Title: Perceived extrinsic mortality risk and reported effort in looking after health: Testing a behavioural ecological prediction

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Abstract:

Socioeconomic gradients in health behaviour are pervasive and well documented. Yet, there is little consensus on their causes. Behavioural ecological theory predicts that, if people of lower socioeconomic position (SEP) perceive greater personal extrinsic mortality risk than those of higher SEP, they should disinvest in their future health. We surveyed North American adults for reported effort in looking after health, perceived extrinsic and intrinsic mortality risks, and measures of SEP. We examined the relationships between these variables and found that lower subjective SEP predicted lower reported health effort. Lower subjective SEP was also associated with higher perceived extrinsic mortality risk, which in turn predicted lower reported health effort. The effect of subjective SEP on reported health effort was completely mediated by perceived extrinsic mortality risk. Our findings indicate that perceived extrinsic mortality risk may be a key factor underlying SEP gradients in motivation to invest in future health.

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Introduction

Socioeconomic gradients in health outcomes are pervasive and well documented (Adler & Ostrove, 1999; Melchior, Choquet, Le Strat, Hassler, & Gorwood, 2011); people of lower SEP have shorter life expectancies and shorter healthy life expectancies than those of higher SEP (Crimmins & Saito, 2001; Liao, McGee, Kaufman, Cao, & Cooper, 1999; Phelan, Link, & Tehranifar, 2010; Wilkinson, 1992). Evidence suggests that socioeconomic differences in health behaviour account for up to half of the socioeconomic health gradient (Mokdad, Marks, Stroup, & Gerberding, 2004; Stringhini et al., 2010). People of lower SEP are more likely to smoke or to drink excessively than those of higher SEP (Harrell, Bangdiwala, Deng, Webb, & Bradley, 1998; Pridemore, Tomkins, Eckhardt, Kiryanov, & Saburova, 2010), and are less likely to take part in regular physical activity (McLaren, 2007; Wardle, Waller, & Jarvis, 2002). They are also less likely to adhere to treatment programmes, even when there is no financial cost to doing so (Barr, Somers, Speizer, & Camargo, 2002; Goldman & Smith, 2002). The reasons for this SEP gradient in health behaviours have become an enduring point of debate across a range of disciplines including epidemiology, public health, health psychology, sociology and behavioural economics (Pampel, Krueger, & Denney, 2010).

Many nuanced explanations for SEP gradients in health behaviour have been put forward, but there is currently little consensus across disciplines regarding their causes (Cutler & Lleras-Muney, 2010; Pampel et al., 2010; Pepper & Nettle, 2013a). Some explanations are based on the idea that people of lower

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SEP face constraints which people of higher SEP do not. These explanations posit that a lack of resources (a fundamental component of SEP), or a lack of specific health knowledge (potentially related to the education component of SEP) constrain people's ability to protect their health. The first constraint-based explanation, that people of lower SEP lack the resources to "purchase" health (Darmon & Drewnowski, 2008), cannot be a considered a complete one, because it does not apply to some of the most common health-damaging behaviours. Smoking, poor diet, physical inactivity and alcohol consumption are major behavioural causes of mortality. Indeed, they were reported to have been the leading causes of death in the United States in the year 2000 (Mokdad et al., 2004). For at least two out of these four behaviours (smoking and alcohol consumption), the unhealthy option (consumption) is more financially costly than the healthy one (abstinence). Thus, the people who can least afford to spend money are spending money on behaviours that damage their health.

The second constraint-based explanation is that the socioeconomic gradient in health behaviour is the result of socioeconomic differences in specific health knowledge (e.g. Siahpush, McNeill, Hammond, & Fong, 2006). However, providing specific health information does not change behaviour equally among high and low SEP individuals. For example, in the UK between 2003 and 2008 there was extensive Government investment in public health information campaigns. Buck & Frosini (2012) examined how four behaviours (smoking, excessive alcohol use, poor diet, and low levels of physical activity) changed during this time. They found that high SEP individuals dramatically reduced their

