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Reexamining the Relationship Between Shift Work and Health Behavior: Do Fluid Intelligence, Socio-economic Status, and Self-control Moderate the Relation?

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In contemporary research, the link between shift work and health has received empirical support. Contrary to the well-established association between shift work and adverse health outcomes, literature on the link between shift work and various negative health-related behavior patterns is limited to a rather small number of studies revealing inconsistent results. This is problematic since it is assumed that shift work affects health outcomes via the effect of health behavior. Therefore, the present study aimed to investigate the relationship between shift work and select indicators of health behavior (namely, smoking, alcohol consumption, and preventive health care) as well as subjective health in a large representative German sample. In the light of inconsistent previous findings in the field, we further examined potential moderators (namely, fluid intelligence, socio-economic status, and self-control). Results are based on data from 2,590 participants. We conducted multiple regression analyses as well as mean-differences analyses. Our results suggest that shift work had no direct mean effect on health-related behavior patterns. Moreover, fluid intelligence, socio-economic status, and self-control did not moderate any effects. In accordance with the findings regarding objective health indicators, shift and day workers did not differ in the subjective perception of their health. These findings inform future research and potential interventions that should aim at fostering a healthier lifestyle not only among shift workers.

Introduction

The proportion of employees engaged in shift work has increased markedly in the last few years (e.g., Statista, 2019b). While in 1992, 11.5 % of all employed individuals between 15 and 64 years of age living in Germany worked shifts, this rate was as high as 17.4 % in 2016. Nowadays, shift work as a working hours scheme is indispensable in our society as it encourages companies to offer their services round the clock and to avoid production stops (Paridon et al., 2012).

However, an established definition for the term "shift work" according to the law on working hours is evasive (Paridon et al., 2012). The European Working Times Regulation 1998 defines shift work as follows:

> "shift work" means any method of organizing work in shifts whereby workers succeed each other at the same workstations according to a certain pattern, including a rotating pattern, and which may be continuous or discontinuous, entailing the need for workers to work at different times over a given period of days or weeks. (*The Working Time Regulations 1998*, 2019, p. 13)

In an ergonomic context, shift work is existent if "work is performed either at changing times (rotating shift) or at constant but unusual times (e.g., continuous night shift)" (Paridon et al., 2012, p. 43 translated).

As working shifts affects different physiological processes (e.g., the circadian rhythm; Haus & Smolensky, 2013), it is not surprising that many adverse effects on health – such as changes in the Body Mass Index (BMI; for a detailed review, see Atkinson et al., 2008) – and health problems – like coronary heart disease (e.g., Biggi et al., 2008; Kawachi et al., 1995; Tenkanen, 1997) – have been found. With the growing body of empirical work, evidence also supported a link between shift work and subjective health (e.g., Kim et al., 2016; Meers et al., 1978) – although coverage of this area is currently limited to a small number of hetero-

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geneous studies differing with respect to sample size and study conception. It is also postulated that working shifts affects health outcomes via the effect of health behavior (Steenland, cited after Kivimäki et al., 2001, p. 4), suggesting that working shifts may lead to poorer health-related habits, which in turn affects one's overall health negatively.

Shift Work and Health Behavior

The majority of previous research has explored the relationship between shift work and smoking as well as the relationship between shift work and alcohol consumption. These two indicators might be considered as relevant health behavior, since they are regarded to be two of the top reasons of the global burden of disease (Ezzati et al., 2002). However, health behavior might be understood as two sides of the same coin – negative behavior (such as smoking and alcohol consumption) on the one hand and positive behavior (such as preventive health care) on the other.

Smoking and Alcohol Consumption

Studies that investigated the relationship between shift work and smoking yielded diverging results. While some studies found significant differences between shift and day workers regarding their smoking behavior (e.g., Biggi et al., 2008; Gomez-Parra et al., 2016; Knutsson & Nilsson, 1998), some other research groups did not (e.g., Gordon et al., 1986; Nakamura et al., 1997; Romon et al., 1992). The same holds true for research concerning the link between shift work and alcohol consumption. While some studies observed a link between shift work and alcohol consumption (e.g., Biggi et al., 2008; Boggild et al., 1998; Gordon et al., 1986; Trinkoff & Storr, 1998), others did not (e.g., Gomez-Parra et al., 2016; Kivimäki et al., 2001; Ohira et al., 2000; Wang et al., 2012). Although per capita alcohol consumption in Germany has decreased since 1960, Germans and Belgians consumed 9.6 liters of alcohol per capita in 2014 – the highest amount across high-income countries in a recent comparison[1] (Ritchie & Roser, 2018). Moreover, when comparing 22 countries, Germany was also one of the top five countries with regard to per capita alcohol consumption in 2016 (Statista, 2019c).

Preventive Health Care

Preventive health care can be regarded as relevant health behavior, as the latter is defined as any behavior to preserve health and/or to avoid illness or disease. It comprises different health-related behavior patterns (such as regular checkups, healthy eating habits, or regular exercise). Regarding shift work, it is conceivable that differences between shift workers and day workers regarding their preventive health care behavior exist in part due to the characteristics of shift work (e.g., people are sleeping during the doctor's office hours). Several studies have investigated the link between shift work and healthy eating habits as one possible preventive health care behavior. Although the majority of studies found no difference in energy intake between day and (night) shift workers, it was reported that the latter consumed, for example, more animal fat and proteins (e.g., Nikolova et al., 1990) or multiple snacks instead of a meal (e.g., Waterhouse et al., 2003). These findings are not surprising, since shift workers might have fewer opportunities to participate in joint meals due to their working hours and might therefore rely more on prepared foods.

In conclusion, previous literature on the link between shift work and health behavior is limited in its number and is inconsistent in its results. This heterogeneity may be due to methodological and/or content-related reasons. For instance, a substantial amount of research focused on homogenous participation groups (e.g., nurses only; Kivimäki et al., 2001; Trinkoff & Storr, 1998) or on specific geographical regions (e.g., Scandinavian countries; Knutsson et al., 1988; Knutsson & Nilsson, 1998). Moreover, the effect sizes reported so far might further call into question the practical meaningfulness of these findings. According to Funder and Ozer (2019), evaluating effect sizes – not only *p* levels – is crucial when drawing implications. One recommendation of the authors is to use correlation values as benchmarks when interpreting results as well as their meaningfulness in the short and in the long run. Furthermore, as the majority of studies were conducted in the 1990s – a time with different statutory provisions on working hours, working place characteristics as well as regulations on tobacco and alcohol consumption – the generalizability of prior findings to today's society is limited. Moreover, the heterogeneity of results may come about in part due to the possible importance of moderating third variables. Oppolzer (2010), for example, pointed out that person-related factors could have a moderating effect on the impact of demands in job environments.

Potential Moderators

Fluid Intelligence as a Potential Moderator

The wide-spread view seems to be one of "variable shiftwork as a blue collar phenomenon" (Gordon et al., 1986, p. 1226). However, Gordon et al. (1986) reported that "education was not clearly related to the probability of being a shift worker" (p.1,226). Bearing in mind the heterogeneity of the occupational groups of shift workers, it makes sense that the IQ distribution is not as restricted as was originally assumed. However, literature in this area is limited to a relatively small number of studies and should therefore be interpreted with caution.

Regarding measured intelligence and health-related behavior patterns, such as alcohol consumption, evidence is mixed with a large proportion of studies revealing a negative relationship (e.g., Sjölund et al., 2015). Batty and colleagues (2007), for example, reported a negative association between child IQ scores and the prevalence of ever having smoked as well as heavy alcohol consumption in adulthood.

1 Here, Belgium, Germany, France, the United Kingdom, Australia, the US, and Italy had been compared.

Moreover, Wraw and colleagues (e.g., 2018) showed that a higher IQ in youth was associated with a lower likelihood of – amongst other things – heavily consuming alcohol or smoking in middle age. In the context of shift work, this link appears to be especially important. Even if shift workers relied on less healthy behavior patterns such as consuming alcohol as, for example, a coping strategy, those with higher cognitive ability may show better health behaviors or might use healthier strategies to cope with stressful working conditions, weakening the link between shift work and negative health-related behavior patterns. This assumption is further supported by the work of Minehan et al. (2008), who showed an association between cognitive ability and coping strategies in the prediction of drug use and by certain empirical models emphasizing an association between substance use and (avoidance) coping strategies (e.g., Ebata & Moos, 1991).

