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Socioeconomic status moderates the effects of health cognitions on health behaviors within participants: Two multi-behavior studies

Benjamin Schüz, PhD[1,2]*

Cameron Brick, PhD[3]

Sarah Wilding, PhD[4]

Mark Conner, PhD[4]

[1]University of Bremen, Institute for Public Health and Nursing, Bremen, Germany

[2]University of Tasmania, School of Medicine, Hobart, Australia

[3]Winton Centre for Risk and Evidence Communication, University of Cambridge, Wilberforce Road, Cambridge CB3 0WB, UK

[4]University of Leeds, Leeds, UK, School of Psychology

*Corresponding author:

Prof Dr Benjamin Schüz

University of Bremen, FB 11

Institute of Public Health and Nursing

Grazer Str. 2

28359 Bremen, Germany

P +49 421 218 68833

E benjamin.schuez@uni-bremen.de

Abstract

Background: Socioeconomic differences in health-related behaviors are a major cause of health inequalities. However, the mechanisms (mediation / moderation) by which socioeconomic status (SES) affects health behavior are a topic of ongoing debate.

Purpose: Current research on SES as moderator of the health cognitions - health behavior relation is inconsistent. Previous studies are limited by diverse operationalizations of SES and health behaviors, demographically narrow samples, and between-person designs addressing within-person processes. This paper presents two studies addressing these shortcomings in a within-person multi-behavior framework using hierarchical linear models.

Methods: Two online studies, one cross-sectional and one 4-week longitudinal, assessed 1,005 (Study 1; Amazon MTurk; US only) and 1,273 participants (Study 2; Prolific; international). Self-reports of multiple SES indicators (education, income, occupation status; ZIP code in Study 1), health cognitions (from the Theory of Planned Behavior) and measures of 6 health behaviors were taken. Multilevel models with cross-level interactions tested wither the within-person relationships between health cognitions and behaviors differed by between-person SES .

Results: Education significantly moderated intention-behavior and attitude-behavior relationships in both studies, with more educated individuals showing stronger positive relationships. In addition, ZIP-level SES (Study 1) moderated attitude-behavior effects such that these relationships were stronger in participants living in areas with higher SES.

Conclusions: Education appears to be an important resource for the translation of intentions and attitudes into behavior. Other SES indicators showed less consistent effects. This has implications for interventions aiming at increasing intentions to change health behaviors, as some interventions might inadvertently increase health inequalities.

Key words: Lifestyle; health behavior; SES; attitudes; education; theory of planned behavior

Socioeconomic status moderates the effects of health cognitions on health behaviors within participants: Two multi-behavior studies

Health-related behaviors are widely recognized as key modifiable risk factors for the leading causes of death in industrialized countries (1). Both individual socioeconomic status (SES) (2) and health cognitions (3) have received considerable attention as determinants of the type and frequency of individual health behaviors. However, less attention has been given to the relationship between the three and whether the relation between health cognitions and health behavior varies as a function of SES (4).

Existing studies report mixed evidence (5, 6) and suffer from limitations such as varying SES measures, selective health cognitions (mainly intentions and perceived control/self-efficacy), relatively homogeneous samples, and between-person research designs which are limited for examining within-person processes such as health behavior self-regulation (7,8). Thus, this study applies a multi-behavior within-person research paradigm that tests SES effects on within-person associations between health cognitions and health behaviors.

SES represents the social standing of an individual or group in the social hierarchy (9, 10). Lower SES is consistently associated with increased morbidity and mortality rates compared to higher SES (at least in industrialized countries, e.g., 11, 12). These morbidity and mortality differences are at least partially due to differences in behaviors (1). Health risk behaviors such as smoking (13) and alcohol abuse (14) are more prevalent in lower compared to higher SES groups, whereas health protective behaviors such as physical activity (15) and healthy eating (16) are less prevalent (17). This suggests SES effects on health are most likely due to differences in multiple rather than single behaviors (18).

In disentangling SES effects on health behaviors, it is important to acknowledge that

there are different facets of SES which may impact health and health behavior via different pathways. Failing to differentiate SES facets or using them interchangeably is likely to disguise the more specific health impacts of different facets of SES (19). Often, measures of SES are broadly split into area-level and individual-level data (20). Area-level measures describe multiple facets of SES such as local housing quality and income, e.g., the UK index of multiple deprivation (21). Indicators of individual SES include income, education, and subjective SES (20, 22). The pathways via which these facets affect behavior are likely to differ: area-level SES indicators might affect individual behavior, for example by providing environmental resources and constraints as well as social norms about behavior (4). On the other hand, individual indicators are more likely to tap personal resources. For instance, more disposable income will facilitate access to healthier food or time for physical activity, perceived standing within society or peer group (subjective SES) might provide better access to social resources and social support for health-related behaviors, and higher educational attainment could facilitate information processing and acquiring of further resources for health.

