$, $SE = 0.072$, $p = .194$ for low, moderate and high levels of IMD respectively) on behaviour decreased and became non-significant at higher levels of IMD (Fig. 1, right panel). Thus, the strength of the autonomy-behaviour relationship decreased as levels of relative deprivation decreased. Third, the relationship between perceived susceptibility and behaviour was significantly moderated by ethnicity (Table 3, Model 4), an effect that remained when also controlling for past behaviour (Table 3, Model 5). Simple slopes analyses (Fig. 2) showed that the effect of perceived susceptibility on behaviour was positive but non-significant in the white sub-sample ($B = 0.102$, $SE = 0.071$, $p = .15$) and positive and significant in the non-white sub-sample ($B = 0.230$, $SE = 0.025$, $p < .001$).

7. Discussion

This study examined socio-structural differences in eight COVID-19 protection behaviours during the national lockdown in the UK in April 2020. In particular, we examined whether the relationships between health cognitions based on the Reasoned Action Approach (RAA; Fishbein and Ajzen, 2010) and behavioural intentions or behaviours differed as a function of socio-structural factors (sex, age, ethnicity, deprivation). Using a within-participant design, the study found evidence for such socio-structural moderation effects – for example, the relationships of intention and autonomy with behaviour were moderated by measures of area-level deprivation such that intention was less predictive, and autonomy more predictive, as deprivation increased. This suggests that the predictive fit of current social cognitive models of health behaviours for COVID-protection behaviours differs by socio-structural factors, which has both theoretical and practical implications as discussed below.

7.1. Moderated effects of health cognitions on behavioural intentions

We found, in particular, ethnicity and sex to moderate the effects of health cognitions on behavioural intentions. The effects of injunctive norms on behavioural intentions were moderated by ethnicity such that the effects of these norms were stronger in participants from white backgrounds. Some previous studies that observed similar effects (e.g., Nehl et al., 2009; Orr et al., 2014; Weden et al., 2006) discuss that participants from non-white, more deprived backgrounds might be exposed to less health-oriented norms and models in their surroundings, which in turn could partly account for stronger norm effects in participants from white backgrounds. Further, the effects of descriptive norms on intentions were stronger in men as compared to women. Previous systematic reviews on health behaviours (e.g., Cooke et al., 2016; McDermott et al., 2015) found no evidence of moderating effects of sex on the norms-intention relationship, although it is possible that social processes could be more salient for men if cognitive attitudes as representations of information are more prominent in women. Further moderated effects were observed for perceived susceptibility in that the effects on intentions were stronger in men compared to women, and in participants from white compared to non-white backgrounds. However, in both cases, the effects were significant in both sex and ethnicity groups, and differences in the slopes were small in magnitude.

7.2. Moderated effects of social cognitions on recommended COVID-19 protection behaviours

Most importantly, we observed interactions between socio-structural variables and RAA variables in predicting behaviour. Behavioural intentions were significantly stronger predictors of behaviour in less compared to more deprived groups. This finding replicates a number of previous studies (e.g., Conner et al., 2013; Schüz et al., 2020), including effects in meta-analytic reviews (Schüz et al., 2017) and multi-behaviour studies (Schüz et al., 2020). Together, these studies suggest some generality to this effect across different health behaviours and samples, although it is worth noting that not all studies observe such moderating effects (e.g., Vasiljevic et al., 2016). Nevertheless, this is an important finding as it suggests that interventions to promote more positive

Table 3

Hierarchical multi-level regressions of behaviour on RAA variables, perceived susceptibility, past behaviour, socio-structural variables and interactions (Nparticipants = 477; Nobservations = 3952).