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levels of unhealthy behaviour during the public health campaign period, while low SEP individuals did not. Receiving specific health information may have improved behaviour in individuals already motivated to invest in health, while failing to change behaviour in others. Other studies have found that knowledge, for example on the harms of smoking or the importance of exercise is widespread and differs minimally by SEP (Layte & Whelan, 2009; Pampel et al., 2010). This raises the possibility that there is greater incentive for higher SEP individuals to invest in protecting their health than there is for individuals of lower SEP. In support of this, evidence suggests that desire to quit and use of smoking cessation tools do not differ across social class, while quitting success does (Kotz & West, 2009). This implies that there is an SEP gradient in motivation to quit, rather than in knowledge that smoking is bad for health. We have given just a few examples here, but there is a wide range of evidence demonstrating SEP differences in response to health interventions (see White, Adams, & Heywood, 2009).

If constraint-based explanations are incomplete, then we must turn to alternatives. We have argued elsewhere that most of the explanations put forward in the non-evolutionary literature are proximate ones, potentially consilient with a single ultimate explanation, which we will now discuss (Pepper & Nettle, 2013a). This ultimate explanation does not necessarily conflict with other explanations invoking proximate mechanisms such as stress, social networks or efficacy and agency. It is simply a different level of explanation.

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In previous work, we presented a theoretical model to explain SEP gradients in health behaviour, using an adaptive framework from behavioural ecology (Nettle, 2010). Following a long tradition in evolutionary biology (Medawar, 1952; Williams, 1957), the model divided the risk of mortality into two components: an extrinsic component, which remains the same regardless of the behavioural decisions that the individual makes, and an intrinsic component, which reflects how much effort the individual invests in preventing the health risks that can be mitigated. The model assumed that health-protecting investments are costly, in the sense that the time and energy devoted to them must be taken away from other activities that individuals value. (There is a trade-off between investing in health behaviour and investing in other adaptively-relevant activities.) The results of model showed that as the *extrinsic* component of mortality risk increases, the optimal investment in protective health behaviour decreases. Under conditions of high extrinsic mortality, the value of health-protecting investments is reduced, since even if one makes them, one may well be killed by something extrinsic anyway. Thus, people facing higher extrinsic mortality risks should reduce their investment in preventative health behaviour and reallocate their investment toward other things. If people of lower SEP perceive that they face increased extrinsic mortality risk relative to people of higher SEP, then reduced investment of energy in long-term health could be an adaptively-patterned response to the perceived environment, rather than a result of constraints or mistakes.

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The model we have just described, though specific to health behaviours, is derived from life history theory. Models of the evolution of life histories predict that adaptively-relevant behaviours such as reproductive scheduling and parental investment should be sensitive to mortality rates (see Stearns, 1992), and this prediction is borne out by comparative evidence (e.g. Harvey & Zammuto, 1985). An extension of this concept within human behavioural ecology is the idea that humans have evolved the capacity to ontogenetically calibrate their reproductive strategies in response to local mortality risk (e.g. Chisholm et al., 1993; Lawson & Mace, 2011; Nettle, 2011; Wilson & Daly, 1997). Indeed, empirical work has demonstrated associations between mortality rates and indicators of life history strategy (Low, Hazel, Parker, & Welch, 2008; Nettle, Coall, & Dickins, 2011; Quinlan, 2010). However, nothing has been done specifically to investigate the associations between perceived extrinsic mortality risk, and motivation to invest in health. Here we will focus on perceived extrinsic mortality risk. We do so because, although evidence suggests that people of lower SEP are generally exposed to greater risk of extrinsic mortality (e.g. Bolte, Tamburlini, & Kohlhuber, 2010; Soskolne & Mano, 2010) we do not know that they perceive this to be the case. We look for SEP differences in reported effort in looking after health and safety in general because, as discussed above, SEP differences in health behaviour may reflect SEP differences in motivation to look after health, rather than constraints in their ability to protect their health.

In this paper, we report our findings from a survey of North American adults, which included questions designed to test our hypothesis; that perceived

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extrinsic mortality risk would mediate the relationship between SEP and effort in looking after health. We collected measures of income, subjective SEP, effort made in looking after health, and perceived risk of mortality. Perceived risk of mortality, or its inverse, subjective life expectancy, has been widely studied before (Dunkel, Mathes, & Decker, 2010; Krupp, 2012), but we introduced a novel method to discriminate the extrinsic component of perceived mortality from the intrinsic component. Based on the evolutionary model described above, we made the following predictions:

1. Lower SEP will be associated with greater perceived extrinsic mortality risk, rather than perceived intrinsic mortality risk.