The degree to which SES interacts with health cognitions in determining health behaviors however is less clear and underspecified (4). Most health behavior theories position health cognitions as proximal and readily modifiable determinants of behavior, compared to SES as a more distal and fixed factor. Prototypical for this approach is the Theory of Planned Behavior (TPB; 25), which combines intentions, attitudes, subjective norms, and self-efficacy/perceived behavioral control (PBC). The TPB assumes that the effects of distal factors such as SES on behavior are mediated by the health cognitions in the model, and a number of studies support this notion (24, 26). However, SES could also moderate the impact of health cognitions on behavior. Previous studies reported more healthy eating intentions and behavior in higher SES groups (e.g., 27, 28), but only a few studies formally tested

whether the impact of health cognitions on health behaviors varies as a function of SES, and the findings are heterogeneous (5, 6, 24, 29-33). While some studies (5, 29-33) found that indicators of SES moderated the relationships between health cognitions and health behaviors such that these relationships are stronger in individuals with higher SES, others (6, 24) find no such effects. This heterogeneous picture could also be due to the fact that the between-person research paradigms used in previous studies are less suitable to examine individual processes (7,8) and potentially confound SES with health cognitions: Essentially, such designs examine rank congruences, e.g., whether the persons with the highest cognitions are also those with the highest levels of behavior and the highest level of SES. Therefore, potential interactions between SES and health cognitions in predicting behavior could be a function of congruent ranks, rather than testing whether the strength and direction of relationships between health cognitions and behavior vary as a function of SES. The present research applies a within-person perspective that examines the relationship between multiple health cognitions and health behaviors within persons, and then tests whether these relationships vary between individuals as a function of SES. In principle, this is similar to analyses that repeatedly assess within-participant couplings of cognitions and behavior across time (e.g., 38), but we extend this to couplings across behaviors within participants. This allows the modeling of within-participant processes to explain differences in these processes with variations between the SES indicators.

The aims of the present research therefore are to provide a more comprehensive test of whether individual and subjective measures of SES moderate the relationship between health cognitions and health behaviors. In doing so, we extend previous research in four important ways. First, we test the moderating impact of individual (income, education, occupational prestige), subjective (social standing in relation to overall society), and area-based (% unemployment in participant ZIP code area) measures of SES. This is the first test

of a comprehensive set of SES indicators as moderators of health cognition-behavior associations. Second, we test moderation effects for four key health cognitions on behavior: intention, self-efficacy/PBC, attitudes, and subjective norms, which extends previous studies that have mainly focused on intentions and self-efficacy/PBC. The TPB assumption of intentions mediating the effects of attitudes and subjective norm on behaviour might be too optimistic, with recent reviews suggesting residual direct effects of norms and attitudes (34). Therefore, we examine the full set of social-cognitive predictors outlined in the TPB. Third, we test SES moderator effects of within-participant relationships of health cognitions and behaviors. This nested approach avoids confounding of single-behavior analyses by sample characteristics (35-37), as essentially a regression model is estimated for every participant, and between-participant differences in parameters of these within-person regressions (intercepts of health behaviors and slopes of health cognitions in predicting behaviors) are explained by between-participant SES. Fourth, we test these models in two large online samples based in the USA (Amazon MTurk; Study 1) and internationally (Prolific; Study 2). This approach yields larger samples with a broader range of SES than typical convenience sampling (e.g., 39), but these essentially remain convenience samples. Both studies are reported in accordance with the STROBE statement (40) for observational studies.

Study 1

Method

Study 1 was a cross-sectional online study using Amazon MTurk. The study received ethical approval from the University of California Santa Barbara Human Subjects Committee (ID 15-0244). Participants were recruited through MTurk and paid $1 each, which in previous research has been identified as sufficient payment to ensure high data quality (39). On entering the start page, participants read an information sheet about the study aims and procedures and then provided informed consent.

Participants

Participants were eligible for the study if they lived in the US and were aged 18 years or over. The study was set up to recruit a sample of approximately 1000, based on the assumption of small interaction effects between SES and health cognitions. In total, 1,005 participants completed the study, of which 473 (47.1%) were female. Participants were M = 33.6 (SD = 12.06) years old, with age ranging between 18 and 77.

Measures

Participants completed an online questionnaire that assessed sociodemographic measures followed by TPB constructs for six different health behaviors (eating five portions of fruit and vegetable per day; engaging in at least 30 minutes of strenuous exercise five or more times per week; consuming a low-fat diet; consuming no more than the daily recommended limit of alcohol; flossing daily; and performing testicular (males) or breast (females) self-examination). The selection of health behaviors was guided by recommendations for health and by behaviors frequently studied in the domains of behavioral medicine and public health (37).

Participants were provided with a definition of each health behavior under study on each page. For example, the instruction for drinking no more than the recommended daily limit of alcohol was specified for females and males in separate targeted information based on initial demographics: “Below you will find a list of statements relating to drinking NO more than the daily recommended limits of alcohol over the next four weeks, which for women is one bottle of beer OR one glass of wine OR two shots of liquor" (shown to females) or “Below you will find a list statements relating to drinking NO more than the daily recommended limits of alcohol over the next four weeks, which for men is: two bottles of beer OR two glasses of wine OR three shots of liquor" (shown to males). In order to reduce participant burden, single items were used for most constructs apart from attitudes, and all

items apart from behavior were answered on 7-point semantic differential scales (37).

Past behavior was assessed by a 4-week recall, for example, “In the last four weeks, I have eaten a low-fat diet.” These items were answered on a 7-point scale from never (1) to always (7). Forced-choice entry was programmed to avoid missing data. Single-item recall measures reduce participant burden but have lower reliability and validity; however, several studies suggest that single-item measures of physical activity (41), alcohol consumption (42), diet quality (43), and flossing (44) have satisfactory validity when compared with objective or more comprehensive assessments of health behavior.