Socio-economic Status as a Potential Moderator

Past research also suggests a link between shift work and socio-economic status. Wang and colleagues (2012), for instance, reported a higher risk of being in the lowest third of the socio-economic status distribution for women who ever worked night shifts compared to women who never worked night shifts. A low(er) socio-economic status might further be associated with unhealthy behavior patterns such as higher rates of smoking (e.g., Pomerleau et al., 1997). This might be due to a reduced consciousness regarding the effects of one's actions and, hence, a reduced probability to choose healthier behavior patterns (Neumark et al., 2003). Thus, health behavior patterns of (shift working) employees might differ depending on a person's socio-economic status.

Self-control as a Potential Moderator

In contemporary psychological science, self-control is understood as a resource used to regulate one's own behavior and, hence, enabling one to be resistant to unwanted tendencies (e.g., temptations or impulses) in favor of desired behavior patterns (Baumeister et al., 2007; Muraven & Baumeister, 2000). In this vein, Bogg and Roberts (2004), for instance, showed that self-control seems to represent a strong predictor for various health behaviors such as tobacco and alcohol consumption. Thus, (shift working) employees low in self-control capacity might show more unhealthy behavior than (shift working) employees high in self-control capacity. Subsequently, self-control may be of interest as a potential moderator in studying the relation between shift work and health behavior.

In sum, the present research was designed to clarify whether the effects of shift work on health behavior are present in a large and heterogeneous German sample. Furthermore, as the data of previous research were assessed at a time when working conditions for shift workers (e.g., regarding resting periods) might have been worse, findings that are applicable to the present working environment are needed. In addition to the two more common negative health behavior patterns of smoking and alcohol consumption, the link to preventive health care was examined for the first time. Furthermore, the role of potential moderating

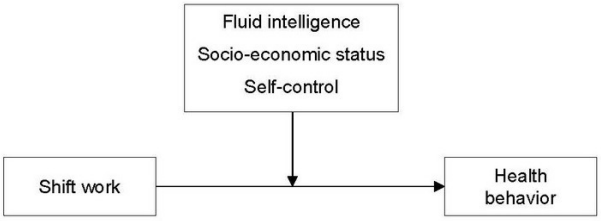

Figure 1: Postulated models for the moderation analysis

variables including fluid intelligence, socio-economic status, and self-control was explored. In order to compare our findings with those reported by previous researchers, subjectively perceived health of shift workers as well as the link between subjectively perceived health and actual health behavior was investigated.

We hypothesized that shift work is related to greater smoking and alcohol consumption, and less preventive health care. In addition, we expected that (a) fluid intelligence, (b) socio-economic status), and (c) self-control may moderate this relationship. In Figure 1, the postulated models are visualized. Subsequently, we assumed that shift workers perceive their subjective state of health as worse than day workers. As there is no literature on the link between subjectively perceived health and actual health behavior, this association was investigated exploratively.

Methods

Participants

The present work used data from the second wave of the German twin family study *TwinLife* (Mönkediek et al., 2019) – an on-going project that aims to investigate social inequalities over the life course. Household (face to face) and telephone interviews are conducted every year at regular rotation (for a detailed overview of this project, see Hahn et al., 2016 or Mönkediek et al., 2019). The initial sample for the present work consisted of 5,691 employees from different fields of employment. We excluded all occasional or irregular employees, (early) retirees, participants in voluntary national service or voluntary social year, participants with other occupational inactivity, and participants with other employment as well as participants with missing information on gender. The remaining sample consisted of 5,570 employed participants. To control for dependency in the data, in a final step, all but one person per family were excluded. This procedure resulted in a total of 2,590 individuals (432 (16.7 %) shift workers, 2,158 (83.3 %) day workers; 54.9 % women), ranging in age between 17 and 67 years (M_{age} = 41.47; SD_{age} = 11.66). Table 1 shows descriptive statistics regarding the final subsample.

A Priori Power Analysis

Based on our literature review, we assumed a small effect size for the relationship between shift work and health behavior. Power analysis conducted with the G*Power soft-

Table 1: Demographic information according to shift versus day work

		Shift workers (*n* = 432)	Day workers (*n* = 2,158)
Age *M* (*SD*)		38.45 (12.41)	42.07 (11.41)
Males		46.8	44.8
Nationality	German	90.0	94.0
	Other	10.0	6.0
Highest education[a]	Abitur / university entrance diploma	27.9	52.4
	University of applied sciences entrance diploma	13.0	13.1
	Intermediate secondary school-leaving certificate	41.1	25.1
	Primary / lower secondary school-leaving certificate	15.1	7.2
	Other or no school-leaving qualification	2.9	2.2
Occupational status	Self-employed	3.3	11.0
	Civil servants	4.0	9.8
	White-collar workers	71.6	69.4
	Blue-collar workers	15.3	5.5
	Apprentices / trainees / interns	5.8	4.3

Note. *M* = mean; *SD* = standard deviation; information on age in years; all other information in percent (%).
[a]Highest education was assessed in face to face wave 1, respectively face to face wave 2 if the highest education was different from the previous wave.

ware (Faul et al., 2007) indicated a total sample size of at least $N = 196$ required for detecting a small effect size ($f^2 = 0.05$) with an alpha of .05 and a power of .80. For the full model (two control and six predictor variables; see step 5 of the hierarchical regression analyses below) of the moderation analyses, a total sample size of at least $N = 759$ was required to detect a small effect size ($f^2 = 0.02$) with an alpha of .05 and a power of .80.

Materials[2]

Shift Work

Shift work activity was measured by asking the respondents whether or not they were working shifts ("Do you work shifts?"). Response options were "yes" and "no". This information retrieval mirrored the one of the project "From heterogeneities to inequalities - interactions between work and private life" (Abendroth et al., 2014).

Health Behavior

Smoking, alcohol consumption, and preventive health care were used as indicators of health behavior. Smoking was assessed by asking the participants whether they were smokers ("Do you smoke?"), rated on a 6-point scale ranging from 0 ("No, I never smoke") to 5 ("Yes, I am a heavy smoker"). Alcohol consumption was assessed by asking "How often do you drink a lot?", rated on a 6-point scale ranging from 0 ("never") to 5 ("daily"). Items on smoking behavior and alcohol consumption were both comparable to the SOEP[3] 2010 questionnaire (TNS Infratest Sozialforschung, 2012). Preventive health care was assessed through one item ("I take active steps to stay healthy") on a 4-point scale ranging from 0 ("not at all") to 3 ("a lot"). Examples of preventive health care behavior provided to the participants included regular check-ups, a healthy diet, and the prevention of behavior harmful to health. This information retrieval mirrored the one of Kornadt and Rothermund (2014).

Fluid Intelligence

Fluid intelligence[4] was assessed in face to face wave 1, using the Culture Fair Intelligence Test (CFT 20-R) (Weiß, 2006). It was assessed two years before the assessment of the other variables. Subtests used were figural reasoning ($\alpha = .65$), figural classification ($\alpha = .68$), matrices ($\alpha = .76$), and reasoning ($\alpha = .60$). Cronbach's alpha across all scales was .75. For more information about the assessment of cognitive ability in the *TwinLife* study, see Gottschling (2017).

2 For more detailed information on the *TwinLife* scales used in this work, please see *TwinLife*'s Scales Manual (Baum et al., 2020) or *TwinLife*'s documentation website.

3 The SOEP study is an ongoing nationally representative longitudinal survey of socioeconomic, health, and psychological variables in Germany. For more information, see Goebel et al. (2019).

4 Fluid intelligence is the ability to solve novel reasoning problems and is correlated with a number of important skills such as comprehension, problem solving, and learning (Unsworth et al., 2014).

