

Myopia prevention, near work, and visual acuity of college students: integrating the theory of planned behavior and self-determination theory

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Received: September 26, 2012 / Accepted: January 25, 2013 / Published online: February 13, 2013
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Abstract There has been little research examining the psychological antecedents of safety-oriented behavior aimed at reducing myopia risk. This study utilizes self-determination theory (SDT) and the theory of planned behavior (TPB) to understand the role of motivational and social-cognitive factors on individuals' near-work behavior. Adopting a prospective design, undergraduate students ($n = 107$) completed an initial questionnaire based on SDT in week 1, a second questionnaire containing measures of TPB variables in week 2, and objective measures of reading distance and visual acuity in week 6. The data were analyzed by variance-based structural equation modeling. The results showed that perceived autonomy support and autonomous motivation from SDT significantly predicted attitude, subjective norm, and perceived behavioral control from the TPB. These social-cognitive factors were significantly associated with intention and intention significantly predicted reading distance. The relationships in the model held when controlling for visual acuity. In conclusion, the integrated model of SDT and the TPB may help explain myopia-preventive behaviors.

Keywords Autonomy support · Motivation · Intention · Reading behavior · Nearsightedness

Introduction

More than a hundred million people suffer from visual impairment caused by some form of uncorrected refractive error (Resnikoff et al., 2008). Myopia is one of the most common types of visual impairment and reduces the clarity of individuals' distance vision (other types include as hyperopia and astigmatism; Morgan, 2003). The prevalence of myopia has been increasing over the last few decades (Fredrick, 2002; Matsumura & Hirai, 1999; Saw et al., 1996), and near work (i.e., working in close proximity to a visual target such as reading a book closely), has been widely accepted and shown in epidemiological studies to be the antecedent of the onset and progression of myopia (Hepsen et al., 2001; Ip et al., 2008; Rosenfield & Gilmartin, 1998; Saw, 2003; Saw et al., 1996). The proposed causal mechanisms behind near work and myopia, including axial elongation and ciliary muscle tonus, are all attributed to continuous and extended accommodation during close-up work (Chen et al., 2003; Ciuffreda & Vasudevan, 2008; Fredrick, 2002), thus reducing the accommodation demands (e.g., reading further away, using reading glasses, and having breaks during extended period of near work) is highly recommended for myopia control. Recognizing the fact that the increased use of computers in everyday working life and in the educational system have dramatically heightened the frequency of near work, modifying the distance between the eye and the visual target during near work might be one of the feasible solutions in the prevention of myopia. From this perspective, near work should be viewed as a self-regulatory

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behavior that is dependent on human factors, such as motivation and social-cognitive beliefs. To empirically test this premise, the present study aims to apply a psychosocial model integrating the theory of planned behavior (Ajzen, 1985) and self-determination theory (Deci & Ryan, 1985) to explain motivation and intention to maintain an appropriate reading distance when engaged in near work.

The theory of planned behavior is a prominent social-cognitive model that has been frequently applied in behavioral medicine to explain the proximal social-cognitive, decision-making, and action planning processes that underpin peoples' health-related behavior (Ajzen, 1985, 1991). It posits that engagement in future behavior is governed by one's intention. Intention reflects the behavioral orientation and commitment towards a future action, and is proposed to be predicted by three belief-based social-cognitive variables [i.e., attitude, subjective norm, and perceived behavioral control (PBC)]. Attitude reflects an individual's personal evaluation of performing a target behavior in the future and subjective norm represents the perceived social appropriateness of the behavior. PBC reflects an individual's perceived capacity to engage in the behavior. According to the theory, the effect of these variables on behavior is proposed to be mediated by intention, with the exception of PBC which is also proposed to influence behavior directly. Even though a substantial amount of research in health behavior has led to support for the predictive validity (McEachan et al., 2011) and application (Hardeman et al., 2002) of the theory of planned behavior for numerous health behaviors, three shortcomings have been frequently identified in the literature which potentially reduce the predictive power and utility of the theory (Bagozzi, 1982). First, the theory does not identify the more superordinate and global cognitive variables that can explain the origin of its constituent variables. Second, the model does not account for how general motives serve as sources of information to direct the social-cognitive processes. Third, the social and environmental factors associated with the formation of the theory of planned behavior variables are not explicitly outlined. Thus, a growing amount of research has attempted to overcome these problems by integrating self-determination theory into the theory of planned behavior. (Hagger, 2009; Hagger & Chatzisarantis, 2009; Hagger et al., 2002a, 2006).

A central premise of self-determination theory is the distinction between three different forms of motivation: autonomous motivation, controlled motivation, and amotivation (Deci & Ryan, 1985; Ryan & Deci, 2000). Autonomous motivation reflects motivation to engage in a behavior consistent with a sense of volition, choice, and

personal agency over action. In contrast, controlled motivation reflects motivation to act determined primarily by external contingencies such as demands, rewards, or social pressure, or to avoid compromising outcomes that threaten contingent self-esteem leading to shame and guilt. On the other hand, amotivation indicates a lack of purpose or reason for behaving. Such differentiation of motivation is important because autonomous motivation is an adaptive form of motivation relative to controlled motivation and amotivation. Research has consistently revealed significant links between autonomous motivation and behavioral perseverance in various health contexts (e.g., physical activity, smoking cessation, diabetic control, and dental care; Halvari et al., 2010; Silva et al., 2010; Williams et al., 2006, 2007). According to self-determination theory, autonomous motivation can be fostered through autonomy-supportive behaviors offered by significant others in the social environment. A perception of autonomy-supportive behaviors (i.e., perceived autonomy support) from significant others, such as the provision of choice and a personal rationale for doing a behavior, acknowledging the perspective of the individual, and providing competence-related feedback, have all been shown to promote autonomous motivation (Reeve & Jang, 2006). Autonomy support has received considerable amount of supporting evidence in the health care contexts for the promotion of autonomous motivation (Halvari et al., 2010; Silva et al., 2010; Williams et al., 2006, 2007).

