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Is the relationship between physical activity intentions and behaviour convex? A test across 13 studies

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ABSTRACT

Objectives: Previous research documented that the construct of intentions related to physical activity participation by a linear function. As a consequence, researchers using linear analysis tacitly conclude that effects of unfavourable and favourable intentions on physical activity participation are exactly the same. In this study, we examined whether favourable and unfavourable intentions exerted differential effects on participation in physical activities across 13 published or unpublished studies.
Method: Data consisted of 13 samples sourced from published and unpublished studies.
Results: In partial support of our hypothesis, non-linear analysis revealed that in 7 out of 13 studies intentions predicted physical activity participation when intentions were favourable, but when intentions were unfavourable effects of intentions on physical activity participation were smaller.
Conclusions: The theoretical significance of the present study is that it identifies a new boundary condition for the construct of intentions that delineates the more specific conditions under which intentions are more likely to predict participation in physical activities.

1. Introduction

Social psychological models of intentional behaviour, such as the theories of reasoned action and planned behaviour (Ajzen, 1991; Ajzen & Fishbein, 1980), protection motivation theory (Rogers, 1983) and the health belief model, identify intention as the most proximal determinant of behaviors such as physical activity. This finding has been established in a number of meta-analytic studies and interventions that detected a moderate to strong correlation between intentions and physical activity participation. For example, in a meta-analysis of 47 experimental studies, Webb and Sheeran (2006) documented that medium to large changes in intentions led to small to medium changes in behaviour (see also Sheeran et al., 2016). Additionally, in a meta-analysis of studies employing the theories of reasoned action and planned behaviour, McEachan, Conner, Taylor, and Lawton (2011) established a statistically significant relationship between intentions and physical activity participation that converged to a medium effect size (Chatzisarantis et al., 2015; Hagger, Chatzisarantis, & Biddle, 2002).

One issue that has been overlooked by previous research is related to functional relationship between intentions and physical activity participation. Previous research has almost exclusively used linear regression analysis in examining effects of intentions on physical activity participation (Hagger et al., 2002; McEachan et al., 2011). As a consequence, researchers using linear models conclude that changes in intentions, from unfavourable to moderate levels, are associated with the same amount of change in physical activity participation as changes in intentions from moderate to favourable levels. The reason for this is that linear models assume that effects associated with changes in intentions are constant across individuals who report unfavourable or favourable intentions (Edwards, 1994). However, based on research stemming from attitude strength literature, it is possible to argue that

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changes in intentions may be associated with much lower effects on behaviour among individuals who report unfavourable intentions than individuals who report favourable intentions-a proposition that implies that the relationship between intentions and behaviour is convex (Howe & Krosnick, 2017; Doorn, Verhoef, & Bijmolt, 2007; Theodorakis, 1994). This proposition is crucial to examine in the context of physical activity research as it means that prospective studies or interventions, that are based on theories of intentional behaviour, may not be very effective in predicting and motivating physical activity participation among physically inactive individuals who usually exhibit low or unfavourable intentions toward physical activity (Lippke, Ziegelmann, & Schwarzer, 2005). Given the importance of convexity in understanding the intention-behaviour relationship, the purpose of the current study was to examine whether the construct of intentions related to physical activity participation by a convex function.

1.1. Conceptual framework

One finding in the literature that examines the attitude-behaviour relationship is that cognitions such as attitudes and intentions do not only differ in direction but also in strength (Howe & Krosnick, 2017). According to Ajzen and Fishbein (1980), the construct of attitude aims to capture individuals' overall evaluative responses towards a behaviour or an object. The direction of an attitude indicates the extent to which individuals exhibit a positive or a negative evaluation toward a behaviour (Krosnick & Petty, 1995). The strength of an attitude, on the other hand, is defined and measured through a number of properties that aim to capture characteristics of attitude (i.e., valence, extremity), structure of attitude (i.e., accessibility of attitudes), beliefs about attitudes (i.e., certainty or confidence) and processes that underpin attitude formation (i.e., elaboration) (Barden & Tormala, 2014).