Table 2: Results of the hierarchical regression analyses

		Smoking								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	√(ΔR²)	√(ΔR²) [95%-CI]
Step 1	Age	-.02	0.02	-.02	[-0.07, 0.03]	.416	.08	[0.04, 0.12]	.08	[0.04, 0.12]
	Gender	**-.08**	**0.02**	**-.08**	**[-0.12, -0.04]**	**<.001**				
Step 2	Age	-.01	0.02	-.01	[-0.06, 0.04]	.722	.13	[0.09, 0.17]	.10	[0.06, 0.14]
	Gender	**-.08**	**0.02**	**-.08**	**[-0.12, -0.04]**	**<.001**				
	Shift work	**.09**	**0.02**	**.09**	**[0.05, 0.14]**	**<.001**				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; √(ΔR²)[95%-CI] = confidence interval for √(ΔR²)

According to Gottschling's (2017) recommendations, the sum values of the subtests were used and a mean scale value was calculated.

Socio-economic Status

Socio-economic status was calculated using the mean of occupational activity, monthly gross income, and ISCED 1997 classification. All variables were z-standardized before calculating the mean.

Self-control

Self-control was assessed using three items of a German short version of the Self-Control Scale (SCS-K-D; Bertrams & Dickhäuser, 2009) in telephone wave 1 (one year after the intelligence assessment) and face to face wave 2 (two years after the intelligence assessment). Items (e.g., "Pleasant activities and pleasures sometimes prevent me from doing my job.") were rated on a 5-point-scale ranging from 0 ("does not apply at all") to 4 ("is absolutely true")[5]. Cronbachs alpha was .58. For 307 participants, self-control values were available at both times (telephone wave 1 and face to face wave 2). Since the two measurements showed a substantial correlation ($r(307) = .51$, $p < .001$), a mean was calculated and used in the analyses. Given the poor reliability, this correlation can be considered as good.

Subjective State of Health

Subjective health was assessed by asking "How would you generally describe your state of health in the last 12 months?" (Item retrieved from SF-8; Ellert et al., 2005), rated on a 5-point scale ranging from 0 ("very bad") to 5 ("excellent").

Occupational Status

Occupational status was measured with the following question: "What is your current occupational status?" (TNS Infratest Sozialforschung, 2014). Participants were advised to indicate this in relation to their main job with one of the following response options: "blue-collar worker", "white-collar worker", "civil servant", "self-employed", and "apprentices / trainees / interns".

Results

Prior to data analyses, we examined the occurrence of missing values in the sample. Between 0.1 % and 19.7 % of the values were missing. Little's MCAR test (Little & Rubin, 2002) indicated that missing data did not occur completely at random ($\chi^2 = 189.51$, $p < .001$). Missing data were therefore handled using multiple imputation and results were pooled based on the recommendations of Urban, Mayerl, and Wahl (2016). Descriptive statistics of all study variables as well as their correlations can be found as supplement material (Table S1). Prior to the analyses, all variables were z-standardized. All analyses were conducted using IBM SPSS Statistics (IBM Corp., 2016) software.

Shift Work and Health Behavior

To investigate whether shift work was a significant predictor of health behavior, we conducted hierarchical regression analyses with shift work as the independent variable and either smoking, alcohol consumption, or preventive health care as dependent variables. Age and gender were included as covariates in step 1. Results can be found in Table 2.

Adding shift work as a predictor significantly predicted smoking behavior ($\beta = .09$, 95%-CI[0.05, 0.14], $p < .001$).

5 Items were recoded so that a higher value reflects a higher expression of the trait.

Table 2 (continued): Results of the hierarchical regression analyses

		Alcohol consumption								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	√(ΔR²)	√(ΔR²) [95%-CI]
Step 1	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.03]**	**.007**	.16	[0.12, 0.20]	.16	[0.12, 0.20]
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18, -0.10]**	**<.001**				
Step 2	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.03]**	**.006**				
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18, -0.10]**	**<.001**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Shift work	-.04	0.02	-.04	[-0.08, 0.00]	.068				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; √(ΔR²)[95%-CI] = confidence interval for √(ΔR²).

Table 2 (continued): Results of the hierarchical regression analyses

		Preventive health care								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	√(ΔR²)	√(ΔR²) [95%-CI]
Step 1	Age	**.12**	**0.03**	**.12**	**[0.07, 0.17]**	**<.001**	.22	[0.18, 0.23]	.22	[0.18, 0.23]
	Gender	**.19**	**0.02**	**.19**	**[0.14, 0.24]**	**<.001**				
Step 2	Age	**.11**	**0.03**	**.11**	**[0.06, 0.17]**	**<.001**	.24	[0.20, 0.28]	.00	[-0.04, 0.04]
	Gender	**.19**	**0.02**	**.19**	**[0.14, 0.23]**	**<.001**				
	Shift work	**-.05**	**0.02**	**-.05**	**[-0.09, -0.01]**	**.011**				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; √(ΔR²)[95%-CI] = confidence interval for √(ΔR²).

The corresponding overall model significantly explained variance ($F(1, 2{,}586) = 13.60$, $p < .001$, R = .13, √(ΔR²) = .10). Regarding alcohol consumption, the prediction was not significant (β = -.04, 95%-CI[-0.08, 0.00], p = .068). Furthermore, adding shift work as a predictor significantly predicted preventive health care (β = -.05, 95%-CI[-0.09, -0.01], p = .011). Again, the corresponding overall model significantly explained variance ($F(1, 2{,}586) = 46.08$, $p < .001$, R = .24, √(ΔR²) = .00).

Fluid Intelligence as a Potential Moderator

To test whether the relationship between shift work and health behavior was moderated by fluid intelligence, we conducted a hierarchical multiple regression analysis. We included age and gender in a first step. In a second step, we included shift work. In a third step, we included fluid intelligence and in a fourth step, we included the interaction term (shift work x fluid intelligence). In a last step, we included several interaction terms (namely, shift work x gender, gender x fluid intelligence, and shift work x gender x fluid intelligence). All results are presented in Table 3. Results for the unstandardized variables can be found in Appendix (S2).

None of the moderation hypotheses concerning fluid intelligence was supported. Nevertheless, adding fluid intelligence in addition to shift work as a predictor significantly predicted smoking behavior and led to a significant improvement of explained variance (β = -.18, 95%-CI[-0.23, -0.14], p <.001). Furthermore, the corresponding overall model significantly explained variance ($F(1, 2{,}585) = 32.65$, $p < .001$, R = .22, √(ΔR²) = .18).

Socio-economic Status as a Potential Moderator

To test whether the relationship between shift work and health behavior was moderated by socio-economic status, we conducted a hierarchical multiple regression analysis. We included age and gender in a first step. In a second step, we included shift work. In a third step, we included socio-economic status and in a fourth step, we included the interaction term (shift work x socio-economic status). In a last step, we included several interaction terms (namely, shift work x gender, gender x socio-economic status, and shift work x gender x socio-economic status). All results are pre-

Table 3: Results of the hierarchical regression analyses with fluid intelligence as a moderator