Predictor	Model 1			Model 2			Model 3			Model 4			Model 5		
	B	OR	95 % CI	B	OR	95 % CI	B	OR	95 % CI	B	OR	95 % CI	B	OR	95 % CI
Intercept (γ_{00})	−0.358	0.699		−0.476	0.621		−0.399	0.671		−0.398	0.672		−0.398	0.671	
Age (γ_{01})	0.010	1.010**	1.003, 1.017	0.011	1.011**	1.004, 1.018	0.009	1.009**	1.003, 1.016	0.009	1.009**	1.003, 1.016	0.009	1.009**	1.003, 1.016
Sex (γ_{02})	0.303	1.354**	1.113, 1.646	0.346	1.414***	1.147, 1.743	0.332	1.394***	1.153, 1.686	0.333	1.396***	1.155, 1.687	0.328	1.389***	1.150, 1.677
Ethnicity (γ_{03})	0.127	1.136	0.854, 1.510	0.086	1.089	0.810, 1.465	0.095	1.099	0.845, 1.430	0.104	1.110	0.852, 1.446	0.108	1.114	0.855, 1.452
IMD (γ_{04})	0.022	1.022	0.986, 1.060	0.013	1.013	0.975, 1.053	0.016	1.016	0.981, 1.052	0.016	1.016	0.981, 1.052	0.015	1.015	0.981, 1.052
Behavioural Intention (γ_{10})				0.612	1.844***	1.726, 1.970	0.257	1.292***	1.216, 1.374	0.233	1.263***	1.187, 1.343	0.257	1.294***	1.215, 1.377
Affective Attitude (γ_{20})							0.038	1.039*	1.001, 1079	0.040	1.041*	1.002, 1.081	0.068	1.070***	1.029, 1.113
Cognitive Attitude (γ_{30})							−0.023	0.978	0.925, 1.033	−0.052	0.949	0.897, 1.005	−0.029	0.971	0.918, 1.027
Injunctive Norms (γ_{40})							−0.026	0.974	0.906, 1.048	−0.031	0.970	0.903, 1.041	−0.025	0.976	0.908, 1.048
Descriptive Norms (γ_{50})							0.146	1.157***	1.092, 1.226	0.145	1.156***	1.091, 1.226	0.152	1.164***	1.098, 1.233
Capability (γ_{60})							0.220	1.246***	1.126, 1.330	0.215	1.240***	1.163, 1.323	0.193	1.213***	1.138, 1.294
Autonomy (γ_{70})							0.085	1.089***	1.040, 1.140	0.099	1.104***	1.054, 1.157	0.108	1.114***	1.064, 1.167
Perceived Susceptibility (γ_{80})										0.126	1.135***	1.079, 1.193	0.139	1.150***	1.093, 1.209
Past Behaviour (γ_{90})													−0.097	0.907***	0.882, 0.933
Behavioural Intention x IMD (γ_{14})				0.033	1.033**	1.008, 1.059	0.029	1.030***	1.015, 1.044	0.029	1.029***	1.015, 1.043	0.028	1.029***	1.015, 1.043
Autonomy x IMD (γ_{74})							−0.020	0.980**	0.965, 0.995	−0.018	0.982*	0.968, 0.997	−0.017	0.983*	0.969, 0.998
Perceived Susceptibility x Ethnicity (γ_{84})										−0.156	0.855**	0.764, 0.957	−0.155	0.857**	0.766, 0.958

Note. B = unstandardized coefficient; OR = odds ratio; 95% CI = 95% confidence interval around OR. Model 1, -2LL = −5320.7; Model 2, -2LL = −5225.4; Model 3, -2LL = −5139.1; Model 4, -2LL = −5130.7; Model 5, -2LL = −5118.9; *$p < .05$; **$p < .01$; ***$p < .001$.

behavioural intentions may not be equally effective across all deprivation groups and could increase disparities across such groups (Lorenc et al., 2013). Acting on intentions requires substantial resources and access to opportunities, which are unequally distributed across the socioeconomic spectrum, especially if the enactment of intentions is dependent on individual resources (Adams et al., 2016).

We also found a negative interaction between autonomy and deprivation, which indicated that autonomy had a non-significant effect on the frequency of COVID-19 protection behaviours among less deprived participants, whereas more deprived participants were less likely to engage in COVID-19 protection behaviours at lower levels of autonomy. This finding suggests that an individual sense of control might reflect non-material resources such as agency (Adams et al., 2016) that enable the performance of COVID-19 protection behaviours – or on the other hand, that autonomy perceptions don't affect behaviour to a greater degree if material resources are available. In terms of interventions, this would suggest that in particular those from more disadvantaged backgrounds could profit from interventions that enable and facilitate control over COVID-19 protection behaviours, such as facilitating access to protection equipment and supportive environments (Núñez et al., 2020).