Intention was measured by one item per behavior, for example “I intend to floss my teeth over the next four weeks”; 1 (strongly disagree) – 7 (strongly agree). Subjective norm was measured as an injunctive norm using one item per behavior, for example “Most people who are important to me think … 1 (I should not eat a low-fat diet over the next four weeks) … 7 (I should eat a low-fat diet over the next four weeks). Self-efficacy/PBC was measured with one item, for example “I have control over whether or not I engage in the recommended levels of activity”; 1 (strongly disagree) – 7 (strongly agree). Attitudes were measured by four items (Conner, McEachan, Taylor, et al., 2015), for example “Eating a low-fat diet over the next four weeks would be…” 1 (worthless) – 7 (valuable), 1 (not enjoyable) – 7 (enjoyable), 1 (harmful) – 7 (beneficial), 1 (unpleasant) – 7 (pleasant). The four attitude items per behavior were aggregated to a mean score per behavior and person, and Cronbach’s α over the six behaviors was .79.

Socioeconomic status

Income was assessed by asking participants to indicate their total household income during the last 12 months using categories from “less than $5,000” to “$200,000 or more”. These categories increased by $2,500 up to a 12-month income of $20,000 and then increased by $10,000. Categorical indicators of household income have been shown to be more reliable

and valid than open response formats (45). Education was assessed by asking participants to indicate the highest level of educational attainment they had achieved using the 10 categories (from "no schooling completed, or less than 1 year" to "Doctorate Degree (PhD, EdD, etc.)" from the US Census Current Population Survey. These categories were then converted into the categories of the International Standard Classification of Education (ISCED) (46). Area-level SES was assessed by matching the ZIP-code area unemployment level of the labor force aged 16 and over (in %) based on the 2011-2015 American Community Survey (47) to the ZIP codes provided by participants. Subjective SES was assessed using the 10-point ladder format subjective SES scale (48). In this scale, participants are asked to indicate on a 10-point ladder where in comparison to the total US population (SES ladder) they stand, following the McArthur Research Network recommendations (22).

Analyses

The analyses modeled within-person associations between health cognitions and health behaviors, and tested whether these associations varied by between-person indicators of SES. We used hierarchical linear models with HLM 7.03 software to model the within-person relationships between four TPB predictors (intention, attitude, subjective norms, perceived behavioral control) and six health behaviors (level-1; behavior level). We then used the different SES facets to test between-participant (level-2) differences in the intercepts (levels) of overall health behavior and the slopes of health cognitions predicting health behaviors (cross-level interactions; 36, 37). Put another way, we estimated the intercepts of health behaviors and the associations (slopes) between health cognitions and health behaviors for each participant, and then tested whether these intercepts and slopes varied as a function of participant- (level-2) level SES. Significant cross-level interactions in the hierarchical linear models indicate that between-participants SES affects the intercepts of health behaviors or the slopes of health cognitions in predicting health behaviors. Note that this within-

participant approach is fundamentally different to summarizing the results of multiple linear regressions of single behaviors on health cognitions, SES, and their interactions, as this would model rank congruences between participants rather than interactions of within-person processes and person-level SES. We report single-behavior regressions in Online Supplement 1 to highlight the different results between our main within-person results and a between-persons approach.

Results

Socioeconomic status

Median reported educational attainment was post-secondary non-tertiary education (ISCED level 4), with responses ranging from "pre-primary education" (0.1%) to "second stage of tertiary education" (3.1%), and participants had an average annual household income of $49,805 (SD = 36,736). Compared with 2014 data from the general US population (49), this indicates a sample with a slightly lower household income than the 2014 median of $51,939, and somewhat higher educational attainment than the 2014 US median ("High school graduate"). The average unemployment rate in the ZIP code areas was 8.12% (SD = 3.74), ranging from 0% to 33.19%. This is roughly comparable to the average unemployment rate (8.3%) of the labor force aged 16 and over projected in the 2011-2015 American Community Survey 5-year estimates. Correlations between the different SES facets were moderate to low (Table 1), suggesting some overlap of the different SES facets.

Random-Effects Models for Health Behaviors

The intraclass correlation coefficient as an indicator of the degree of within-participant variation compared to between-participant variation was above.10, which has been suggested as medium clustering effect (50) for all variables in the model (intention ρ = .10, norms ρ = .25, PBC ρ = .29, attitudes ρ = .19, past behavior ρ = .10). In subsequent multilevel analyses, intention, PBC, attitudes and subjective norms emerged as significant

independent predictors of past behaviors (Table 2). The within-participant effects indicate that higher intentions, self-efficacy/PBC, positive attitudes and subjective norm were associated with higher past health protective and lower past health risk behaviors. On the between-participant level, we examined whether differences in the SES facets could account for differences in the within-participants intercepts of behavior and the within-participant slopes of subjective norm, PBC and intentions in predicting behaviors (Table 2). We found that area-level unemployment had a significant cross-level interaction with the intercepts of behaviors such that health behaviors were less frequent in individuals living in postcode areas with higher unemployment.