The integration of the theory of planned behavior and self-determination theory stipulates that the motivational variables from self-determination theory are distal factors that exert effects on the proximal social-cognitive variables from the theory of planned behavior. (Hagger & Chatzisarantis, 2009; Hagger et al., 2002a, 2006). This tenet has been examined in a number of health-related contexts such as the prevention of injury (Chan & Hagger, 2012a, b, c), reduction in binge drinking (Hagger et al., 2012a, b), promotion of adherence to regular physical activity (Hagger et al., 2002a, 2006), maintenance of healthy eating (Hagger et al., 2002a, 2006), and sleep hygiene (Kor & Mullan, 2011). A recent meta-analysis (Hagger & Chatzisarantis, 2009) also confirmed the premises in the integrated model across a number of studies, that the effect of perceived autonomy support on attitude, subjective norm, and PBC was fully mediated by the motivational constructs from self-determination theory, and that the three theory of planned behavior variables mediated the effect of the motivational variables from self-determination theory on intention and health behavior. Yet, no previous study has tested the motivational sequence proposed in this model in myopia prevention, regardless of the growing prevalence of myopia (Fredrick, 2002; Matsumura & Hirai, 1999; Saw et al., 1996) and how severely this visual deficiency neg-

actively impacts on quality of life (Resnikoff et al., 2008; Saw, 2003).

Present study

Our study is the first investigation that integrates the theory of planned behavior and self-determination theory into a unified model to explain myopia-preventive behaviors (i.e., near work). It is also a preliminary investigation of the model that prospectively examines individual’s natural behavioral pattern with an objective measure of behavior specifically designed for the current study to measure reading distance during near work (c.f., Hagger & Chatzisarantis, 2009). We tested the model in China where the nation has one of the highest incidences of myopia in the world (Keeffe et al., 2002; Saw, 2003) and the government has regarded vision care a primary issue in community healthcare development since the 1990s (Lai, 2002). More importantly, it is widely accepted among parents, schools, and healthcare professionals in China that maintaining healthy reading habits (e.g., reading in an optimal distance with adequate lighting) is a way to minimise visual impairments (Sang et al., 2007; Zhang et al., 2011). Based on the theory of planned behavior, self-determination theory, and previous research on the integration of the two theories (Chan & Hagger, 2012a, b, c; Hagger & Chatzisarantis, 2009; Hagger et al. 2002a), we propose a motivational sequence in which (1) perceived autonomy support from most salient interpersonal source relevant to visual impairment prevention (e.g., optician, parent etc.) exerts positive effects on attitude, subjective norm, and PBC (belief-based social-cognitive variables) through the mediation of autonomous motivation; (2) effects of perceived autonomy support on controlled motivation and amotivation are either negative or non-significant; (3) the positive effect of autonomous motivation on intention is mediated fully by the three belief-based social-cognitive variables; (4) effects of controlled motivation and amotivation on intention are either negative or non-significant; and (5) the three belief-oriented social-cognitive variables are positively related to reading distance through the mediation of intention (full mediation for attitude and subjective norm, and partial mediation for PBC). Visual acuity serves as a control variable in our model because the causal link between visual acuity and reading distance is theoretically reciprocal. Specifically, years of near work may impair visual acuity (Matsumura & Hirai, 1999; Morgan, 2003), but visual acuity directly determines the maximum viewing distance for clear vision (Ferris & Bailey, 1996; Ricci et al., 1998), and visual acuity is a clinical function that might exert its effects on the psychological variables

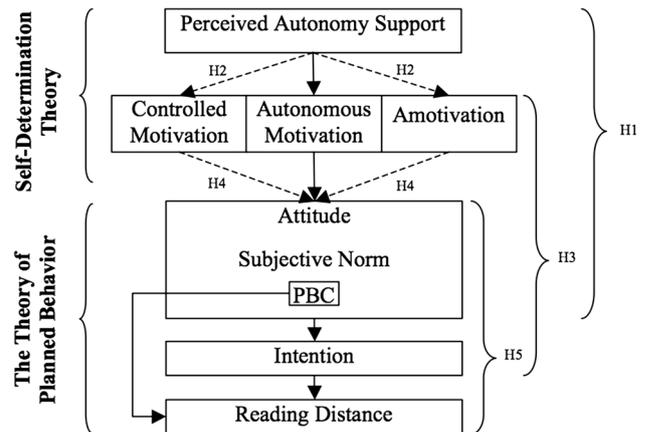


Fig. 1 The hypothesized model. *Note.* H1 to H5 indicate the paths or mediation pathways of hypothesis 1–5. The normal vectors are hypothesized to be positive and significant, and the dotted vectors are hypothesized to be negative or non-significant. Distance visual acuity and near visual acuity are hypothesized control variables and set to predict all of factors in the model

associated with near work. See Fig. 1 for the hypothesized model.