The significant interaction between perceived susceptibility and ethnicity suggests that susceptibility has stronger effects on behaviour in non-white participants. Some previous studies have reported higher levels of susceptibility perceptions for viral diseases (J. K. Kim and Crimmins, 2020), which might reflect more personal exposure and thus higher personal relevance of virus-related diseases in minority participants. People from non-white ethnic groups have been found to have higher COVID-19 mortality rates than those from a white ethnic background in England and Wales (Office for National Statistics, 2020a). Our findings may reflect such a higher relevance such that perceptions of susceptibility in non-white participants could be more salient through higher personal exposure – and thus potentially be more predictive of actual behaviour.

7.3. *Implications for theory and practice*

The findings of the current study have some relevant implications for refining theories of health behaviour. The observed moderation effects with for example stronger effects of behavioural intentions in less deprived participants suggest that current social-cognitive theories with a strong focus on volitional behaviour regulation might fit some population subgroups better than others. It has been discussed that experiencing material and social deprivation can affect the levels of available cognitive resources (Bickel et al., 2014), and that the availability of such resources in turn facilitates or hinders the enactment of cognitions ('agency'; Adams et al., 2016). Simply put, such models are less suited to explain and modify behaviours in people affected by disadvantage, and additional factors reflecting resources might need to be added to current theories.

The current findings also have particularly relevant practical implications. The moderating effects of socio-structural variables suggest intervention components that aim at increasing intentions might not benefit participants from more disadvantaged backgrounds and as such could inadvertently increase health risk differentials (intervention-generated inequalities; Lorenc et al., 2013). Here, structural interventions may be necessary to aid people from more deprived backgrounds (both geographically and minority groups) to translate intentions into behaviour, and at the same time reduce the impact of low perceived agency on behaviour (Adams et al., 2016). Moreover, interventions that provide different options for participants might be useful to increase perceptions of autonomy in participants with lower access to resources – in particular if these options are targeted at alleviating structural disadvantages. Thus, interventions that promote autonomy (e.g., through enabling individuals to have choices relating to behaviour change; Deci and Ryan, 2000) may particularly benefit those

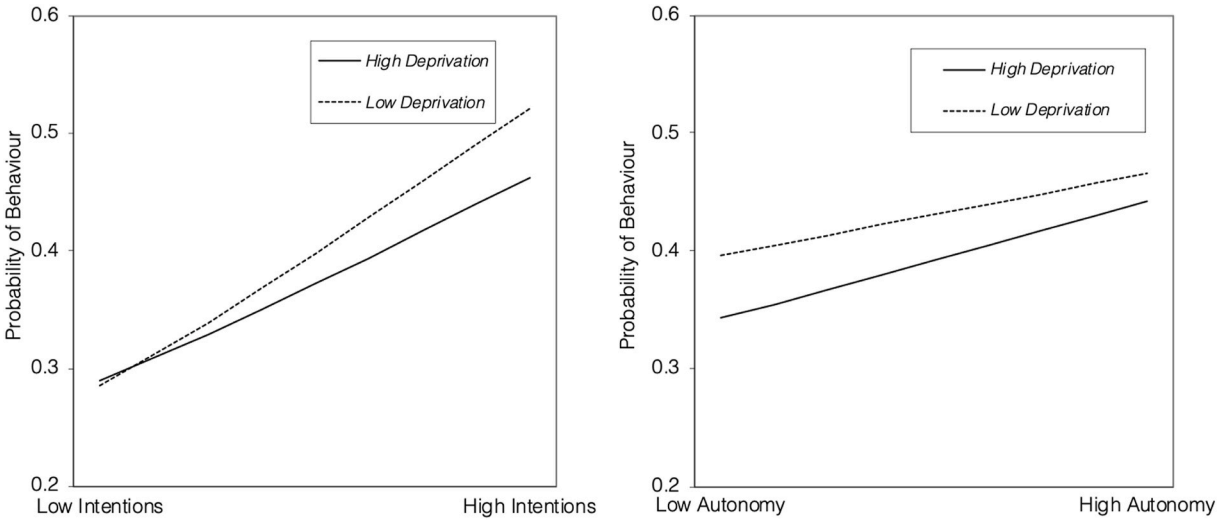

Fig. 1. Interactions between intentions plus autonomy and index of multiple deprivation in predicting COVID-19 protection behaviours.