We also found significant cross-level interactions between SES facets and the slopes of TPB variables in predicting past behavior (Table 2; Figure 1). The within-participant effects of attitudes increased from 0.84 ($p < .001$) in participants with education below high-school to 0.98 ($p < .001$) in those with at least high school education. Similarly, the effects of intention on past behavior increased from 0.70 ($p < .001$) in those with less than high school to .79 ($p < .001$) in those with at least a high school education. Significant cross-level interactions were also found for area-level unemployment: Simple slopes analyses suggest that the effects of attitude on past behavior increase from 0.90 ($p < .001$) in areas with unemployment 1 SD above the mean to 1.01 ($p < .001$) in areas with unemployment 1 SD below the mean.

The significant residual variance in intercepts and the slopes of intention and subjective norm indicates that after considering SES indicators, there remain significant differences between participants in the intercepts of past behavior and in the effects of intention and subjective norm on behavior within participants.

Discussion

Study 1 revealed that some of the differences in within-person associations between

Theory of Planned Behavior (TPB) variables and behavior were explained by socioeconomic status (SES), such that the associations between intentions and behavior were stronger in individuals with higher educational attainment. SES did not predict differences in the within-participant associations of self-efficacy/PBC and behavior. This finding is in line with TPB assumptions given that the control beliefs underlying PBC are assumed to reflect both external (such as SES) and subjective control factors. Study 1 further found that differences in the within-person effects of attitudes on behaviors were predicted by an area-level indicator of SES (% unemployment) such that these relationships were closer in areas with less unemployment. This is consistent with previous research (33) and suggests that environmental indicators of socioeconomic differences could have unique contributions to health cognition-behavior relationships, e.g., via the provision of resources in the environment and potentially via social processes that might include modeling and other facilitation processes (4).

Study 1 had several limitations. The cross-sectional design makes assumptions about directional relationships impossible, and in particular the discrepancy between the temporal framing of health cognitions ("*in the next four weeks"*), and the assessment of past behavior could have led to biased estimates of the relationships between cognitions and behavior. The assessment of a 'low-fat diet' without clear definition could have led to highly subjective definitions of this behavior, making comparisons between people difficult. Further, the structure and relative position of educational attainment and even income differs between countries, but due to MTurk specifications, our sample was restricted to participants living in the US. Thus, a replication in a broader international context using a longitudinal design would be a valuable test for convergent evidence.

Study 2

In order to overcome the limitations of Study 1, Study 2 employed a longitudinal

design (4-week follow-up) and recruited participants via Prolific, a crowdsourcing web platform similar to Amazon MTurk based in the UK, thus potentially reaching more participants internationally.

Method

Participants

The data for Study 2 were collected as part of a larger study (51) and included other measures not reported here. The study received approval from the human research ethics boards of the University of Leeds. Participants were recruited through Prolific and paid the equivalent of $5.24 (£4.30) for completing questionnaires on two occasions separated by one month. After completing informed consent, participants were randomized to one of six different conditions that manipulated the order of questions and questions that were asked [not reported here]. All analyses controlled for the effects of question order and the measurement of other variables. The study was set up to recruit approximately 1200 participants across the six conditions. A total of 1,273 individuals completed the two questionnaires, age M = 31.57 years (SD = 11.21), and 50.5% were female.

Measures

Participants completed an online questionnaire that was very similar to the one employed in Study 1. The six health behaviors examined were guided by the availability of recommendations for health and the selection of behaviors frequently used in the domain of behavioral medicine and public health (eating fruit and vegetables, performing recommended levels of physical activity, flossing daily, not drinking over recommended levels per week, not sitting for extended periods of time, not consuming unhealthy snacks), and were accompanied with a brief definition and recommended levels based on UK guidelines to improve consistency compared to Study 1.

Intention was measured by three items per behavior, e.g., “I intend to eat 5 fruit and

vegetables per day over the next four weeks"; 1 (strongly disagree) – 7 (strongly agree) that were aggregated (the average Cronbach's α over the six behaviors was .88). Subjective norm was measured by two items per behavior, for example "Most people who are important to me think … 1 (I should not eat 5 fruit and vegetables per day over the next four weeks) … 7 (I should eat 5 fruit and vegetables per day over the next four weeks) that were aggregated (the average correlation between the two items over the six behaviors was .58). Self-efficacy/PBC was measured with two items, for example "If it were entirely up to me, I am confident that I could eat 5 fruit and vegetables per day over the next four weeks"; 1 (strongly disagree) – 7 (strongly agree) that were aggregated (average correlation between the two items over the six behaviors was .57). Attitudes were measured by four items, for example "Eating five fruit and vegetables a day over the next four weeks would be …" 1 (worthless) – 7 (valuable), 1 (not enjoyable) – 7 (enjoyable), 1 (harmful) – 7 (beneficial), 1 (unpleasant) – 7 (pleasant) (the average Cronbach's α over the six behaviors was .79).

Past behavior was assessed using a single item for each behavior, e.g., "How often do you eat five portions of fruit or vegetables per day?", 1 (never), 2 (rarely), 3 (sometimes), 4 (often), 5 (always).

Behavior was assessed after four weeks (28 days) with one question per behavior using the day recall method, e.g., "On how many days did you eat 5 portions of fruit and vegetables over the past four weeks"?