Method

Participants and procedures

Subsequent to the approval of the study by the Research Ethics Committee of the first author’s institution, invitations to participate in the study were sent to 120 undergraduate students who attended a *Sport Psychology* course at the Chengdu Sport University in China. They received information about the general purpose and procedures of the study and their participation rights (i.e., voluntary nature, right to withdraw, confidentiality). One hundred and seven respondents (response rate 89.17 %; mean age = 21.14, SD = 2.98 years; age range, 18–22 years; 79.40 % male) agreed to participate and signed consent forms. Participants spent a considerable amount of time on near work during the week, such as revision of lecture notes (mean = 6.30 h/week, SD = 7.62), homework (mean = 4.73 h/week, SD = 6.05), reading textbooks (mean = 6.78 h/week, SD = 7.71), working on a computer (mean = 24.73 h/week, SD = 20.40), and playing video games (mean = 10.07 h/week, SD = 14.65). They did not have any major visual disability, but a number of them wore prescribed spectacles for myopia (32.70 %), hyperopia (10.30 %), or/and astigmatism (0.90 %). The participants either regarded maximizing reading distance (90.1 %) and/or avoiding close-up reading (i.e., reading too closely from the source reading material; 86.4 %) as important ways to prevent myopia. To reduce response

burden and common method variance (Doty & Glick, 1998), respondents were asked to complete a questionnaire measuring self-determination theory variables and demographic items at baseline, and another questionnaire measuring the theory of planned behavior variables in the following week. Adopting a prospective design, we assessed the reading distance and visual acuity of participants in a laboratory 1 month after their completion of both questionnaires. A trained experimenter was responsible for delivering and collecting the questionnaires at the two time-points, and for running the laboratory assessments with the help of two research assistants. Participants who did not return the follow-up questionnaire or did not show up during the laboratory appointments were given reminders and were provided with opportunities to complete the assessment in the following day. As a result, dropout was not observed in the study. The native language of the participants was Chinese, so the questionnaires, scale instructions, and study information were either translated from their original English versions into Chinese using standardized back-translation procedures (Hambleton, 2005) or adapted from the Chinese versions developed in a previous study (Chan & Hagger, 2012c).

Measures

Psychological variables

The Health Care Climate Questionnaire (HCCQ; Williams et al., 1996) was used to assess the perceived autonomy support for eye protection and care. The HCCQ has been frequently used to assess perceived psychosocial environment conceptualized by the self-determination theory in clinical (e.g., physiotherapy (Chan et al., 2009) and diabetes care (Williams et al., 2007)) and non-clinical (e.g., physical activity and weight control; Silva et al., 2010) health care contexts. This study adopted the six-item Chinese version of the HCCQ validated in previous studies (Chan & Hagger, 2012a; Chan et al., 2011). The items were modified for use in the context of vision care (e.g., “I feel that he/she provides me choices and options about how to protect my eyes”), and participants responded to the items with reference to the most important person (66.4 % parents; 28.0 % optometrists; 5.6 % physicians) who had talked to them about eye protection on seven-point Likert-type scales ranging from 1 (“strongly disagree”) to 7 (“strongly agree”). A one-way ANOVA did not reveal any significant difference between the scores corresponding to parents, optometrists, and physicians [$F(2, 88) = 0.57, p = .57, \eta_p^2 = .01$], so we did not conduct separate analyses for each type of social agent.

The Treatment Self-Regulation Questionnaire (TSRQ) was used to measure participants’ motivation for myopia prevention. The TSRQ has been adapted for use in different

health contexts, such as prescribed weight control or smoking cessation programs (Levesque et al., 2007), and received support for its reliability and validity. In this study, we developed the myopia prevention version of the TSRQ based on a Chinese version of TSRQ validated in an injury preventive context (Chan & Hagger, 2012c). The three dimensions, namely, autonomous motivation (6 items; e.g., “I want to prevent myopia because I personally believe it is the best thing for my eyes”), controlled motivation [6 items; e.g., “I want to prevent myopia because I would feel guilty or ashamed of myself if I became (more) short-sighted”], and amotivation (3 items; e.g., “I really don’t think about preventing myopia”) for myopia prevention, were rated on a 7-point Likert-scale ranging from 1 (“not at all true”) to 7 (“very true”).

The theory of planned behavior variables, including attitude, subjective norm, and PBC of the target behavior (i.e., reading at optimal distance), were developed according to Ajzen’s guidelines (Ajzen, 2002). Items measuring attitude were preceded by the common stem, “Reading at an optimal distance from the reading material in the forthcoming month is ...” and participants’ responses were made on six seven-point semantic differential scales with the following bi-polar adjectives: “valuable–worthless”, “beneficial–harmful”, “pleasant–unpleasant”, “enjoyable–unenjoyable”, “good–bad”, and “virtuous–not virtuous”. Measures of subjective norm (three items; e.g., “Most people who are important to me think that I should read at an optimal distance from the reading material in the forthcoming month”), PBC (five items; e.g., “It is possible for me to read at an optimal distance from the reading material in the forthcoming month”), and intention (three items; e.g., “I intend to read at an optimal distance from the reading material in the forthcoming month”) were rated on seven-point Likert-type scales ranging from 1 (“strongly disagree”) to 7 (“strong agree”).