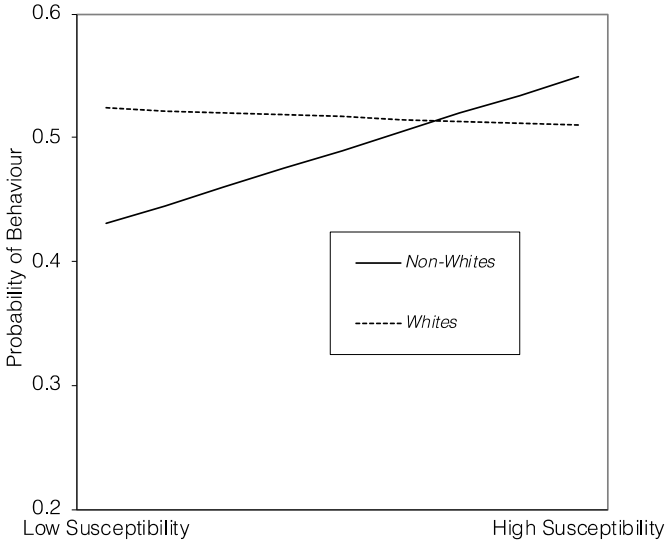

Fig. 2. Interaction between perceived susceptibility and ethnicity in predicting COVID-19 protection behaviours.

from more deprived backgrounds and therefore help to reduce health inequalities.

7.4. Strengths and limitations

The study benefitted from using of a prospective design, a large sample that was broadly representative sample of UK adults, and an examination of multiple behaviours which permitted within-person analyses that focus on effects within individuals across behaviours in a way that is more consistent with descriptions of the TPB/RAA as a model of individual decision making. Limitations include the use of self-report measures of behaviour that are open to socially desirable responding, a short follow-up period (one week), and a sample that only allowed us to examine effects of white versus non-white sub-groups rather than distinguishing specific ethnic groups. Further, applying separate moderated hierarchical regression models for the prediction of intentions and then behaviour did not provide a test of the RAA as a whole. However, this strategy provides evidence on moderation effects on two end points (intentions and behaviour) separately, as outlined in the study aims. In addition, compared to within-person longitudinal analyses (e.g., Inauen et al., 2016), we were unable to test non-linear effects over time as only two time points were assessed. Finally, as the study was conducted in the UK at an early time point in the pandemic, future research should explore if similar moderator effects are evident in other countries and whether, and how, the relationships between health cognitions, socio-structural factors, and COVID-19 protection behaviours have changed over the course of the COVID-19 pandemic.

8. Conclusions

This study systematically explored whether the relationships between health cognitions and multiple COVID-19 protection behaviours vary by socio-structural factors. It was notable that there were relatively few significant moderation effects observed. However, consistent with several previous studies, the impact of behavioural intentions on behaviour was moderated by measures of deprivation with weaker relationships being observed in more deprived groups. Autonomy further buffered deprivation-related differences in behaviour, as the effects were stronger in more deprived groups. Our findings suggest that strategies to increase individual adherence to COVID-19 protection behaviours, currently the most effective means to curb the spread of the SARS-CoV2 pandemic apart from complete lockdowns, must consider these socio-structural differences in order to reach into all segments of the population as required in order to tackle a global pandemic.

Credit author statement

Mark Conner and Paul Norman conceptualised the study and with Sarah Wilding helped collect the data. Andrew Prestwich and Rana Alhawtan contributed to developing the measures. Benjamin Schüz wrote the first draft of the manuscript. Mark Conner carried out the analyses. All authors contributed to writing and revising the manuscript. None of the authors have any conflict of interests regarding this manuscript.

Ethical statement

Ethical approval was obtained for the reported study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2021.114261.

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