2. Greater perceived extrinsic mortality risk will be associated with lower reported effort in looking after health.

3. The relationship between SEP and reported effort in looking after health will be mediated by perceived extrinsic mortality risk.

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Methods

Data collection

The study was approved by the Newcastle University Faculty of Medical Sciences Ethics Committee. 600 North American volunteers were surveyed anonymously online using the SocialSci survey platform [www.socialsci.com]. Respondents had previously signed up to take part in surveys via this platform. SocialSci recruit using a distributed online advertising network, print media and live recruitment. They award Amazon (www.amazon.com) credit to respondents for taking part in their surveys. Respondents completed an electronic consent form before proceeding. They were then asked for basic demographic information: age, gender and gross annual income. Following this, we collected measures of reported effort spent looking after health, perceived risk of mortality and subjective SEP respectively.

Measures of SEP

We measured SEP in two different ways. First, we asked respondents to enter their gross annual income in US$ into a free-text box. This measure was taken at the beginning of the survey along with age and gender. A free-text box was used to avoid unintentional priming effects that could be elicited by using income brackets (Haisley, Mostafa, & Loewenstein, 2008). Income was square-root transformed for analysis. Respondents were also asked to complete a subjective measure of SEP taken from prior studies (Griskevicius, Tybur, Delton, & Robertson, 2011). This was done at the end of the survey, to avoid priming

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effects. They were asked to rate their agreement on a scale from one (strongly disagree) to seven (strongly agree) with the statements: a) “I don’t worry too much about paying my bills”; b) “I have enough money to buy things I want”, and; c) “I don’t think I’ll have to worry about money too much in the future.” The three responses correlated well with one another (r=0.56-0.68, p<0.01) and hence we summed them to give an overall subjective SEP score. The income and subjective SEP measures were correlated with one another (r=0.30, p<0.01), but not so highly as to treat them as equivalent. Income and subjective SEP were therefore entered separately into all our analyses.

Reported effort in looking after health

As a measure of motivation to invest in health, respondents were asked to indicate their answer to the following on a scale, “How much effort do you make to look after your health and ensure your safety these days? 0 is ‘no effort at all’ and 100 is ‘the maximum effort you could make’.” This question was asked before the questions used to determine perceived risk of mortality. Questions about general motivation towards protecting health have been found to be predictive of a range of health behaviours (e.g. Becker, Drachman, & Kirscht, 1972; Mirotznik, Ginzler, Zagon, & Baptiste, 1998). We used a single general question about motivation because responses to multiple questions about individual health behaviours often need to be summed to show the same effect as a single more general motivation question in relation to actual behaviour (e.g. Becker, Maiman, Kirscht, Haefner, & Drachman, 1977; Mirotznik, Feldman, & Stein, 1995; Mirotznik et al., 1998).

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Perceived risk of extrinsic and intrinsic mortality

We created two novel survey items to separate out the extrinsic and intrinsic components of perceived mortality risk. We asked, "If you made the maximum effort you could make to look after your health and ensure your safety, what do you think the chances would be that you would live to be 75 or more? 0 is 'no chance' and 100 is 'definitely'." The extrinsic component of subjective mortality risk (henceforth *perceived extrinsic mortality risk*) is 100 minus this response. It is the portion of perceived mortality risk that the individual believes they cannot reduce via health effort. We then asked respondents, "If you made no effort at all to look after your health and ensure your safety, what do you think the chances would be that you would live to be 75 or more? Again, 0 is 'no chance' and 100 is 'definitely'." Our *perceived intrinsic mortality risk* variable was the difference between the preceding question and this one. That is, it is the portion of overall perceived mortality risk which the respondent believes they are able to reduce via health effort. The relationship between our original measures and these variables is illustrated in **Error! Reference source not found.**1. We have also illustrated the predicted relationship between perceived mortality risks and subjective SEP in Figure 2a.