Socioeconomic status (SES)

SES was assessed as in Study 1. Due to the fact that participants were recruited internationally, no ZIP codes and accordingly no area-based SES indicator was assessed.

Analyses

Analyses were conducted analogously to those in Study 1, except that to model behavior change over time, baseline behavior was entered as a covariate in the multilevel

regression analyses. Similar to study 1, results of concurrent multiple regression analyses can be found in an online appendix (Online Supplement 2).

Results

Sociodemographic and socioeconomic status

The median educational attainment was post-secondary non-tertiary education (ISCED level 4), and the largest educational attainment group was first stage of tertiary education (completed undergraduate degree; ISCED level 5, 37.1%). Mean annual household income was equivalent to $32,652 (SD = 26,104). Table 1 shows the correlations between SES facets and health behaviors.

Random-Effects Models for Health Behaviors

The intraclass correlation coefficient for behavior in Study 2 was $\rho = .13$, suggesting substantial clustering of behaviors within individuals. Similar to Study 1, intention, attitudes, self-efficacy/PBC, and subjective norm emerged as significant predictors of follow-up behavior on the within-participant level (Table 3). Differences between participants in the within-person intercepts of behavior and the within-person associations of health cognitions and behavior were again predicted with SES indicators. Per 1,000 US$ household income increase, participants engaged in the health behaviors on .02 days more over the 4-week study period (controlling for baseline behavior). No SES facet besides income significantly predicted the intercepts of behavior.

Income also predicted between-participant differences in the within-person associations between attitudes and behavior. Simple slopes analyses show that the effect of attitude increased from 0.37 ($p = 0.01$) in those with income 1 SD below to 0.95 ($p < .001$) in those with income 1 SD above the mean. Education significantly explained differences between participants in the within-person effects of intention (increasing from 0.38; $p = .01$ in those with less than high school to 0.66; $p < .001$ in those with at least high school),

attitude (increasing from 0.05; n.s. to 0.58; $p < .001$), and subjective norm (increasing from 0.20; n.s. to 0.60; $p < .001$) on behavior. Finally, subjective SES moderated the effects of intention and attitude on behavior such that the within-person effects of intention and attitude on behavior were larger in individuals with higher subjective SES (Table 3, Figure 2).

Similar to study 1, there was significant residual variance in the intercepts of behavior, indicating between-participant differences in health behavior.

Discussion

The longitudinal findings in Study 2 are consistent with the cross-sectional findings of Study 1 in that within-person effects of attitude and intention on behavior were stronger in individuals with higher educational attainment and weaker in those with lower educational attainment. Study 2 also showed the within-person effects of social norm on behavior to be moderated by education. Study 2 also found that within-person associations between attitudes and behavior were stronger in those with higher income, and weaker in those with lower incomes. Similarly, within-person effects of intention and attitude on behavior were stronger in people with higher subjective SES and weaker in those with lower subjective SES. Study 2 corroborated the findings from Study 1 with SES effects in a longitudinal setting and an international sample. However, the measurement of past behavior (5-point scale) and behavior at follow-up (number of days) were assessed using different metrics. While this approach avoids shared method variance in behavior reports, it prohibits interpreting the residual effects as change in behaviour.

General Discussion

The present research examined whether multiple facets of SES moderated the within-person effects of social-cognitive factors on health behaviors in two large-scale studies using a hierarchical perspective on within-person associations between health cognitions and multiple health behaviors (35-37). The within-person effects of intentions, attitudes (both

studies) and subjective norm (Study 2) on behavior varied with education such that these effects were stronger in those with higher educational attainment and weaker in those with lower attainment. In addition, an area-based measure of SES (Study 1) as well as income and subjective SES (Study 2) moderated within-person attitude and intention effects on behavior. This approach overcomes many of the limitations of previous research on the role of SES in health cognition-health behavior relations in i) applying a range of SES indicators, ii) testing the full set of reasoned action predictors of behavior, iii) recruiting two large samples with variation in SES, and iv) applying a within-person perspective on SES in the self-regulation of health, which disentangles the confounding of health cognitions and SES in previous between-person research designs.

Overall, the effects of health cognitions (intention, self-efficacy/PBC, attitudes, subjective norm) on behavior are consistent with previous research in health behaviors (52).

SES as a Moderator of Within-Person Cognition–Behavior Effects

Education was found to moderate the within-person effects of intention and attitudes on health behavior in both studies, such that these associations were closer in participants with higher educational attainment and weaker in those with lower educational attainment. These findings illustrate a mechanism that can potentially explain the well-established effects of educational attainment on preventative health behaviors (e.g., 17) and ultimately on health (53). Individuals with higher educational attainment are able to access better informational resources and understand the resources more fully, for example regarding nutrition-related information (e.g., 54). Individuals with lower educational attainment often display lower levels of health literacy, which has been implicated in greater difficulties in obtaining, interpreting, and acting on health-related information (e.g., 55). In addition, better educational attainment might enable individuals to formulate more realistic and therefore more effective implementation intentions that facilitate behavior enactment (56).