		Smoking								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	√(ΔR²)	√(ΔR²) [95%-CI]
Step 1	Age	-.02	0.02	-.02	[-0.07, 0.03]	.416	.08	[0.04, 0.12]	.08	[0.04, 0.12]
	Gender	**-.08**	**0.02**	**-.08**	**[-0.12, -0.04]**	**<.001**				
Step 2	Age	-.01	0.02	-.01	[-0.06, 0.04]	.722	.13	[0.09, 0.17]	.10	[0.06, 0.14]
	Gender	**-.08**	**0.02**	**-.08**	**[-0.12, -0.04]**	**<.001**				
	Shift work	**.09**	**0.02**	**.09**	**[0.05, 0.14]**	**<.001**				
Step 3	Age	-.04	0.02	-.04	[-0.08, 0.01]	.118	.22	[0.18, 0.26]	.18	[0.14, 0.22]
	Gender	**-.09**	**0.02**	**-.09**	**[-0.13, -0.05]**	**<.001**				
	Shift work	**.07**	**0.02**	**.07**	**[0.03, 0.12]**	**.002**				
	Fluid intelligence	**-.18**	**0.02**	**-.18**	**[-0.23, -0.14]**	**<.001**				
Step 4	Age	-.04	0.02	-.04	[-0.08, 0.01]	.120	.22	[0.18, 0.26]	.00	[-0.04, 0.04]
	Gender	**-.09**	**0.02**	**-.09**	**[-0.13, -0.05]**	**<.001**				
	Shift work	.03	0.10	.03	[-0.17, 0.23]	.764				
	Fluid intelligence	**-.19**	**0.02**	**-.19**	**[-0.23, -0.14]**	**<.001**				
	Shift work x fluid intelligence	.04	0.10	.04	[-0.16, 0.24]	.687				
Step 5	Age	-.04	0.02	-.04	[-0.08, 0.01]	.116	.22	[0.18, 0.26]	.00	[-0.04, 0.04]
	Gender	-.08	0.16	-.08	[-0.40, 0.24]	.623				
	Shift work	.11	0.43	.11	[-0.80, 1.02]	.801				
	Fluid intelligence	-.18	0.09	-.18	[-0.47, 0.00]	.053				
	Shift work x fluid intelligence	-.01	0.44	-.01	[-0.94, 0.91]	.976				
	Shift work x gender	-.09	0.44	-.09	[-1.02, 0.85]	.849				
	Gender x fluid intelligence	-.01	0.17	-.01	[-0.36, 0.34]	.950				
	Shift work x gender x fluid intelligence	.06	0.44	.06	[-0.88, 0.99]	.896				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; √(ΔR²)[95%-CI] = confidence interval for √(ΔR²).

sented in Table 4. Results for the unstandardized variables can be found in Appendix (S3).

Table 3 (continued): Results of the hierarchical regression analyses with fluid intelligence as a moderator

		Alcohol consumption								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	$\sqrt{(\Delta R^2)}$	$\sqrt{(\Delta R^2)}$ [95%-CI]
Step 1	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.03]**	**.007**	.16	[0.12, 0.20]	.16	[0.12, 0.20]
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18, -0.10]**	**<.001**				
Step 2	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.03]**	**.006**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18, -0.10]**	**<.001**				
	Shift work	-.04	0.02	-.04	[-0.08, 0.00]	.068				
Step 3	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.04]**	**.003**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18. -0.10]**	**<.001**				
	Shift work	-.04	0.02	-.04	[-0.08, 0.00]	.063				
	Fluid intelligence	-.01	0.03	-.01	[-0.07, 0.05]	.694				
Step 4	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.04]**	**.003**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18, -0.10]**	**<.001**				
	Shift work	-.06	0.12	-.06	[-0.32, 0.19]	.617				
	Fluid intelligence	-.01	0.03	-.01	[-0.07, 0.05]	.655				
	Shift work x fluid intelligence	.02	0.12	.02	[-0.23, 0.27]	.849				
Step 5	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.04]**	**.003**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Gender	-.16	0.17	-.16	[-0.05, 0.19]	.357				
	Shift work	-.29	0.41	-.29	[-1.13, 0.54]	.476				
	Fluid intelligence	-.01	0.09	-.01	[-0.21, 0.18]	.877				
	Shift work x fluid intelligence	.17	0.40	.17	[-0.67, 1.00]	.688				
	Shift work x gender	.25	0.41	.25	[-0.59, 1.08]	.552				
	Gender x fluid intelligence	.00	0.19	.00	[-0.39, 0.39]	.994				
	Shift work x gender x fluid intelligence	-.15	0.41	-.15	[-0.98, 0.68]	.716				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; $\sqrt{(\Delta R^2)}$[95%-CI] = confidence interval for $\sqrt{(\Delta R^2)}$.

Table 3 (continued): Results of the hierarchical regression analyses with fluid intelligence as a moderator

		Preventive health care								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	$\sqrt{(\Delta R^2)}$	$\sqrt{(\Delta R^2)}$ [95%-CI]
Step 1	Age	**.12**	**0.03**	**.12**	**[0.07, 0.17]**	**<.001**	.22	[0.18, 0.23]	.22	[0.18, 0.23]
	Gender	**.19**	**0.02**	**.19**	**[0.14, 0.24]**	**<.001**				
Step 2	Age	**.11**	**0.03**	**.11**	**[0.06, 0.17]**	**<.001**	.23	[0.19, 0.27]	.00	[-0.04, 0.04]
	Gender	**.19**	**0.02**	**.19**	**[0.14, 0.23]**	**<.001**				
	Shift work	**-.05**	**0.02**	**-.05**	**[-0.09, -0.01]**	**.011**				
Step 3	Age	**.12**	**0.02**	**.12**	**[0.07, 0.17]**	**<.001**	.23	[0.19, 0.27]	.00	[-0.04, 0.04]
	Gender	**.19**	**0.02**	**.19**	**[0.15, 0.24]**	**<.001**				
	Shift work	**-.05**	**0.02**	**-.05**	**[-0.09, -0.01]**	**.017**				
	Fluid intelligence	.02	0.03	.02	[-0.03, 0.08]	.359				
Step 4	Age	**.12**	**0.02**	**.12**	**[0.07, 0.17]**	**<.001**	.23	[0.19, 0.27]	.00	[-0.04, 0.04]
	Gender	**.19**	**0.02**	**.19**	**[0.15, 0.23]**	**<.001**				
	Shift work	-.17	0.10	-.17	[-0.37, 0.03]	.099				
	Fluid intelligence	.01	0.03	.01	[-0.05, 0.07]	.672				
	Shift work x fluid intelligence	.12	0.10	.12	[-0.08, 0.32]	.224				
Step 5	Age	**.12**	**0.02**	**.12**	**[0.07, 0.17]**	**<.001**	.23	[0.19, 0.27]	.00	[-0.04, 0.04]
	Gender	-.06	0.15	-.06	[-0.37, 0.26]	.713				
	Shift work	-.37	0.37	-.37	[-1.12, 0.37]	.321				
	Fluid intelligence	-.13	0.08	-.13	[-0.29, .003]	.103				
	Shift work x fluid intelligence	.38	0.37	.38	[-0.36, 1.13]	.304				
	Shift work x gender	.21	0.40	.21	[-0.59, 1.02]	.594				
	Gender x fluid intelligence	.29	0.16	.29	[-0.05, 0.62]	.089				
	Shift work x gender x fluid intelligence	-.28	0.40	-.28	[-1.08, 0.53]	.492				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; $\sqrt{(\Delta R^2)}$[95%-CI] = confidence interval for $\sqrt{(\Delta R^2)}$.

Table 4: Results of the hierarchical regression analyses with socio-economic status as a moderator

		Smoking								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	√(ΔR²)	√(ΔR²) [95%-CI]
Step 1	Age	-.02	0.02	-.02	[-0.07, 0.03]	.416	.08	[0.04, 0.12]	.10	[0.03, 0.14]
	Gender	**-.08**	**0.02**	**-.08**	**[-0.12, -0.04]**	**<.001**				
Step 2	Age	-.01	0.02	-.01	[-0.06, 0.04]	.722	.13	[0.09, 0.17]	.10	[0.06, 0.14]
	Gender	**-.08**	**0.02**	**-.08**	**[-0.12, -0.04]**	**<.001**				
	Shift work	**.09**	**0.02**	**.09**	**[0.05, 0.14]**	**<.001**				
Step 3	Age	**.05**	**.02**	**.05**	**[0.00, 0.10]**	**.048**	.23	[0.19, 0.27]	.20	[0.16, 0.24]
	Gender	**-.05**	**.02**	**-.05**	**[-0.09, -0.01]**	**.012**				
	Shift work	**.06**	**.02**	**.06**	**[0.02, 0.11]**	**.008**				
	Socio-economic status	**-.21**	**.02**	**-.21**	**[-0.25, -0.17]**	**<.001**				
Step 4	Age	**.05**	**.02**	**.05**	**[0.00, 0.10]**	**.048**	.23	[0.19, 0.27]	.00	[-0.04, 0.04]
	Gender	**-.05**	**.02**	**-.05**	**[-0.09, -0.01]**	**.013**				
	Shift work	**.06**	**.03**	**.06**	**[0.01, 0.11]**	**.015**				
	Socio-economic status	**-.21**	**.02**	**-.21**	**[-0.26, 0.16]**	**<.001**				
	Shift work x socio-economic status	.00	.02	.00	[-0.05, 0.05]	.984				
Step 5	Age	**.05**	**.02**	**.05**	**[0.00, 0.10]**	**.040**	.23	[0.19, 0.27]	.00	[-0.04, 0.04]
	Gender	**-.06**	**.02**	**-.06**	**[-0.10, -0.01]**	**.011**				
	Shift work	.08	.09	.08	[-0.09, 0.25]	.347				
	Socio-economic status	**-.25**	**.07**	**-.25**	**[-0.39, -0.11]**	**.001**				
	Shift work x socio-economic status	.11	.09	.11	[-0.07, 0.29]	.231				
	Shift work x gender	-.01	.08	-.01	[-0.16, 0.14]	.890				
	Gender x socio-economic status	.04	.07	.04	[-0.10, 0.19]	.554				
	Shift work x gender x socio-economic status	-.11	.08	-.11	[-0.27, 0.05]	.185				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; √(ΔR²)[95%-CI] = confidence interval for √(ΔR²).