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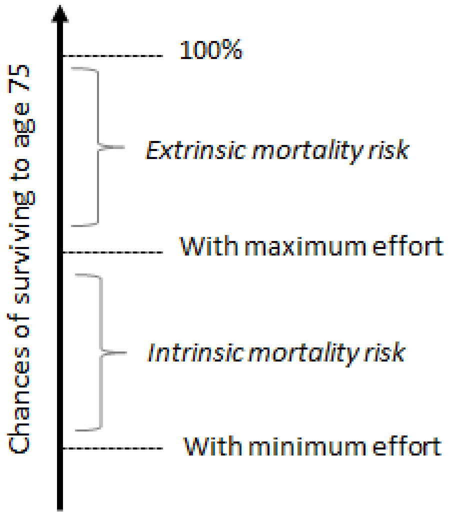

Fig 1. Schematic of our measures of perceived extrinsic and intrinsic mortality risk. The perceived extrinsic risk is the difference between 100% and the perceived chances of surviving to age 75 with maximum effort in looking after health. It is the portion of perceived mortality risk that the individual believes they cannot reduce via health effort. The perceived intrinsic risk is the difference between the perceived chances of living to 75 with maximum effort in looking after health, and with minimum effort in looking after health. It is the portion of perceived mortality risk which the individual believes they can reduce via health effort.

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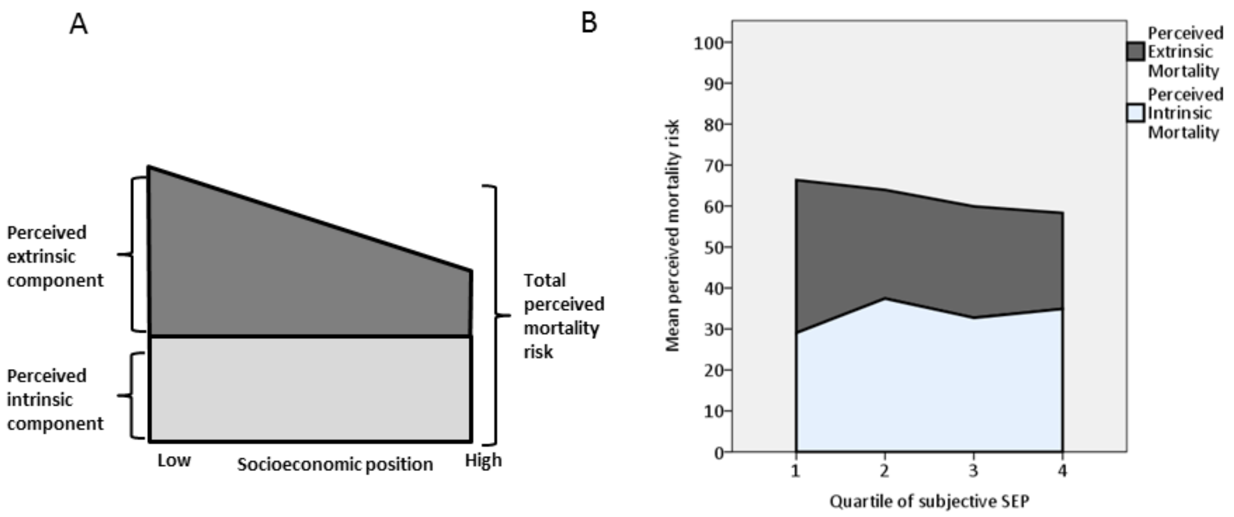

Fig 2. A: Predicted relationship between SEP and perceived mortality risk (arbitrary units). We predicted that it would be the perceived extrinsic mortality risk rather than the perceived intrinsic mortality risk that would show a social gradient. B: A plot of the observed relationship between our subjective SEP measure and perceived mortality with subjective SEP split into quartiles.

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Analysis

We excluded 138 respondents who were under the age of 21, as measures of income and subjective SEP are likely to be unstable in participants younger than this age. We also excluded 22 individuals who spent less than 2 minutes completing the survey, the minimum possible time to engage with the questions established by piloting; 1 individual whose reported income was more than 10 standard deviations above the mean, and 1 individual whose sex was missing. This left a final sample of 438 respondents. We give details of the effect of these exclusions in the results section. We tested our three predictions using General Linear Models (GLM) in SPSS version 19.0, with age and sex as control variables in all cases. For prediction 3, we tested the statistical significance of mediation with a Sobel test (Preacher & Hayes, 2004).