Reading distance

Our primary dependent variable was reading distance measured objectively during a novel reading task in laboratory conditions. The task was to read out 18 upper-case alphabetical letters (i.e., the reading material) as quickly and accurately as possible. The letters were printed in *Sloan* font (the letters used in standard visual acuity tests with consistent proportion and visibility; Pelli et al., 1988) on non-reflective photo-papers with a resolution of 300dpi (see Fig. 2). The reading distance test was preceded by a



Fig. 2 Example reading material for the reading distance test

“practice trial” of the task, where participants could freely adjust the reading distance in the range between 40 and 1,340 mm (by rolling the pulley) until they felt that it was their optimal reading distance. The reading distance was then recorded when the participants were reading out the letters in the “test trial” in which the reading distance was not allowed to be changed.

We used a purpose-built apparatus constructed by a biomechanical engineer to measure participants’ natural reading distance in a highly-controlled laboratory setting (see Fig. 3). Reading distance was assessed by an ultrasound distance sensor (Keyence UD-300; range = 20–1,300 mm) attached at the bottom of the apparatus which simultaneously detected the distance between participants’ eye and the reading material. The laboratory was insulated from external lights, such that the LED light on the apparatus provided a consistent luminance (158–166 cd/m² measured at 4 corners) to the reading material regardless of reading distance. The reading distance measured by our apparatus was calibrated using the measurement taken from video motion capturing system (VICON, UK).

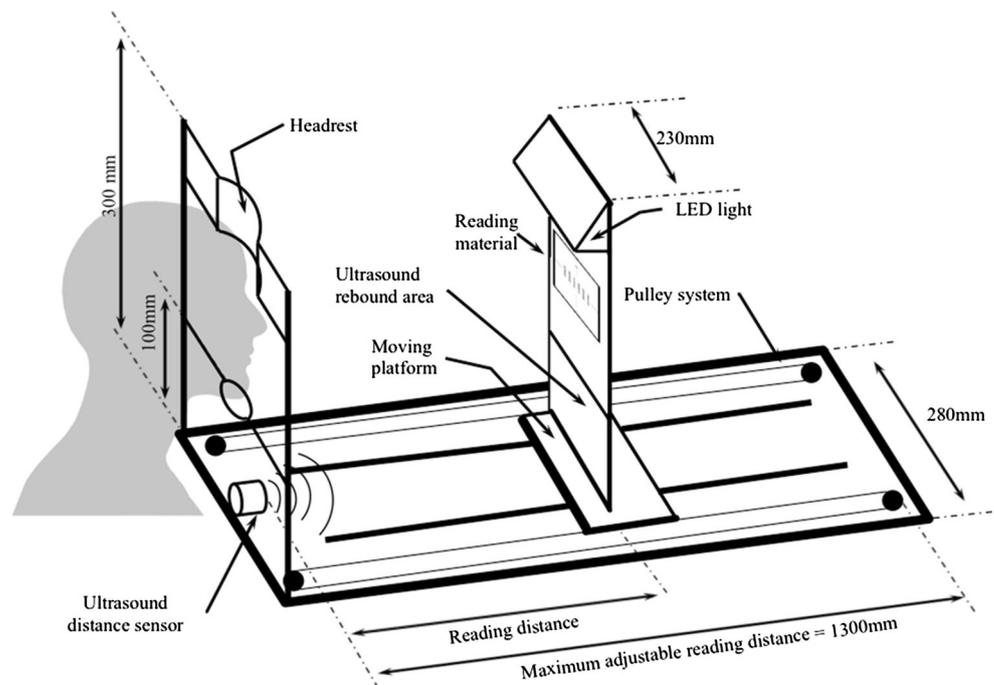
We examined the reading distance for five different font sizes (M0.25, M0.5, M1, M1.5, and M2; equivalent to font sizes of 2, 4, 8, 12, and 16 points respectively), and each font size was tested twice. To minimize practice effect, the letter combination for each trial was unique and participants were asked to close their eyes between the trials. The order of the font sizes was also counter-balanced to control for order effects. We then took the standardized reading distance measured at each trial as an indicator of the

overall reading distance in the analysis. Participants were allowed to perform the test with their own prescribed spectacles (a total of 21 participants did; 19.6 % of the sample), but we did not statistically control for this variable because we did not find a significant difference of the reading distance between the participants who completed the test with or without spectacles [$t(105) = 0.30$; $p = 0.92$, $d = .06$].

Visual acuity

Two types of visual acuity (distance acuity and near acuity; Ricci et al., 1998) were assessed in a laboratory with standard lighting. Distance visual acuity was examined using the two logMAR ETDRS-revised charts (chart 1 for right eyes and chart 2 for left eyes; Cat No. 212, Sussex Vision Ltd., UK) at a viewing distance of 4.0 m. Near visual acuity was measured using logMAR ETDRS double-sided near-vision card (side-1 for right eyes and side-2 for left eyes; Cat No. 210-6, Sussex Vision Ltd., UK) at a viewing distance of 40.0 cm. The luminance at the centers and the four corners of the charts ranged from 162 to 180 cd/m² and was thus considered acceptable for standard measurement of visual acuity (Ferris & Bailey, 1996). Participants read the charts from the top to bottom until 2 or more letters were misread on a line, and a logMAR score was recorded from the lowest line on the chart at which participants could correctly identify three of the five letters (Ferris & Bailey, 1996; Ricci et al., 1998). For statistical analysis, we transformed the logarithmic progressive logMAR score into a linear visual acuity score by subtracting

Fig. 3 The apparatus for measuring reading distance. Note. The height of the reading material was adjusted to match participants’ eye level so that the visual angle (horizontal) was standardized



10^{logMAR} [i.e., MAR (Ricci et al., 1998)] from 101, so that normal vision (i.e., denoted as 20/20 in Snellen chart or 0.0 logMAR) and near blindness (i.e., 20/2,000 in Snellen chart or 2.0 logMAR) were indicated by a visual acuity score of 100 and 0 respectively.