The few previous studies examining the effects of educational attainment on the relationships between social cognitions and health behaviors yielded conflicting results. While Pan et al. (30) and Vasiljevic et al. (6) found no moderating effects of education in the relationship between intentions and behavior, Godin et al. (24) found moderator effects similar to those in the present studies. One previous study (57) also reports the effects of attitudes on health behavior were moderated by educational attainment. The finding that education moderated the effects of subjective norm on behavior in Study 2 is novel, but can be interpreted in line with the idea that education seems to be a key resource that allows individuals to align their behavior more closely to their cognitions. Concerning household income, findings from Study 2 (but not Study 1) reveal that higher income is associated with stronger effects of attitudes on behavior. This finding is in line with the general idea that more disposable income will facilitate the access to resources to translate attitudes into behavior, e.g., healthier food or access to facilities supporting physical activity such as a gym. At the same time, a lack of income makes accessing key components of health behaviors more difficult. In particular higher costs for "healthier" foodstuffs, low costs for high-fat dietary items, and more competing interests for limited income (e.g., rent, electricity) can be key barriers for the implementation of health behaviors (e.g., 58). However, the lack of previous research examining this moderating effect suggests the need for replication.

Study 1 further revealed that the effects of attitude on behavior are moderated by an area-level indicator of SES (% unemployed per ZIP code), such that these effects are stronger in participants living in areas with lower unemployment. This moderating effect is in line with one previous study (33) that observed an attitude-behavior moderation effect for an area-level measure of GDP. However, this finding suggests that SES might not only affect health behavior through person-level resources such as education or income, but through the embedding of people in environments that differ in socioeconomic strength. Ideally, this

would be examined in a multilevel framework that accounts for similarities between people living in the same area (4), but the small cell sizes in US ZIP code areas (the maximum was 3 people living in the same ZIP code area) prevented us from running these analyses.

The findings that subjective SES (48) moderated intention-behavior and attitude-behavior effects in Study 2 suggest that these effects increase with increasing subjective standing in society (Figure 2e and 2f). These findings differ from those in Study 1 (cross-sectional), suggesting a potential role of subjective SES in predicting behavior change rather than concurrent behavior. Subjective SES may measure a degree of availability of social support if needed (e.g., 22), thus stressing that differences in SES are not limited to being able to access tangible resources such as education or income. However, this finding can also be interpreted in line with the contingent consistency hypothesis (59) that suggests that attitudes may be more predictive of the decision to act and action when the social environment is supportive of the proposed action. Numerous previous studies (e.g., (60)) have shown that attitudes towards health behaviors are more favorable in those with higher socioeconomic standing.

The effects of perceived behavioral control on behavior were not moderated by any SES indicator. The TPB (25) suggests that perceived behavioral control mediates the effects of control beliefs and actual control (reflecting socioeconomic resources) on behavior. In line with this, previous studies (24,26) suggest that the effects of indicators of SES on behavior are largely mediated by perceived behavioral control. If this was the case in our study, the effects of PBC on behavior would be rendered identical across the different levels of SES indicators.

Consistent with our predictions, we found that within-person associations between health cognitions and health behavior were moderated by SES. Researchers interested in healthy lifestyle patterns benefit from examining multiple behaviors simultaneously, and self-

regulatory processes are best understood as within-person processes (38). In supplementary analyses, we took an alternative approach to examine SES moderator effects by running multiple regression analyses separately for each behavior in Study 1 (Supplementary Table 1) and 2 (Supplementary Table 2). Here, the moderating effects of SES on cognition-behavior relationships appears to be much less consistent for individual behaviors, and the number of significant interactions falls within the limits of what would be expected by chance if the conventional alpha error level of .05 was applied. These additional analyses examine for each behavior whether, across participants, for example those with more positive attitudes are more physically active, and whether these associations differ by SES. However, these analyses remain silent to within-participant processes and differences in these processes. The seemingly inconsistent pattern of findings between the within-person analyses and the between-person analyses may in part explain the inconsistency seen in the literature that has generally focused on individual behaviors. This also suggests that more research on both within-person processes and between-person SES differences is needed to fully understand the influence of different indicators of SES on health behavior.

Strengths and Limitations

The strengths of the present research include the examination of multiple individual-level SES measures (subjective SES for the first time), and the inclusion of multiple health cognitions in a within-person perspective with multiple health behaviors. The current research also benefits from examining SES moderator effects in two samples that are potentially more diverse and display a broader range of SES than is typical in previous research. By combining a cross-sectional and a longitudinal data set, it also goes beyond the cross-sectional designs employed in previous research in the area (30, 57).

An important weakness of the present research is the focus on self-reported health behaviors. Relatively few studies in the area use objective measures of health behavior and

the evidence based on such measures in relation to the moderating effects of SES is mixed (5, 6). The use of single-item measures for health behavior recall is a further limitation, although some studies suggest at least satisfactory validity of such measures (41-44). A further weakness of the present research is the failure to examine direct ecological influences on health behavior such as the availability and density of food outlets on eating behavior (e.g., (61)), although these would be expected to be at least partially reflected in individual SES measures and subjective SES in particular. We assessed overall household income and not individual income or the fraction of household income available to an individual, and therefore effects might differ for individual income. In Study 2, the fact that participants were drawn from a number of countries complicates the comparability of SES indicators, even with standard international classifications such as ISCED. Neither type of SES measure alone may adequately capture the opportunities or barriers of ecological factors that moderate individuals' attempts to engage in health behaviors. These ecological opportunities and barriers were identified as key facilitators of health behaviors in early integration exercises (62). Finally, the study samples remain convenience samples, which limits their generalizability. While MTurk samples tend to be more heterogeneous than mere convenience samples, they are not representative for national populations. On the other hand, the main purpose of this study was to examine whether differences in SES corresponded to differential effects of health cognitions on behavior, which might rely less on representativeness, and more on the finding that classic social psychological phenomena are reproducible using these online samples (39, 63).