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Results

The raw data are downloadable as an online supplement to this paper. Of the 438 respondents included in the analysis, 184 were male and 254 were female. Ages ranged from 21-72 years (mean 30.11 years, s.d. 9.65). Reported personal annual incomes ranged from $0 to $250,000 (untransformed mean $39,307, s.d. $38,888). Subjective SEP ranged from the minimum possible score of 3 to the maximum possible score of 21 (mean 11.11, s.d. 4.90).

Prediction 1: Lower SEP will be associated with greater perceived extrinsic mortality risk, rather than perceived intrinsic mortality risk.

We ran a multivariate GLM with perceived extrinsic and intrinsic mortality risk as the outcome variables, and income, subjective SEP, age and sex as the predictors. Subjective SEP was negatively associated with perceived extrinsic mortality ($F_{1,433} = 6.97$, $p < 0.01$). That is, higher subjective SEP was associated with lower perceived extrinsic mortality (B = -0.83, s.e.[B] = 0.31). Income was not associated with perceived extrinsic mortality risk ($F_{1,433} = 1.34$, $p = 0.25$). Neither subjective SEP ($F_{1,433} = 0.86$, $p = 0.36$) nor income ($F_{1,433} = 0.18$, $p = 0.67$) were significantly associated with perceived intrinsic mortality risk. (See table 1 for full model results). Thus, for subjective SEP but not for income, our results conformed to the pattern predicted we predicted (see figure 2b).

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Table 1. Results of a GLM predicting perceived extrinsic mortality risk (top) and perceived intrinsic mortality risk (bottom) from age, income, subjective SEP and sex.

	Outcome	B	Standard error [B]	F ratio	p	Lower Bound (95% CI)	Upper Bound (95% CI)	Effect size
Age	**Perceived extrinsic mortality**	0.23	0.17	1.96	0.162	-0.09	0.56	0.005
Income		-0.02	0.02	1.34	0.248	-0.05	0.01	0.003
Subjective SEP		-0.83	0.31	6.97	0.009*	-1.45	-0.21	0.016
Sex		-2.01	2.95	0.46	0.497	-7.81	3.79	0.001
Age	**Perceived intrinsic mortality**	-0.31	0.15	4.02	0.046*	-0.61	-0.01	0.009
Income		0.01	0.02	0.18	0.670	-0.02	0.04	0.000
Subjective SEP		0.27	0.29	0.86	0.355	-0.30	0.84	0.002
Sex		2.49	2.72	0.84	0.361	-2.86	7.84	0.002

df = 1, error = 433, p = significance (*p < 0.05), reference category for sex is female, effect size = η_p

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Prediction 2: Greater perceived extrinsic mortality risk will be associated with lower reported effort in looking after health.

In a GLM with reported effort looking after health as the outcome variable and perceived extrinsic and intrinsic mortality risk along with age and sex as the predictors, both perceived extrinsic ($F_{1,433}$ = 244.13, p < 0.01) and perceived intrinsic mortality risk ($F_{1, 433}$ = 5.42, p = 0.20) were significantly associated with reported effort looking after health. Both associations were negative, with higher perceived mortality risk associated with lower reported effort (extrinsic: B = -0.64, s.e.[B] = 0.04; intrinsic: B = -0.10, s.e.[B] = 0.04). However, the association of reported health effort with perceived extrinsic mortality risk was much stronger than that with perceived intrinsic mortality risk. Perceived extrinsic mortality risk explained a substantial fraction of the variation not accounted for by other variables (η_p^2 = 0.362), and perceived intrinsic mortality risk explained very little of the variation not accounted for by other variables (η_p^2 = 0.012). (See table 2 for full model results).

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Table 2. Results of a GLM predicting reported health effort from subjective SEP, income, perceived extrinsic mortality risk, perceived intrinsic mortality risk, age and sex.