Deception

In order to reduce response bias in our assessment of the psychological and behavioral variables, participants were informed that we were primarily interested in students' learning motivation and reading speed. As part of the cover story, the self-determination theory, theory of planned behavior, and demographic items relating to myopia prevention in the questionnaires and the visual acuity test were described as measures of control variables, and the two questionnaires also embraced items of learning based on both theories. The reading distance test was framed as a test of reading speed and the ultra-sound device was described as a sound recorder for recognizing the speed and accuracy of participants' speech. As a manipulation check of the deception, participants were asked to write down the purpose of the study at the end of the experiment, and none of their responses indicated that reading distance was measured. All the participants were formally debriefed about the true purpose of the study at the end of the experiment and were provided opportunity to withdraw their data. None of the participants expressed a wish to do so.

Analysis

The data were analyzed by variance-based structural equation modeling (VB-SEM) using the SmartPLS 2.0 statistical software (Ringle et al., 2005). VB-SEM is able to force measurement error to zero by constructing latent factors, and its model estimation based on a partial least-squares algorithm (as opposed to the typical ordinary least-squares algorithm used in multiple regression) is supposed to be distribution-free (i.e., the estimation is not affected by the complexity of the model, small sample size, or non-normality of the data) making it ideal for use with the current data set (Reinartz et al., 2009). In addition, the convergent and discriminant validity of the hypothesized factors could be evaluated using a number of indices (i.e., factor loadings, cross-loadings, average variance extracted (AVE), composite score reliability, and Cronbach's alpha) taken at the measurement level of the model. A goodness of fit (GoF) index was computed to reveal the global fit of the model to the data (Tenenhaus et al., 2005). To verify the robustness of model, a bootstrapping resampling technique with 5,000 replications was utilized to estimate

reliable averaged path estimates and associated significance levels.

Mediation analysis was conducted to test the proposed mediation effects in the hypothesized model. A significant mediation effect was evidenced by significant direct and total indirect effects (Aroian, 1947) of the independent variable in question on the dependent variable (Zhao et al., 2010). The type of mediation was determined by whether the direct effect of the independent variable on the dependent variable was not significant (indication of full mediation) or significantly reduced (indication of partial mediation) when controlling for the effect of the mediator (Zhao et al., 2010). Furthermore, we examined the partial indirect effects of each mediator by Preacher and Hayes' (2008) resampling strategies when two or more mediators were involved in the mediation pathways.

Results

The fit indices of the VB-SEM fully supported the convergent and discriminant validity of the proposed model in the current data. The Cronbach's alpha (range = 0.70–0.99), composite score reliability (range = 0.78–0.99), AVE (range = 0.50–0.85), and factor loadings (range = 0.61–0.95) of each factor met published criteria for acceptable convergent validity. Similarly, the fit indices revealed acceptable level of discriminant validity. The loadings for the items on each factor were higher than the cross-loadings by an average of 0.65 (range = 0.44–0.93), and the square-root of the AVE of any construct was higher than its correlation with other constructs by an average of 0.64 (range = 0.42–0.90). The goodness-of-fit of the model was .38, which exceeded the proposed criteria for a well-fitting model (.10, .25, and .36 for small, medium, and large effect sizes, respectively) for VB-SEM (Pauwels et al., 2009). Table 1 displays the zero-order correlation matrix, descriptive statistics, and details of the validity indices for each factor.

The bootstrapped estimates and significance levels of the paths in our hypothesized model are presented in Fig. 4. Perceived autonomy support formed significant positive associations with autonomous motivation and controlled motivation, but its relationship with amotivation was not significant. Attitude, subjective norm, and PBC were significantly and positively predicted by autonomous motivation¹, and these variables had significant positive relationships with intention², but their associations with

¹ Autonomous motivation was responsible for 72.19, 65.52, and 42.08 % of the total explained variance of attitude, subjective norm, and PBC, respectively.

² Attitude, subjective norm, and PBC were responsible for explaining 13.87, 49.05, and 15.73 %, respectively, of the total variance of intention.

Table 1 Correlation matrix, descriptive statistics, and fit indices of the proposed integrated model

	A-support	Auto-mtv	Cont-mtv	Amotv	Attitude	Norm	PBC	Intention	Distance	VA-dis	VA-near
A-support	–										
Week 1 Auto-mtv	0.43**	–									
Cont-mtv	0.40**	0.48**	–								
Amotv	–0.10	–0.21*	0.29**	–							
Week 2 Attitude	0.20*	0.45**	0.13	–0.28**	–						
Norm	0.18*	0.37**	0.21*	–0.17	0.42**	–					
PBC	0.22*	0.35**	0.17	–0.06	0.44**	0.37**	–				
Intention	0.25*	0.42**	0.28**	–0.04	0.55**	0.60**	0.50**	–			
Week 6 Distance	0.13	0.18	0.11	–0.05	0.23*	0.16	0.31**	0.38**	–		
VA-dis	0.08	–0.01	–0.09	–0.04	0.03	–0.01	–0.11	0.18	0.23*	–	
VA-near	0.01	0.02	0.06	–0.05	0.11	0.13	0.34**	0.12	0.11	0.50**	–
Mean	4.88	5.41	4.18	3.14	5.61	5.48	4.83	4.92	0.00	92.67	99.29
SD	1.37	1.10	1.22	1.61	1.10	1.06	1.39	1.72	0.95	2.90	1.96
α	0.79	0.77	0.73	0.70	0.82	0.72	0.76	0.91	0.99	0.80	0.78
CR	0.84	0.84	0.78	0.80	0.87	0.82	0.83	0.94	0.99	0.85	0.90
AVE	0.61	0.61	0.51	0.58	0.53	0.60	0.50	0.85	0.90	0.81	0.72
F-loading	0.68	0.68	0.61	0.75	0.72	0.77	0.71	0.92	0.95	0.75	0.81
C-loading	0.16	0.20	0.18	–0.06	0.20	0.19	0.23	0.27	0.13	0.05	0.03