Implications and Conclusion

In summary, the present research demonstrates that Theory of Planned Behavior variables (25) and SES are both important determinants of health behaviors across two diverse sets of adults and in multiple health behaviors. More importantly, this research

highlights that the strength of the effects of the health cognitions outlined in the TPB is moderated by SES: here, mainly by educational attainment. This implies that traditional health education programs that focus on increasing the intention to engage in health behaviors, e.g., by targeting attitudes and subjective norm, might actually lead to an increase in health disparities, as populations with lower educational attainment may find the translation of these cognitions into behavior more difficult. This poses a challenging conundrum for those interested in reducing health inequalities across SES groups given that many health promotion interventions designed to change health behaviors attempt to target subjective norms, attitudes, and intentions.

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Table 1. Study 1 and Study 2: Socioeconomic status facet medians, ranges, and correlations

Variable	Mean/ Median	Range	2	3	4
Study 1					
1. Education (ISCED level)	4 (Median)	1-11	.19**	.24**	-.05
2. Income (in 1,000 US$)	49.81 (36.73)	5-200		.49**	-.14***
3. Subjective SES	4.92	1-10			-.10***
4. Area-based unemployment (%)	8.13	0-100			
Study 2					
1. Education (ISCED level)	4 (Median)	1-11	.10**	.17**	.15**
2. Income (in 1,000 US$)	32.65 (26.10)	2.5 - 250		.12**	.08**
3. Subjective SES	5.43 (1.58)	1-10			.03
4. Personal employment	3 (Median)	1-3			

Note. * $p < .05$, ** $p < .01$

Table 2. Study 1: Unstandardized parameter estimates from random-effects regression models with cross-level interactions.

Predictors	Income (in 1,000 US$)	Education	Subjective SES	Area-based SES
	Parameter Estimates (SE)			
Fixed Effects (Behavior Level)				
Intercept	4.03 (0.04)***	4.04 (0.04)***	4.04 (0.04)***	4.04 (0.04)***
Intention (INT)	0.76 (0.01)***	0.77 (0.01)***	0.75 (0.01)***	0.75 (0.01)***
Perceived Behavioral Control (PBC)	0.37 (0.03)***	0.37 (0.03)***	0.37 (0.03)***	0.38 (0.03)***
Attitudes (Att)	0.95 (0.02)***	0.95 (0.02)***	0.95 (0.02)***	0.95 (0.02)***
Subjective Norms (SN)	0.42 (0.03)***	0.42 (0.02)***	0.42 (0.03)***	0.42 (0.03)***
Fixed Effects (Person Level)				
Intercept on SES facet	0.00 (0.001)	-0.01 (0.03)	-0.01 (0.02)	-0.02 (0.01)**
Slope INT on SES facet	-0.0002 (0.0003)	0.02 (0.01)*	-0.01 (0.01)	-0.00 (0.00)
Slope PBC on SES facet	-0.0004 (0.0007)	-0.02 (0.02)	-0.01 (0.01)	0.00 (0.01)
Slope Att on SES facet	0.0005 (0.0007)	0.04 (0.02)*	0.01 (0.01)	-0.01 (0.00)**
Slope SN on SES facet	-0.001 (0.0007)	-0.02 (0.02)	-0.02 (0.01)	-0.00 (0.01)
Random Effects				
Residual Variance Intercept (σ_{u0}^2)	0.58**	0.58**	0.58***	0.85***
Residual Variance Slope (INT, σ_{u1}^2)	0.02***	0.06***	0.02***	0.03***
Residual Variance Slope (PBC, σ_{u2}^2)	0.04	0.06*	0.03	0.03
Residual Variance Slope (Att, σ_{u3}^2)	0.03	0.03	0.03	0.03
Residual Variance Slope (SN, σ_{u4}^2)	0.10***	0.10***	0.11***	0.11***

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 3. Study 2: Unstandardized parameter estimates from random-effects regression models with cross-level interactions.