	B	Standard error [B]	F ratio	p	Lower Bound (95% CI)	Upper Bound (95% CI)	Effect size
Subjective SEP	0.05	0.21	0.06	0.803	-0.37	0.47	0.000
Income	-0.00	0.01	0.09	0.769	-0.03	0.02	0.000
Perceived Extrinsic Mortality	-0.64	0.04	244.13	0.000*	-0.72	-0.56	0.362
Perceived Intrinsic Mortality	-0.10	0.04	5.42	0.020*	-0.19	-0.02	0.012
Age	0.09	0.11	0.69	0.407	-0.13	0.32	0.002
Sex	-3.49	1.99	3.08	0.080	-7.40	0.42	0.007

df = 1, error = 433, p = significance (*p<0.05), reference category for sex is female, effect size = η_p^2

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Prediction 3: The relationship between SEP and reported effort in looking after health will be mediated by perceived extrinsic mortality risk.

To test prediction 3, we followed the steps laid out by Baron and Kenny (Baron & Kenny, 1986) for detecting mediation effects. We could not test for mediation of the association between income and reported health effort, because the former was not a predictor of the latter. However, subjective SEP was a significant predictor of reported effort in looking after health, with age, sex and income controlled ($F_{1,433} = 3.94$, $p = 0.048$, $B = 0.56$, s.e.[B] = 0.28, see table 3 for full model results). We had already established that subjective SEP was a predictor of extrinsic mortality perception (see Prediction 1 above). To test for mediation, we added perceived extrinsic mortality to the GLM predicting reported effort in looking after health from age, sex, subjective SEP and income (note that this is simply the model in table 2). We found that the relationship between subjective SEP and health behaviour was no longer significant ($F_{1,433} = 0.06$, $p = 0.803$), because perceived extrinsic mortality ($F_{1,433} = 244.13$, $p < 0.01$) explained the variation that was explained by SEP in Model 1 (see table 4). This suggests complete mediation (Baron & Kenny, 1986), a conclusion supported by a significant Sobel test ($z = 2.65$, $p < 0.01$).

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Table 3. Reports of a GLM predicting reported effort in looking after health from subjective SEP, income, age and sex.

	B	Standard Error [B]	F ratio	p	Lower Bound (95% CI)	Upper Bound (95% CI)	Effect size
Subjective SEP	0.56	0.28	3.94	0.048*	0.01	1.11	0.009
Income	0.01	0.02	0.32	0.574	-0.02	0.04	0.001
Age	-0.02	0.15	0.03	0.873	-0.32	0.27	0.000
Sex	-2.46	2.63	0.88	0.349	-7.63	2.70	0.002

df = 1, error = 433, p = significance (*p<0.05), reference category for sex is female, effect size = η_p^2

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Table 4. A summary of the models (tables 1-3) used to examine the mediation of the relationship between subjective SEP and reported effort in looking after health by perceived extrinsic mortality risk.

		B	Standard error [B]	F ratio	p	Lower Bound (95% CI)	Upper Bound (95% CI)	Effect size
Model 1	**Subjective SEP as a predictor of health effort†**	0.56	0.28	3.94	0.048*	0.01	1.11	0.009
Model 2	**Subjective SEP as a predictor of perceived extrinsic mortality†**	-0.83	0.31	6.97	0.009*	-1.45	-0.21	0.016
Model 3	**Perceived extrinsic mortality as a predictor of health effort with Subjective SEP controlled†**	-0.64	0.04	244.13	0.000*	-0.72	-0.56	0.362
	Subjective SEP as a predictor of health effort with extrinsic mortality controlled†	0.05	0.21	0.06	0.803	-0.37	0.47	0.000

	Sobel Z	Standard error	p
Mediation	2.65	0.20	0.008*

†Age, sex and income are also controlled in all models, df = 1, error = 433, p = significance (*$p < 0.05$), effect size = η_p^2

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Effects of including participants under the age of 21 on our results