Table 4 (continued): Results of the hierarchical regression analyses with socio-economic status as a moderator

		Alcohol consumption								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	√(ΔR²)	√(ΔR²) [95%-CI]
Step 1	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.03]**	**.007**	.16	[0.12, 0.20]	.17	[0.13, 0.21]
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18, -0.10]**	**<.001**				
Step 2	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.03]**	**.006**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18, -0.10]**	**<.001**				
	Shift work	-.04	0.02	-.04	[-0.08, 0.00]	.068				
Step 3	Age	**-.10**	**.03**	**-.10**	**[-0.17, -0.03]**	**.008**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Gender	**-.15**	**.02**	**-.15**	**[-0.19, -0.10]**	**<.001**				
	Shift work	-.03	.02	-.03	[-0.08, 0.01]	.110				
	Socio-economic status	.03	.03	.03	[-0.03, 0.08]	.319				
Step 4	Age	**-.10**	**.03**	**-.10**	**[-0.17, -0.03]**	**.008**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Gender	**-.15**	**.02**	**-.15**	**[-0.19, -0.11]**	**<.001**				
	Shift work	-.03	.02	-.03	[-0.08, 0.02]	.186				
	Socio-economic status	.02	.03	.02	[-0.03, 0.08]	.404				
	Shift work x socio-economic status	.01	.02	.01	[-0.04, 0.06]	.697				
Step 5	Age	**-.10**	**.03**	**-.10**	**[-0.17, -0.03]**	**.009**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Gender	**-.16**	**.02**	**-.16**	**[-0.20, -0.11]**	**<.001**				
	Shift work	-.08	.09	-.08	[-0.26, 0.09]	.352				
	Socio-economic status	.02	.07	.02	[-0.12, 0.16]	.738				
	Shift work x socio-economic status	.07	.09	.07	[-0.10, 0.24]	.419				
	Shift work x gender	.06	.08	.06	[-0.11, 0.22]	.488				
	Gender x socio-economic status	.00	.08	.00	[-0.15, 0.15]	.989				
	Shift work x gender x socio-economic status	-.07	.08	-.07	[-0.23, 0.09]	.390				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; √(ΔR²)[95%-CI] = confidence interval for √(ΔR²).

Table 4 (continued): Results of the hierarchical regression analyses with socio-economic status as a moderator

		Preventive health care								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	√(ΔR²)	√(ΔR²) [95%-CI]
Step 1	Age	**.12**	**0.03**	**.12**	**[0.07, 0.17]**	**<.001**	.22	[0.18, 0.23]	.22	[0.18, 0.23]
	Gender	**.19**	**0.02**	**.19**	**[0.14, 0.24]**	**<.001**				
Step 2	Age	**.11**	**0.03**	**.11**	**[0.06, 0.17]**	**<.001**	.23	[0.19, 0.27]	.00	[-0.04, 0.04]
	Gender	**.19**	**0.02**	**.19**	**[0.14, 0.23]**	**<.001**				
	Shift work	**-.05**	**0.02**	**-.05**	**[-0.09, -0.01]**	**.011**				
Step 3	Age	**.08**	**.03**	**.08**	**[0.03, 0.14]**	**.005**	.25	[0.21, 0.29]	.10	[0.06, 0.14]
	Gender	**.17**	**.02**	**.17**	**[0.13, 0.22]**	**<.001**				
	Shift work	-.03	.02	-.03	[-0.07, 0.01]	.092				
	Socio-economic status	**.11**	**.02**	**.11**	**[0.07, 0.16]**	**<.001**				
Step 4	Age	**.08**	**.03**	**.08**	**[0.03, 0.14]**	**.005**	.25	[0.21, 0.29]	.00	[-0.04, 0.04]
	Gender	**.18**	**.02**	**.18**	**[0.13, 0.22]**	**<.001**				
	Shift work	-.04	.02	-.04	[-0.08, 0.01]	.109				
	Socio-economic status	**.11**	**.02**	**.11**	**[0.07, 0.16]**	**<.001**				
	Shift work x socio-economic status	-.01	.03	-.01	[-0.06, 0.05]	.850				
Step 5	Age	**.08**	**.03**	**.08**	**[0.03, 0.14]**	**.005**	.25	[0.21, 0.29]	.00	[-0.04, 0.04]
	Gender	**.19**	**.02**	**.19**	**[]0.14, 0.24**	**<.001**				
	Shift work	.11	.08	.11	[-0.05, 0.27]	.163				
	Socio-economic status	.01	.07	.01	[-0.14, 0.16]	.914				
	Shift work x socio-economic status	.11	.09	.11	[-0.07, 0.29]	.224				
	Shift work x gender	-.15	.08	-.15	[-0.29, 0.00]	.056				
	Gender x socio-economic status	.11	.08	.11	[-0.05, 0.27]	.160				
	Shift work x gender x socio-economic status	-.10	.08	-.10	[-0.26, 0.06]	.199				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; √(ΔR²)[95%-CI] = confidence interval for √(ΔR²).

Concerning socio-economic status, none of the investigated moderation terms yielded significant results. Nevertheless, adding socio-economic status in addition to shift work as a predictor significantly predicted smoking as well as preventive health care behavior and led to a significant improvement of explained variance (smoking: β = -.21, 95%-CI[-0.25, -0.17], p <.001; preventive health care: β = .11, 95%-CI[0.07, 0.16], p <.001). Furthermore, the corresponding overall models significantly explained variance (smoking: $F(1, 2{,}585) = 36.71$, p <.001, R = .23, $\sqrt{(\Delta R^2)} = .20$; preventive health care: $F(1, 2{,}585) = 42.52$, p <.001, R = .25, $\sqrt{(\Delta R^2)} = .10$).

Self-control as a Potential Moderator

The procedure to test whether the relationship between shift work and health behavior was moderated by self-control, mirrored the one described in the sections above. We included age and gender in a first step. In a second step, we included shift work. In a third step, we included self-control and in a fourth step, we included the interaction term (shift work x self-control). In a last step, we included several interaction terms (namely, shift work x gender, gender x self-control, and shift work x gender x self-control). Table 5 contains all results. Results for the unstandardized variables can be found in Appendix (S4).