A-Support = perceived autonomy-support, Auto-Mtv = autonomous motivation, Cont-Mtv = controlled motivation, Amotv = amotivation, Norm = subjective norm, PBC = perceived behavioral control, Distance = standardized reading distance, VA-Dis = distance visual acuity (4 m), VA-Near = near visual acuity (40 cm), CR = composite reliability, F-loading = mean factor loadings, C-loading = mean cross loadings
 * $p < .05$ for a two-tailed test; ** $p < .01$ for a two-tailed test

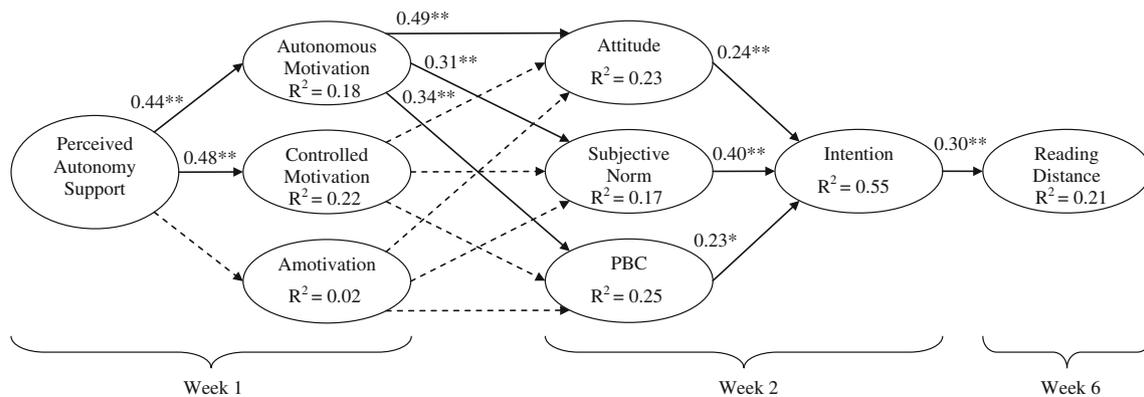


Fig. 4 Path estimates in the integrated model of self-determination theory and theory of planned behavior. Non-significant paths ($p > .05$) are represented by dotted vectors. * $p < .05$ for a two-tailed test, ** $p < .01$ for a two-tailed test. Distance visual acuity and near visual acuity were control variables (measured at week 6) and set to

predict all of factors in the model. These paths are omitted for clarity. None of the effects were significant apart from the effect of distance visual acuity on reading distance ($\beta = 0.31^{**}$) and the effect of near visual acuity on subjective norm ($\beta = 0.17^*$)

controlled motivation and amotivation were not significant. Intention was a significant positive predictor of reading distance³. All variables in the model were set to be predicted by the visual acuity variables and only the effect of

distance visual acuity on reading distance, and that of near visual acuity on subjective norm, was significant.

Mediation analyses revealed that the positive effects of perceived autonomy support on attitude, subjective norm, and PBC were fully mediated by autonomous motivation, but not by controlled motivation and amotivation. Autonomous motivation, instead of controlled motivation, positively predicted intention via the complete mediation of

³ Intention was responsible for 45.49 % of the total explained variance of reading distance.

Table 2 Mediation analysis results

Path	Mediators ^a	Direct effect	Combined effects	Total effect	Indirect effect	Mediation type
A-support → attitude	Auto-mtv*, Cont-mtv, Amotv	.22*	.01	.21*	.15*	Full
A-support → norm	Auto-mtv*, Cont-mtv, Amotv	.17*	−.03	.21*	.14*	Full
A-support → PBC	Auto-mtv*, Cont-mtv, Amotv	.22*	.04	.16	.09*	Full
Auto-mtv → intention	Attitude*, norm*, PBC*	.43**	.12	.37**	.53*	Full
Cont-mtv → intention	Attitude, norm*, PBC*	.31*	.12	.14	.21*	Full
Amotv → intention	Attitude, norm, PBC	−.04	.08	.05	−.19	None
Attitude → distance	Intention*	.24**	.03	.20**	.17*	Full
Norm → distance	Intention*	.18	−.12	.10	.18*	None
PBC → distance	Intention*	.33**	.16	.27**	.14*	Full

A-Support = perceived autonomy-support, Auto-Mtv = autonomous motivation, Cont-Mtv = controlled motivation, Amotv = amotivation, Norm = subjective norm, PBC = perceived behavioral control, Distance = standardized reading distance

* $p < .05$ for a two-tailed test; ** $p < .01$ for a two-tailed test

^a Significant partial indirect effects (lower bound of 95 % confidence interval > 0) were marked by asterisk

attitude, subjective norm, and PBC. Intention fully mediated the positive effects of attitude and PBC on reading distance, but did not mediate on the corresponding effect for subjective norm. A summary of the results of the mediation analysis is presented in Table 2.