In the analyses reported above, we excluded 138 respondents who were under the age of 21, because we felt that personal income would not be an accurate reflection of their actual SEP, and parental income measures are often inaccurately reported (Boyce, Torsheim, Currie, & Zambon, 2006). Indeed, the correlation of income with subjective SEP increased from r = 0.20 ($p < 0.01$) to r = 0.30 ($p < 0.01$) after these younger participants were excluded. Nonetheless, for completeness, we will also present the results of the analyses without any data excluded. They are as follows: The association between subjective SEP and reported health effort (controlling for age, sex and income) was no longer significant when participants under 21 were included ($F_{1,559} = 2.51$, $p = 0.114$, $\eta_p^2 = 0.004$). This means that we were unable to test for mediation with participants under the age of 21 included in the analysis. However, with the younger participants included, perceived extrinsic mortality (controlling for age, sex, income, subjective SEP and perceived intrinsic mortality) remained a significant predictor of reported health effort, with a large effect size ($F_{1,559} = 318.20$, $p < 0.01$, $\eta_p^2 = 0.364$). Despite the fact that we were unable to formally test for mediation, this result supports our hypothesis that perceived extrinsic mortality risk, which is often associated with SEP, is a potentially a better predictor of health effort than SEP per se.

Discussion

Our previously presented theoretical model (Nettle, 2010) led us to predict that perceptions of high extrinsic mortality risk would trigger psychological mechanisms that cause disinvestment in preventative health measures. We argued that this might explain the socioeconomic gradient in health behaviour, if people of lower SEP are, or perceive themselves to be, at greater risk of extrinsic mortality (Nettle, 2010; Pepper & Nettle, 2013a). Here, we collected survey data to test this hypothesis. We found that there was a socioeconomic gradient in perceived mortality risk, with greater perceived risk amongst those of lower subjective SEP. Separating out the extrinsic and intrinsic components of this risk showed that it was entirely the extrinsic component of perceived

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risk which increased as subjective SEP decreased, with no gradient in the intrinsic component (figure 2b). Perceived extrinsic mortality risk was strongly negatively associated with reported effort in looking after health, whereas perceived intrinsic mortality risk was only weakly associated with it (table 2). We found that our subjective measure of SEP, but not gross annual income, was positively associated with reported effort in looking after health. However, this association was completely mediated by perceived extrinsic mortality risk. This suggests that people of lower subjective SEP may be less motivated to look after their health, but only because they perceive themselves to be subject to risks of mortality which are beyond their control.

These results are consistent with previous empirical findings that people of lower SEP tend to be more fatalistic about their health outcomes and have a greater belief in the influence of chance on their health than those of higher SEP (Wardle & Steptoe, 2003). However, they also demonstrate the benefits of taking an adaptively-informed approach to understand variation in human behaviour in the sphere of health. It was our *a priori* theoretical model (Nettle, 2010), based on previous behavioural ecological literature, that suggested the potential importance of distinguishing extrinsic from intrinsic mortality, and predicted that it would be extrinsic mortality that motivated people to reduce their effort in looking after their health.

There are a number of limitations to the current study. We used an opportunity sample recruited through an existing online participant pool. It would be desirable to investigate whether the same patterns are found in population-representative samples. Our main SEP measures were income and a self-report scale. Income reporting in surveys is often inaccurate; disposable income, though more complex to assess, may be a better predictor of behaviour (Moore, Stinson, & Welniak, 2000; Winkler, Turrell, & Patterson, 2006). The subjective SEP measure which we used did capture some more fine-grained aspects of resource availability, such as disposable income and financial stability, which would not be captured simply by asking people for their gross annual income. However, this was self-report measure of SEP: Although it was simple to administer, its relationship to more objective factors such as education and occupational status has not been explored here. To address this it would be ideal for a measure of perceived extrinsic mortality risk to be included in large health surveys in which respondents' SEPs are well characterised. The socioeconomic gradient in reported health effort was only detectable in our sample with the participants under the age of 21 excluded from analysis. However, the existence of socioeconomic gradients in health behaviour is extremely well documented in previous literature, and the null association in our sample without exclusions may simply reflect the instability of self-reported income and subjective SEP in participants who are not yet financially independent. It is important to note that studies on the relationship between SEP and health behaviours, even with large samples, often find small effects, especially when they use individual health behaviours rather than composite measures (e.g. Friestad & Klepp, 2006; Halleröd & Gustafsson, 2011; Hanson & Chen, 2007). So, though associations between SEP and health behaviour are reliably uncovered in a variety of studies, effect sizes in individual studies tend to be small. Our findings suggest that this may be because there is a third variable - extrinsic mortality risk – which accounts for much of the relationship between SEP and health behaviour. In our data, the effect size for the relationship between perceived extrinsic mortality risk and reported health effort ($\eta_p^2 = 0.362$) was substantially greater than for the association between our subjective SEP measure and reported health effort ($\eta_p^2 = 0.009$). Indeed, the relationship between subjective SEP and reported health effort was entirely extinguished when perceived extrinsic mortality risk was added to the model (table 4). This may be because our measures of SEP were not comprehensive. However, it may be because SEP-related differences in perceived extrinsic mortality risk have greater power to explain differences in health effort than SEP per se. This possibility should be investigated further.