Table 5: Results of the hierarchical regression analyses with self-control as a moderator

		Smoking								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	$\sqrt{(\Delta R^2)}$	$\sqrt{(\Delta R^2)}$ [95%-CI]
Step 1	Age	-.02	0.02	-.02	[-0.07, 0.03]	.416	.08	[0.04, 0.12]	.08	[0.04, 0.12]
	Gender	**-.08**	**0.02**	**-.08**	**[-0.12, -0.04]**	**<.001**				
Step 2	Age	-.01	0.02	-.01	[-0.06, 0.04]	.722	.13	[0.09, 0.17]	.10	[0.06, 0.14]
	Gender	**-.08**	**0.02**	**-.08**	**[-0.12, -0.04]**	**<.001**				
	Shift work	**.09**	**0.02**	**.09**	**[0.05, 0.14]**	**<.001**				
Step 3	Age	.01	0.02	.01	[-0.04, 0.05]	.670	.16	[0.12, 0.20]	.10	[0.06, 0.14]
	Gender	**-.07**	**0.02**	**-.07**	**[-0.11, -0.03]**	**.001**				
	Shift work	**.09**	**0.02**	**.09**	**[0.05, 0.13]**	**<.001**				
	Self-control	**-.10**	**0.03**	**-.10**	**[-0.17, -0.03]**	**.014**				
Step 4	Age	.01	0.02	.01	[-0.03, 0.05]	.661	.16	[0.12, 0.20]	.00	[-0.04, 0.04]
	Gender	**-.07**	**0.02**	**-.07**	**[-0.11, -0.03]**	**.002**				
	Shift work	.02	0.05	.02	[-0.08, 0.13]	.675				
	Self-control	**-.11**	**0.03**	**-.11**	**[-0.18, -0.03]**	**.008**				
	Shift work x self-control	.07	0.06	.07	[-0.04, 0.18]	.207				
Step 5	Age	.01	0.02	.01	[-0.03, 0.05]	.658	.16	[0.12, 0.20]	.00	[-0.04, 0.04]
	Gender	-.11	0.07	-.11	[-0.25, 0.02]	.107				
	Shift work	-.05	0.18	-.05	[-0.41, 0.31]	.793				
	Self-control	-.17	0.09	-.17	[-0.35, 0.01]	.068				
	Shift work x self-control	.19	0.19	.19	[-0.18, 0.56]	.303				
	Shift work x gender	.08	0.19	.08	[-0.30, 0.45]	.697				
	Gender x self-control	.08	0.11	.08	[-0.13, 0.30]	.446				
	Shift work x gender x self-control	-.13	0.19	-.13	[-0.51, 0.26]	.510				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; $\sqrt{(\Delta R^2)}$[95%-CI] = confidence interval for $\sqrt{(\Delta R^2)}$.

Table 5 (continued): Results of the hierarchical regression analyses with self-control as a moderator

		Alcohol consumption								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	$\sqrt{(\Delta R^2)}$	$\sqrt{(\Delta R^2)}$ [95%-CI]
Step 1	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.03]**	**.007**	.16	[0.12, 0.20]	.16	[0.12, 0.20]
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18, -0.10]**	**<.001**				
Step 2	Age	**-.09**	**0.03**	**-.09**	**[-0.15, -0.03]**	**.006**	.17	[0.13, 0.21]	.00	[-0.04, 0.04]
	Gender	**-.14**	**0.02**	**-.14**	**[-0.18, -0.10]**	**<.001**				
	Shift work	-.04	0.02	-.04	[-0.08, 0.00]	.068				
Step 3	Age	**-.08**	**0.03**	**-.08**	**[-0.13, -0.02]**	**.011**	.19	[0.15, 0.23]	.10	[0.06, 0.14]
	Gender	**-.13**	**0.02**	**-.13**	**[-0.17, -0.09]**	**<.001**				
	Shift work	**-.04**	**0.02**	**-.04**	**[-0.09, 0.00]**	**.041**				
	Self-control	**-.09**	**0.04**	**-.09**	**-0.18, -0.01**	**.032**				
Step 4	Age	**-.07**	**0.03**	**-.07**	**-0.13, -0.02**	**.012**	.20	[0.16, 0.24]	.00	[-0.04, 0.04]
	Gender	**-.13**	**0.02**	**-.13**	**-0.17, -0.09**	**<.001**				
	Shift work	**-.13**	**0.06**	**-.13**	**[-0.26, 0.00]**	**.049**				
	Self-control	**-.11**	**0.04**	**-.11**	**[-0.19, -0.03]**	**.014**				
	Shift work x self-control	.09	.07	.09	[-0.04, 0.22]	.171				
Step 5	Age	**-.07**	**0.03**	**-.07**	**[-0.13, -0.02]**	**.013**	.20	[0.16, 0.24]	.00	[-0.04, 0.04]
	Gender	**-.25**	**0.07**	**-.25**	**[-0.39, -0.10]**	**.001**				
	Shift work	**-.40**	**0.18**	**-.40**	**[-0.76, -0.04]**	**.029**				
	Self-control	**-.23**	**0.10**	**-.23**	**[-0.44, -0.01]**	**.041**				
	Shift work x self-control	.29	0.20	.29	[-0.10, 0.68]	.139				
	Shift work x gender	.30	0.20	.30	[-0.10, 0.70]	.142				
	Gender x self-control	.17	0.11	.17	[-0.06, 0.40]	.144				
	Shift work x gender x self-control	-.22	0.22	-.22	[-0.66, 0.22]	.315				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; $\sqrt{(\Delta R^2)}$[95%-CI] = confidence interval for $\sqrt{(\Delta R^2)}$

Table 5 (continued): Results of the hierarchical regression analyses with self-control as a moderator

		Preventive health care								
		b	SE b	Beta	[95%-CI]	*p*	R	R [95%-CI]	$\sqrt{(\Delta R^2)}$	$\sqrt{(\Delta R^2)}$ [95%-CI]
Step 1	Age	**.12**	**0.03**	**.12**	**[0.07, 0.17]**	**<.001**	.22	[0.18, 0.23]	.22	[0.18, 0.23]
	Gender	**.19**	**0.02**	**.19**	**[0.14, 0.24]**	**<.001**				
Step 2	Age	**.11**	**0.03**	**.11**	**[0.06, 0.17]**	**<.001**	.23	[0.19, 0.27]	.00	[-0.04, 0.04]
	Gender	**.19**	**0.02**	**.19**	**[0.14, 0.23]**	**<.001**				
	Shift work	**-.05**	**0.02**	**-.05**	**[-0.09, -0.01]**	**.011**				
Step 3	Age	**.08**	**0.02**	**.08**	**[0.04, 0.13]**	**.001**	.28	[0.24, 0.32]	.16	[0.12, 0.20]
	Gender	**.17**	**0.02**	**.17**	**[0.13, 0.21]**	**<.001**				
	Shift work	**-.04**	**0.02**	**-.04**	**[-0.08, 0.00]**	**.037**				
	Self-control	**.16**	**0.03**	**.16**	**[0.10, 0.23]**	**.000**				
Step 4	Age	**.08**	**0.02**	**.08**	**[0.04, 0.13]**	**.001**	.27	[0.23, 0.31]	.00	[-0.04, 0.04]
	Gender	**.17**	**0.02**	**.17**	**[0.13, 0.21]**	**<.001**				
	Shift work	.02	0.06	.02	[-0.10, 0.13]	.759				
	Self-control	**.17**	**0.03**	**.17**	**[0.10, 0.25]**	**.000**				
	Shift work x self-control	-.06	0.06	-.06	[-0.18, 0.05]	.285				
Step 5	Age	**.08**	**0.02**	**.08**	**[0.04, 0.13]**	**.001**	.27	[0.23, 0.31]	.00	[-0.04, 0.04]
	Gender	**.19**	**0.07**	**.19**	**[0.00, 0.26]**	**.044**				
	Shift work	.00	0.18	.00	[-0.35, 0.35]	.989				
	Self-control	.12	0.08	.12	[-0.03, 0.27]	.122				
	Shift work x self-control	.01	0.18	.01	[-0.34, 0.37]	.940				
	Shift work x gender	.01	0.20	.01	[-0.38, 0.40]	.945				
	Gender x self-control	.08	0.10	.08	[-0.12, 0.28]	.449				
	Shift work x gender x self-control	-.08	0.20	-.08	[-0.48, 0.32]	.696				

Note. SE = standard error; [95%-CI] = confidence interval for b and Beta; *p* = *p*-value; R[95%-CI] = confidence interval for R; $\sqrt{(\Delta R^2)}$[95%-CI] = confidence interval for $\sqrt{(\Delta R^2)}$.