Predictors	Income (in 1,000 US$)	Education	Subjective SES	Employment
	Parameter Estimates (SE)			
Fixed Effects (Behavior Level)				
Intercept	9.03 (0.13)***	9.01 (0.14)***	9.03 (0.14)***	9.02 (0.14)***
Intention (INT)	0.50 (0.08)***	0.49 (0.08)***	0.50 (0.08)	0.50 (0.08)***
Perceived Behavioral Control (PBC)	0.67 (0.09)***	0.67 (0.08)***	0.67 (0.08)***	0.68 (0.09)***
Attitudes (Att)	0.66 (0.12)***	0.64 (0.12)***	0.65 (0.12)***	0.66 (0.12)***
Subjective Norms (SN)	0.66 (0.11)***	0.65 (0.11)***	0.66 (0.11)***	0.66 (0.11)
Fixed Effects (Person Level)				
Intercept on SES facet	0.02 (0.00)***	0.13 (0.09)	0.07 (0.08)	-0.01 (0.06)
Slope INT on SES facet	0.00 (0.00)	0.14 (0.05)**	0.09 (0.04)*	-0.04 (0.03)
Slope PBC on SES facet	0.00 (0.00)	0.05 (0.06)	0.03 (0.05)	-0.05 (0.04)
Slope Att on SES facet	0.01 (0.00)*	0.27 (0.08)**	0.14 (0.07)*	0.01 (0.05)
Slope SN on SES facet	0.00 (0.00)	0.20 (0.08)**	0.08 (0.07)	0.01 (0.04)
Random Effects				
Residual Variance Intercept (σ_{u0}^2)	5.42***	5.65***	5.64***	5.67***
Residual Variance Slope (INT, σ_{u1}^2)	0.13	0.13	0.14	0.14
Residual Variance Slope (PBC, σ_{u2}^2)	0.16	0.15	0.15	0.16
Residual Variance Slope (Att, σ_{u3}^2)	0.98	0.80	0.89	0.91
Residual Variance Slope (SN, σ_{u4}^2)	0.66	0.59	0.66	0.66

Note. All analyses controlled for condition (on person-level) and past behavior (on behavior level); * $p < .05$, ** $p < .01$, *** $p < .001$

Figure 1. Study 1: Simple slopes of significant cross-level interactions between education and intentions (1a), education and attitude (1b), and area-level SES and intention (1c)

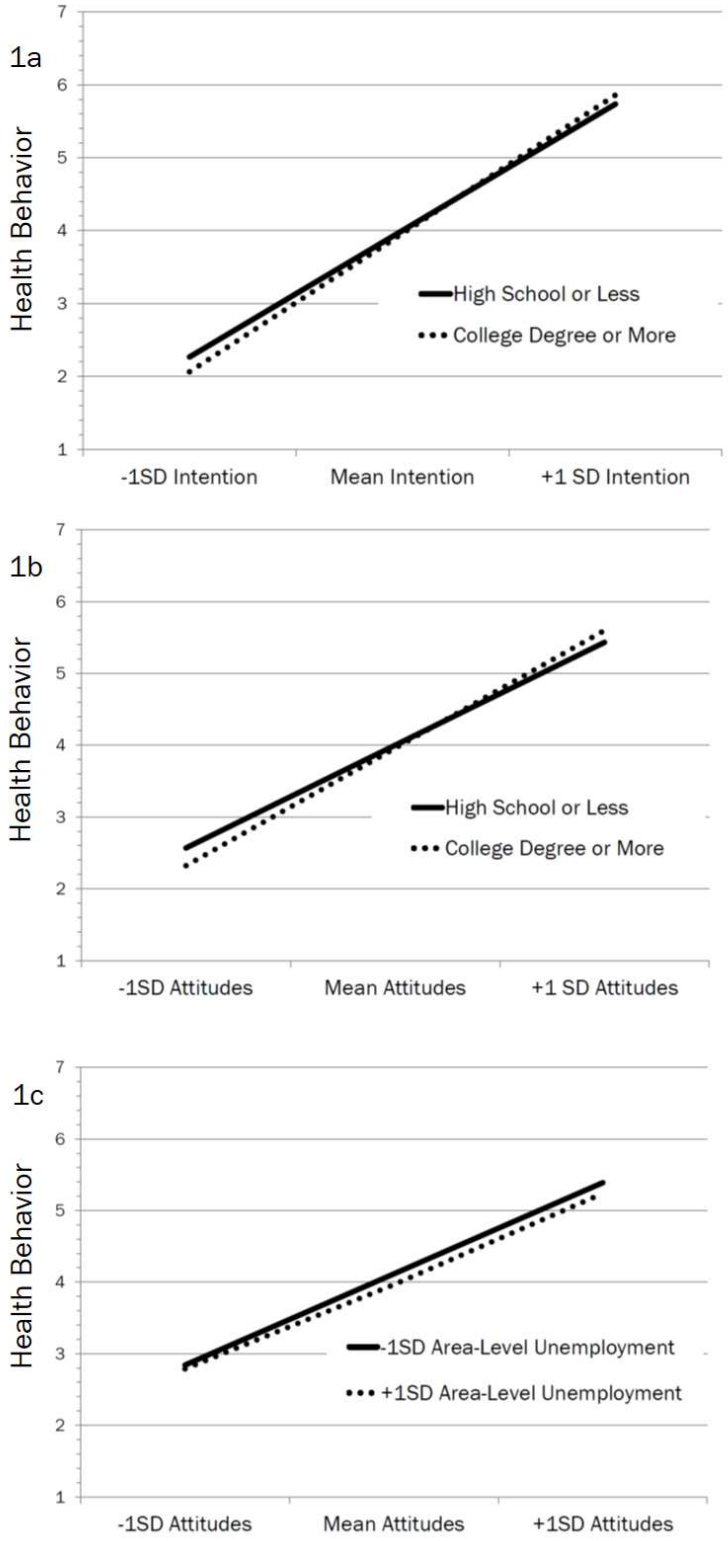

Figure 2. Study 2: Simple slopes of significant cross-level interactions between income and attitudes (2a), education and intention (2b) as well as attitude (2c) and social norm (2d), and subjective SES and attitude (2e) as well as intention (2f).