There are potential applied implications to our findings. They suggest that people of lower SEP may not make less effort to look after their health whimsically or through ignorance. Rather, they perceive that whatever they do, there is a relatively high chance that they will be killed by something that they can do nothing about, so they follow a behavioural strategy of investing more of their energies in other things. Improving our understanding of what shapes perceived extrinsic

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mortality risk, and how to alter it, could therefore increase the efficacy of public health interventions.

As discussed in the introduction, our predictions about SEP gradients in health effort were derived from life history theory. Models of the evolution of life histories predict that behaviours such as health effort, reproductive scheduling and parental investment should be sensitive to mortality risk. However, in addition to this they predict that if extrinsic mortality risk is high, we might expect a more general shift in time horizons (Hill, Jenkins, & Farmer, 2008; Kruger, Reischl, & Zimmerman, 2008; Wilson & Daly, 1997). That is, we might predict an increased tendency to prioritise immediate rewards and costs above delayed ones, because when risk of death is higher, the odds of being alive to receive future rewards are lower. There is some evidence that changes in time horizon occur in response to perceived mortality risk. People who reported having low childhood SEP, when experimentally exposed to mortality primes have been found to discount the future more steeply than those who were exposed to control primes (Griskevicius et al., 2011). People who reported suffering a greater number of recent close bereavements have been found to discount the future more steeply than those who had suffered fewer (Pepper & Nettle, 2013b). Exposure to violence has been found to be associated with future discounting (Ramos, Victor, Seidl-de-Moura, & Daly, 2013) and earthquake survivors have been found to discount future rewards more steeply than controls (Li et al., 2012). This is important to note, because there is a large body of literature linking time perspective and related concepts, such as delay discounting and impulsivity, to health behaviour (Adams, 2009; Adams & Nettle, 2009; Beenstock, Adams, & White, 2011; White et al., 2009). It is plausible that perceived extrinsic mortality risk affects both time horizons and motivation towards health effort, thus accounting for the associations found between them. However, to our knowledge, there have been no direct tests of the impact of extrinsic mortality cues on health behaviours. It is important that such tests be developed.

The research presented here focused on perceived extrinsic mortality risk. However, relatively little is known about the environmental cues that produce these perceptions. Cues might include exposure to violent crime, or knowing people who have died due to circumstances beyond their control. Indeed, evidence suggests that fear of crime and experiences of bereavement are associated with poor health (Chandola, 2001; Stafford, Chandola, & Marmot, 2007; Stroebe, Schut, & Stroebe, 2007). It would be useful to understand to what extent such cues contribute to a person's perceived extrinsic mortality risk and whether qualitative differences between cues are important. It would also be useful to know how accurate people's perceptions of mortality risk are. Some epidemiological evidence that suggests that actual as well as perceived extrinsic mortality risk is higher in low-SEP communities (Bolte et al., 2010; Soskolne & Mano, 2010). However, although there may be a veridical basis to these perceptions, they may be inflated by media scare stories or by exaggerated accounts from peers. If this is the case, then something as simple as correcting people's perceptions may be enough to improve their health behaviours. However, this is not to understate the fundamental importance of public action to tackle the sources of extrinsic mortality that differentially affect those of lower SEP. Making low-SEP neighbourhoods and work places safer would not only have the primary benefit of reducing extrinsic mortality, but it could also produce a secondary benefit of improved health behaviours. This would have the overall effect of reducing socioeconomic inequalities in health.

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Supplementary data. The supplementary .xls file contains the raw data in Microsoft Excel format.

The first tab of the .xls file contains descriptions of each variable and further read me information.

Conflict of interest: The authors declare that they have no conflict of interest.

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