Table 6: Correlations between subjective health and actual health behavior

		Smoking			Alcohol consumption			Preventive health care		
		r	*p*	p_{corr}	*r*	*p*	p_{corr}	*r*	*p*	p_{corr}
Shift workers	Subjective health	-.08	.500	1.00	-.06	.658	1.00	.11	.336	1.00
Day workers		-.13	.493	1.00	-.04	.823	1.00	.06	.596	1.00

Note. *r* = Pearson correlation coefficient; *p* = *p*-value; p_{corr} = Bonferroni correction *p*-value.

None of the interaction terms yielded significant results. However, adding self-control in addition to shift work as a predictor significantly predicted smoking behavior and led to a significant improvement of explained variance (β = -.10, 95%-CI[-0.17, -0.03], p = .014). Furthermore, the corresponding overall model significantly explained variance (F(1, 2,585) = 16.30, p <.001, R = .16, $\sqrt{(\Delta R^2)}$ = .10). Regarding alcohol consumption, self-control was a significant predictor and significantly improved explained variance (β = -.09, 95%-CI[-0.18, -0.01], p = .032). Again, the overall model significantly explained variance (F(1, 2,585) = 24.97, p <.001, R = .19, $\sqrt{(\Delta R^2)}$ = .10). Taking preventive health care into account, self-control also was a significant predictor and significantly improved explained variance (β = .16, 95%-CI[0.10, 0.23], p <.001). The overall model significantly explained variance (F(1, 2,585) = 53.65, p <.001, R = .28, $\sqrt{(\Delta R^2)}$ = .16).

As supplement material (see Table S5 and Table S6), we further provide analyses containing fluid intelligence, socio-economic status, and self-control in a single model.

Shift Work and Subjective Health

To investigate whether shift workers had a more negative perception of their subjective health than day workers, we conducted mean-difference analyses for shift versus day workers.

The compared groups did not differ significantly regarding the perception of their subjective health (t(2,588) = 0.84, 95%-CI[-4.35, 16.35], p = .408, d = -0.06). Mean evaluation of subjective health was -0.05 for the shift working group (SD = 1.01) and 0.01 for the day working participants (SD = 1.00).

Exploratory Analyses

To investigate the link between subjective health and actual health behavior and to further test additional assumptions that were not included in our original research project, we conducted several exploratory analyses. To highlight findings that could be of interest for future studies, an alpha level of .05 was assumed. Furthermore, Bonferroni correction was applied in all exploratory analyses to counteract an increase in alpha error.

Health Behavior and Subjective Health

An additional aim of the present study was to investigate the link between actual health behavior and subjective health in an exploratory fashion. As can be seen in Table 6, there was no significant relationship between subjectively reported health and health behavior.

Shift Work, Health Behavior, and Occupational Status

As previous research has frequently only considered select occupational groups, we also examine the link between shift work and health behavior for different occupational statuses. Subsequently, we investigated whether shift work had an influence only in certain (educational) shifts. In considering this, besides shift work, we also focused on occupational status. Table 7 shows the results from the ANOVAs conducted. The corresponding standardized and unstandardized mean values can be found as supplement material (Table S7 and Table S8).

As can be seen, none of the interaction terms yielded significant results. However, there was a significant effect of occupational status on smoking behavior (F(9, 2,571) = 6.694, Bonferroni correction p = <.001, η^2 = .01) and preventive health care (F(9, 2,571) = 5.62, Bonferroni correction p = <.001, η^2 = .01).

Differences between Shift and Day Workers Regarding Their Health Behavior

To further exploratory investigate whether shift workers and day workers differed regarding their health behavior, we conducted mean-difference analyses.

The compared groups significantly differed regarding their smoking behavior (t(570.547) = -4.49, 95%-CI[0.16, 0.36], p_{corr} = <.001, d = 0.25) as well as their preventive health care behavior (t(2,588) = 3.41, 95%-CI[0.08, 0.28], p_{corr} = <.001, d = 0.18). Mean of the shift working group was 0.22, respectively -0.15 (SD = 1.12, respectively SD = 0.99) and -0.04, respectively 0.03 for the day working participants (SD = 0.97, respectively SD = 1.00). The groups did not differ significantly regarding their alcohol consumption (t(646.221) = 1.37, 95%-CI[-0.03, 0.17], p_{corr} = .258, d = 0.07). Mean of the shift working group was -0.06, (SD = 0.94) and 0.01 for the day working participants (SD = 1.01).

Table 7: Results of the ANOVAs including occupational status and shift work

	Smoking					Alcohol consumption					Preventive health care				
	$F(\eta^2)$	p	p_{corr}	R	R [95%-CI]	$F(\eta^2)$	p	p_{corr}	R	R [95%-CI]	$F(\eta^2)$	p	p_{corr}	R	R [95%-CI]
Occupational status	**6.94 (.01)**	**<.001**	**<.001**			1.29 (.00)	.272	1.00			**5.62 (.01)**	**<.001**	**<.001**		
Shift work	3.10 (.00)	.078	.702	.16	[0.12, 0.20]	0.06 (.00)	.807	1.00	.10	[0.06, 0.14]	2.52 (.00)	.113	1.00	.14	[0.10, 0.18]
Occupational status x shift work	0.92 (.00)	.451	1.00			0.52 (.00)	.721	1.00			0.54 (.00)	.706	1.00		

Note. F = F-distribution; η^2 = Eta-squared; p = p-value; p_{corr} = Bonferroni correction p-value; R[95%-CI] = confidence interval for R.

Discussion

The present work aimed to replicate and expand previous findings on the relationship between shift work and health behavior (namely, smoking, alcohol consumption, and preventive health care) by testing for potentially moderating effects of fluid intelligence, socio-economic status, and self-control. Bearing in mind the recommendations by Funder and Ozer (2019) mentioned earlier, our findings do not support our hypotheses that non-standard work schedules are associated with any of the investigated health-related behavior patterns. Although – in line with our hypotheses – shift work was found to be a significant predictor of smoking and preventive health care, effect sizes revealed that shift work was not a meaningful predictor of any of the investigated outcomes. Associations between shift work and health behavior patterns were small. Moreover, when adding interaction variables to the model, the associations between shift work and smoking, respectively preventive health care, did not remain significant. However, neither the moderation analyses nor the examination of subjective health showed significant associations. Fluid intelligence, socio-economic status, and self-control significantly predicted some of the relevant health-related behavior patterns (e.g., smoking). Effect sizes revealed that these associations were small to medium.

In sum, our results do not support the assumption that shift work (still) has that direct impact on health behavior many earlier researchers postulated (for an overview, see Zhao & Turner, 2008). Nevertheless, our results are partly consistent with former findings (e.g., Gordon et al., 1986; Kivimäki et al., 2001; Nakamura et al., 1997; Romon et al., 1992). Kivimäki and colleagues (2001), for instance, also reported small effect sizes regarding their association between shift work and smoking (d = .19 / r = .09) as well as between shift work and heavy drinking (Odds $\text{Ratio}_{\text{women}}$ = 1.22, respectively Odds $\text{Ratio}_{\text{men}}$ = 1.55). In a former study, Knutsson and Nilsson (1998) investigated both men and women across six different shift systems and found that shift work was significantly associated with current smoking – but also reported a small effect size (Odds Ratio = 1.30). Moreover, in a recently conducted longitudinal study, Ramin and colleagues (2015) found comparable associations between shift work and smoking (Odds Ratio = 1.30). It should be noted, however, that – especially in the context of health – even small enhancements or deteriorations can be of interest for employees, employers, politics, as well as the health system as a whole, particularly since these findings have been reported in independent studies.

There are several possible explanations for the results described above. First, it is conceivable that social change towards a healthier lifestyle or country-specific regulations on, for example, tobacco consumption (e.g., rising prices for cigarettes or warnings on cigarette packs) have meant that negative health behavior such as smoking today is not (any longer) such an attractive means of coping with stress – neither for day workers nor for shift workers (smoking rates in Germany have steadily decreased since 2000; Statista, 2019a). Concerning alcohol consumption, there has been similarly intense social efforts to reduce harmful consumer behavior (e.g., The 1984 National Minimum Drinking Age Act, which allows the purchase of alcohol only from the age of 21).