Discussion

The objective of the present study was to apply an integrated model based on the theory of planned behavior and self-determination theory to understand the motivational and social-cognitive process involving myopia-preventive behavior (reading distance). We hypothesized a motivational sequence in which perceived autonomy support and motivation (autonomous motivation, controlled motivation, and amotivation) from self-determination theory had direct and indirect links to the social-cognitive variables (attitude, subjective norm, and PBC) and intention from the theory of planned behavior. In addition, intentions were proposed to predict future preventive behavior regarding near work and mediate the effects of the other variables in the sequence on behavior. In the following sections we deal with the current findings for each component part of the proposed motivational sequence and how these findings are relevant to the understanding myopia-preventive behavior.

Self-determination theory components

Apart from the significant positive association between perceived autonomy support and controlled motivation, all the paths associated with autonomous motivation were significant and positive as predicted, and the paths that linked to controlled motivation and amotivation were non-significant in accordance with our hypotheses. This pattern

is consistent with self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000), and suggests that applying an autonomy-supportive style in the delivery of vision-care messages could enhance the likelihood that people will endorse autonomous motivates for myopia prevention, the key motivational factor of intentions to engage in myopia-preventive behaviors. We did, however, find relationships that were contrary to hypotheses such as the link between perceived autonomy support and controlled motivation. A possible explanation for this anomalous effect could be that a majority of the significant autonomy support providers were parents. In a Chinese culture listening to the advice of parents is a moral obligation because parents are typically regarded as authoritative figures (Fulgini, 1998). In some cases an autonomy-supportive style is likely to foster autonomous motivation in the theoretically-predicted pattern. However, in this particular culture, even though significant others may be perceived to display autonomy-supportive behaviors, these may, nevertheless, be interpreted as part of the moral obligation brought about by the cultural environment. Such obligations are experienced as reinforcing and other-referenced rather than self-referenced even if the significant others are perceived to provide autonomy support (Kim et al., 2000; Schouten & Meeuwesen, 2006).

Controlled motivation, together with amotivation, was not predictive of the social-cognitive and behavioral variables in the model, which is consistent with the tenets of self-determination theory with respect to the importance of autonomous motivation in motivating initiative and persistence in behavior (Deci & Ryan, 1985; Ryan & Deci, 2000). Amotivation, on the other hand, represents a gross deficiency or complete absence of behavioral motives according to self-determination theory. Although the analysis did not reveal any significant links between

amotivation and the social-cognitive or behavioral variables in the model, the significant negative correlation of this variable with autonomous motivation and its positive correlation with controlled motivation suggests that individuals who are motivated to prevent myopia for the value and meaning associated with the action were less likely to be amotivated than those motivated to prevent myopia merely for meeting external demands or for ego-protective reasons. This pattern again highlights the importance of ameliorating the sense of personal agency with regard to health behaviors among individuals who are encountering risk of health problems, and explains why autonomous motivation is advantageous to behavioral persistence in managing long-term illness or the maintenance of new health habits (Chan et al., 2009, 2011; Halvari et al., 2010; Williams et al., 1996, 2006, 2007).

The theory of planned behavior components

Autonomous motivation was an important predictor of intentions to engage in myopia-preventive action, yet its effect was fully mediated by the three belief-based social-cognitive variables from the TPB as hypothesized in the integrated model (Chan & Hagger, 2012a, c; Hagger & Chatzisarantis, 2009; Hagger et al., 2002a, 2006). This result pattern explains why autonomous motivation is adaptive according to self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000) because autonomously-motivated individuals are more likely to regard the action (i.e., reading in an optimal distance) as something worthwhile (attitude), socially appropriate (subjective norm), and manageable (PBC) given that these positive beliefs are strong correlates of the intention, the most proximate predictor of future behavioral engagement (Ajzen, 1985, 1991).

All the three belief-based social-cognitive variables significantly predicted more than half of the variance in intentions to engage in myopia-preventive behavior, which was comparable to previous studies in other preventive contexts (Chan & Hagger, 2012a, b, c; Hagger et al., 2002a, 2006) and the meta-analysis of studies applying the theoretical integration between the theory of planned behavior and the self-determination theory (Hagger & Chatzisarantis, 2009). However, even though subjective norm was shown to be the strongest predictor of intention among the three belief-based social-cognitive variables, only the effects of attitude and PBC on behavior (i.e., reading distance) were supported and mediated by intention according to our hypotheses. These patterns might infer that subjective norm is as influential in the prediction of intention as attitude and PBC, but its indirect effect on behavior is smaller by comparison. Moreover, intention fully mediated the effect of PBC on behavior, which was

inconsistent to our hypothesis of a partial mediation of this pathway. This was likely because the measure of PBC in the current study reflected perceived rather than actual barriers and control beliefs relating to the behavior (Chan & Hagger, 2012a). Ajzen (1991) suggests that to the extent that PBC reflects actual control over behavior, PBC will predict behavior directly. But if it reflects only perceived aspects of control, then it should be fully mediated by intention because the effects are motivational rather than directly inhibitive of behavioral engagement.