It is further conceivable that shift work in Germany is not such a stressful working condition due to, for instance, better regulations by law (e.g., rest period regulation between working days; Arbeitszeitgesetz (ArbZG) § 5 Ruhezeit, n.d.). This might further imply that potential effects on health behavior may rather be an effect of working conditions than an effect of shift work per se. This assumption is also supported by numerous findings in the occupational group of nurses (e.g., Kivimäki et al., 2001; Trinkoff & Storr, 1998). It is possible that this occupational group is particularly affected because, in addition to working shifts, they are also exposed to the stress of dealing with (dead) sick people. Since special characteristics of the working conditions as well as the social and market system could crucially contribute to explain effects on health behavior, they should at best be taken more into account in the future. The present study tried to shed first light on this by exploratory taking occupational status into account. As mentioned before, we did not find any interaction effects. However, since the degree of granularity is limited in our study because no specific occupational groups are covered, future work should also cover select occupational groups and assess how stressful working conditions are.

In addition, healthcare legal conditions could play a crucial role. The many different services offered by health insurance companies, which are legally obliged to insure in Germany, could help employees under potentially stressful working conditions to compensate for stress through better strategies rather than unhealthy behavior. Moreover, as we did not assess how long the participants in our sample have been working shifts so far, it cannot be completely excluded that the results were at least partly due to the "healthy worker effect"[6]. It would therefore be possible that especially those employees who were already affected or diseased have already left shift work.

Based on the present findings, however, shift work does not seem to be meaningfully related to negative (namely, smoking and alcohol consumption) or positive (namely, preventive health care) health behavior patterns. Nevertheless, as even the non-confirmation of hypotheses leads to a gain in knowledge, the present work can contribute to an understanding of the relationship between shift work and health behavior. In sum, it seems that working shifts per se has no effect and that certain (working) conditions or legal law regulations may be met in order to contribute to the explanation of health behavior.

With regard to the associations between fluid intelli-

6 The so-called "Healthy Worker Effect" means that those with a better state of health are over-represented in the assessment of health in the organizational context because those with a worse state of health are more likely to be excluded from employment (for more information, see Li & Sung, 1999; Shah, 2009).

gence, socio-economic status, and self- control, the effects found in the present work were of a small (e.g., associations between self-control and smoking) to medium (e.g., association between self-control and preventive health care) magnitude. This is partly in line with previous work that has continuously reported small to medium associations between, for instance, self-control and health-related outcomes such as smoking or (excessive) alcohol consumption (Daly et al., 2016; Geist & McNew Herrmann, 1990). However, evidence is mixed because some studies have reported large to very large associations. In their meta-analysis, Bogg and Roberts (2004) reported self-control to be one of the two strongest predictors for various health behaviors such as tobacco and excessive alcohol consumption – with effect sizes ranging between r = -.21 for tobacco use and r = -.29 for alcohol use. In a recently conducted study, Hagger and colleagues (2019) found large to very large associations between self-control and alcohol consumption (r = -.35) or impulsive drinking (r = -.40). Although our results do not resolve the question of the association between certain person-related factors such as fluid intelligence and self-control, they may inform for future research. To sum up, the present article not only replicates former findings, but also expands current knowledge with regard to preventive health care as a rather positive health-related behavior pattern and, hence, indicates avenues for future research.

Constraints on Generality (COG)

It must be noted that the generalizability of the present findings might be restricted due to international differences regarding labor or health policies and health care systems. As mentioned earlier, Germany is a country with broad regulations both regarding the labor law to protect the health and well-being of employees as well as health policies to protect health and well-being of every individual. For instance, labor law regulations in Germany are rooted at the country level and, thus, apply equally to all federal states – whereas in the USA, for example, such regulations can vary from state to state. Moreover, in Germany, there is a highly developed health care system that is – in its basic and many additional services – mostly independent of one's financial or social standing and provides a low-threshold service for every citizen. The statutory health insurance represents an essential part of this health care system. In addition, since 2009, health assurance has been mandatory for all citizens residing in Germany (for more detailed information on the German health care system, see Busse & Blümel, 2017). This means that a solid health care system is provided equally for everyone and only a number of additional services are not covered by the insurer and must be paid by the insured person itself. Thus, the results found in this study may not be applicable to other countries with less strict labor protection laws and health policies or with lower availability of healthcare services and more difficult accessibility to the healthcare system for every individual.

Strengths and Limitations

The present research has several strengths. In our view, the major aspect is the broad sample, which had a positive effect on the power of the study. Our sample is based on a nationwide collected sample that does not exclude any occupational group from the outset.

As with any study, there are some limitations that deserve attention and further provide ideas for future research. Another concern is about the reliability of the data because they are assessed as self-reports and not through more objective measures. This carries the risk of participants declaring their consumption to be lower than it actually is. Moreover, although not untypical for very short scales, the internal consistency for our three-item self-control measure is rather low. Unfortunately, time constraints prevented the use of the full 13-item inventory (SCS-K-D; Bertrams & Dickhäuser, 2009). A further limitation can be seen in the categorical nature of the question regarding shift work (yes versus no), since no information on, for example, the specification of the concrete shift duty or shift rhythm was gathered. It is conceivable and – due to the nature of the survey in this paper – cannot be excluded that an (moderating) effect of the shift system exists.

Implications

The present study was conducted due to the practical relevance of the topic, above all in the sense of increasing knowledge for future decisions with regard to labor law and improving the health of shift workers. The results of the present study indicate, however, that shift work does not meaningfully contribute to the prediction of health behavior. This implies that potential interventions in the field of occupational health management should be of a more general nature. In this regard, a number of possible precautionary options and interventions are conceivable, which should be designed as broadly as possible and, above all, low-threshold.

Conclusion

In conclusion, our study expanded the understanding of the relationship between shift work and health behavior. In sum, effect sizes challenge the relevance of shift work as a predictor of any health behavior investigated. Neither fluid intelligence nor socio-economic status or self-control were found to be moderators. These findings indicated that other variables may play a crucial role in predicting health behavior of (shift) workers. Moreover, when investigating subjective perceptions of health in shift and day workers, the compared groups did not differ. Investigating actual health behavior and subjectively perceived health indicated no relationships for any health-related behavior pattern. Although our results do not resolve the initial question concerning the relationship between shift work and health behavior entirely, our results make an important contribution to research in this area as they expand the understanding of this complex association and further raise new questions that have to be solved in the future. Although shift work as a working condition plays no meaningful role in explaining harmful health behavior patterns, it is conceivable that there may be other effects on the individual level. Subsequently, it is important to foster positive health behavior patterns of both shift and day workers through labor law or corporate interventions.

Author Contributions

All authors contributed to the study concept and design. Statistical analyses were performed by MAB. FMS is member of the PI-team of the TwinLife study. Results were discussed with EH and FMS. MAB drafted the manuscript and all remaining authors provided critical revisions. All authors approved the final version of the manuscript.

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Competing Interests

The authors have no competing interests to declare.

Data Accessibility Statement

The previous study was pre-registered on 11/12/2018 at www.osf.io (doi:10.17605/OSF.IO/2H4G5). Data syntax and supplementary material can be found at the osf-repository. The scientific usefile of the TwinLife data is available at Gesis (doi:10.4232/1.13208).

Supplementary Materials

Table S1. Descriptive statistics and correlations for the study variables

Table S2. Results of the hierarchical regression analyses with fluid intelligence as a moderator for the unstandardized variables (except for age and gender)

Table S3. Results of the hierarchical regression analyses with socio-economic status as a moderator for the unstandardized variables (except for age and gender)

Table S4. Results of the hierarchical regression analyses with self-control as a moderator for the unstandardized variables (except for age and gender)

Table S5. Results of the hierarchical regression analyses with fluid intelligence, socio-economic status, and self-control (standardized variables)

Table S6. Results of the hierarchical regression analyses with fluid intelligence, socio-economic status, and self-control (unstandardized variables except for age and gender)

Table S7. Standardized mean values of health behavior in the compared groups

Table S8. Unstandardized mean values of health behavior in the compared groups

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