The importance of subjective norm in predicting intention is consistent with the cross-cultural research adopting the theory of planned behavior. The research revealed that the effect of subjective norms on intentions in a Chinese population (Abrams et al., 1998), or in people from collectivistic countries (Hagger et al., 2007), was higher in magnitude than those in Western or individualistic countries. Indeed, the indirect effect of subjective norm on behavior was not significant. This was not in line with our hypothesis and findings from previous studies (Hagger et al., 2002b; Hardeman et al., 2002; McEachan et al., 2011). This may have been because people who perceived the behavior as socially appropriate (i.e., those who rated subjective norm highly) were more likely to over-evaluate their behavior (Budd & Spencer, 1986). Our assessment of behavior was supposed to be unaffected by response bias, general response tendency, and self-fulfilling hypothesis because the participants were blinded from the true purpose of the study, thus such methodology could be as a solution for revealing the true relationships between the theory of planned behavior variables and behavior by minimizing confounding effects in the measurement of behavior.

Reading distance and visual acuity

In the current study, behavior was measured by participants' reading distance, and it was significantly predicted by intention when controlling for the effect of visual acuity, corroborating the tenets of individual (Hagger et al., 2007, 2012) and meta-analytic (Hagger & Chatzisarantis, 2009; Hardeman et al., 2002; McEachan et al., 2011) tests of the theory of planned behavior. In addition, this may imply that maintaining an optimal reading distance for near work is indeed a volitional or habitual behavior and is not merely a function of visual acuity, but it also closely related to intention and other psychological variables in our integrated model. However, it is important to point out that reading distance is only one aspect of near work. We selected this dependent variable because other potential behavioral indicators such as the total volume of near work, the time of continuous close-up reading, and the frequency of rest periods between bouts of near work have been shown to produce inconsistent results (Ip et al., 2008)

and assessments relying on self-reported near work are subject to memory bias and social desirability. Therefore, future studies should continue to adopt comprehensive and reliable assessments of near work to objectively quantify how working close to reading materials contributes to the impairment of visual acuity over time.

On the other hand, we regarded visual acuity as a control variable in the model rather than specifying its causal effect on reading distance even though reading distance was significantly correlated with distance visual acuity. It is because a significant reduction in visual acuity due to the progression of myopia was not likely to be detected during the course of our study as the degeneration is long term, and so the significant correlation is more likely to be attributable to the possibility that individuals with an impaired distance visual acuity tend to perform near work at a shorter viewing distance, but our one-month prospective design was unable to offer strong evidence to support this argument (see the [Limitations](#) section). Moreover, other uncorrected refractive errors may also contribute to the impairment of visual acuity, so future studies should use refractive error measured in diopter (the standard optometric scale; Fredrick, 2002; Morgan, 2003) to assess myopic symptoms. Finally, the significant positive effect of near visual acuity on subjective norm raises a plausible possibility about the relationship between perceived social appropriateness of myopia-preventive behaviors and individuals' clarity of vision for near objects, and testing their causal link may be an interesting avenue for further research.

Limitations

In addition to the previously-cited limitations, we also acknowledge a few more limitations of the present investigation that may stimulate future research. First of all, although the variables from the theory of planned behavior, self-determination theory, and the hypothesized outcome (i.e., reading distance) were measured on separate occasions, the follow-up measures were short-term in nature and limited our ability to draw conclusions about the temporal and causal nature of the relationships in the model. For instance, myopia is likely to take several years to develop (Fredrick, 2002; Matsumura & Hirai, 1999) and so the effect of psychosocial factors and preventive behaviors on ameliorating the progression of myopia could hardly be revealed over such a short period. A cohort design with longitudinal assessments would be more effective in testing this hypothesis. However, our model and assessment tools may serve as a basis for the design, implementation, and evaluation of a community-based psychosocial intervention (Dombrowski et al., 2011; Hagger et al., 2012a, b; Michie & Johnston, 2012; Stavri &

Michie, 2012) for enhancing the motivational, social-cognitive, and behavioral factors associated with myopia prevention. Secondly, even though our study applied deception and the dependent variables were assessed objectively, the confounding effects of response bias were still not completely eliminated because the psychological variables in the model were measured by self-report. This is a typical weakness in survey-based research, and underscores the need for the development of implicit measures of motivation (Keatley et al., 2012a, b, c) and belief-based measures of attitudes (Karpinski & Steinman, 2006) in future tests of the model for myopia prevention and other health contexts. Last, but not least, the sample was obtained from a homogenous population, that identified parents as the significant others primarily concerned with vision care, so future studies should examine the generalizability of the model in diverse populations including samples from different age groups, occupations, educational levels, and cultural backgrounds.

Conclusions

The present investigation provided preliminary support for the application of an integrated theoretical model comprising the theory of planned behavior and self-determination theory to myopia prevention (Hagger, 2009; Hagger & Chatzisarantis, 2009). Results corroborated evidence from previous social psychology research with respect to the importance of autonomous motivation and social-cognitive beliefs in predicting behavioral compliance toward health and safety recommendations. Delivering health advice in an autonomy-supportive manner appears to be the most optimal intervention technique to promote the formation of autonomous motivation and adaptive beliefs that link to the target health behaviors. The study may provide important information for health practitioners and policy makers about the potential benefits of reinforcing autonomy-supportive health-care environments regarding health-promoting behaviors.

Acknowledgments This research was supported by an International Research Scholarship awarded by the University of Nottingham to Derwin K.C. Chan. The authors are grateful to Dr. Andrew Astle from University of Nottingham for his professional advices on the use of optometric assessments in this study.

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