To date, researchers have identified a number of properties of attitude strength. Some of these properties refer, but are not limited, to knowledge (the size of information one has about an attitude or behaviour; Fazio & Zanna, 1978), accessibility (the ease with which an attitude comes to mind; Fazio, 1995), consistency (congruence between affective and cognitive components of an attitude or between evaluations and information underpinning the formation of an attitude; Chaiken, Pomerantz, & Giner-Sorolla, 1995) and ambivalence (the extent to which individuals simultaneously hold positive and negative evaluations toward a behaviour; Conner & Sparks, 2002). The literature is also replete with evidence showing that attitudes vary along dimensions that aim to capture attitude importance or involvement (the extent to which an individual has a vested interest in the consequences of a behaviour or attach psychological significance to an attitude; Petty, Cacioppo, & Schumann, 1983), certainty or confidence (the extent to which individuals believe that their evaluations accurately represent their overall attitudes; Barden & Tormala, 2014) and elaboration (the extent to which individuals scrutinise information related to consequences of behaviour; Petty & Wegener, 1998). Finally, a property that indicates attitude strength is attitude extremity that captures the extent to which an attitude deviates from neutrality and it is either extremely positive or extremely negative (Howe & Krosnick, 2017). Broadly speaking, an attitude is said to be strong if individuals have a vested interest in the consequences of a behaviour, think carefully about those consequences during the process of attitude formation and therefore develop a rich and highly accessible knowledge base that is also consistent with attitudes. Additionally, attitudes are strong if they are not ambivalent but extremely positive or negative and held with high degrees of confidence.

The literature on attitude strength has attracted considerable attention because studies have shown that strong attitudes are more predictive of future behaviour than weak attitudes. For example, in a meta-analysis of 44 studies, Cooke and Sheeran (2004) demonstrated that important attitudes were more predictive of behavioural engagement than less important attitudes. The reason for the higher predictive validity of strong attitudes is that in comparison to weak attitudes, strong attitudes are more resistant to counter-attitudinal influences that aim to change individuals' attitudes toward a behaviour or an object (Petty & Wegener, 1998). Most relevant, in a study that aimed to predict purchase of organic foods, Doorn, Verhoef, and Binjmolt (2007) established a convex relationship between the extremity dimension of attitude strength and purchase behaviour. Specifically, using non-linear analysis, these authors demonstrated that changes in environmental concerns from extremely low to moderate did not change actual purchase of organic foods whereas changes in environmental concerns from moderate to strong had a positive effect on purchase behaviour.

The observation that measures of attitude strength relate to behaviours by a convex function has important implications for understanding the functional relationship between intentions and behaviour. It raises the possibility that the construct of intentions will also relate to behaviour by a convex function. The reason for this is that an assumption behind attitude strength models is that intentions 'inherit' properties of attitude strength (Cooke & Sheeran, 2004). In fact, in some studies, researchers have been 'treating' the construct of intention as a proxy measure of attitude strength or as a criterion in evaluating whether experimental manipulations of attitude strength were successful in creating strong attitudes (Tormala & Petty, 2002). For example, in a series of studies conducted by Tormala and Petty (2004), the relationship between attitude and intentions was considered to indicate the certainty dimension of attitude strength. Most relevant, evidence stemming from the physical activity literature has shown that intentions capture the effects that different properties of attitude strength exert on physical activity participation (Theodorakis, Goudas, & Bagiatis, 1995). For instance, in a study that measured direction and strength of attitudes independently, Theodorakis (1994) showed that favourable attitudes were associated with higher levels of physical activity intentions when favourable attitudes were strong rather than weak (see also Cooke & Sheeran, 2013; Sheeran & Abraham, 2003). Given the close relationship between intention and attitude strength and the fact that measures of attitude strength relate to behaviour by a convex function, it plausible that intentions relate to physical activity participation by a convex function. Specifically, based on the extant literature (Doorn et al., 2007; Tormala & Petty, 2004), it can be argued that the effects of unfavourable or less favourable intentions on physical activity participation will be much smaller than corresponding effects of favourable intentions. The reason for this is that the formation of less favourable intentions is based on weak attitudes that are less predictive of physical activity participation, whereas favourable intentions are formed on the basis of strong attitudes that predict physical activity participation (Theodorakis, 1994; Theodorakis et al., 1995).

There are theoretical and practical grounds for testing the functional relationship between intentions and physical activity participation. As we have already mentioned, previous primary and meta-analytic studies have been estimating effects of intentions on physical activity participation by way of using a linear model. However, linear analysis does not rule out the alternative hypothesis that intentions relate to physical activity by a non-linear function (Aiken & West, 1991; Ganzach, 1997). Hence, it is unknown at the moment whether effects sizes, reported by previous primary or meta-analytic studies, support effects of unfavourable intentions on physical activity participation. Such additional information about unfavourable intentions is crucial to obtain because physical activity researchers need to know whether changes in intentions are associated with the same or different effects on physical activity participation across individuals with unfavourable and favourable intentions. This is because researchers are interested in predicting and motivating physical activity participation among non-intenders who are less likely to engage in physical activities as well as intenders who are more likely to engage in physical activity participation.

Table 1
Study characteristics.

	N	Age	Gender split (female)	Sample	Nationality	Time gap/ attrition	Intention measure	Behaviour measure	Past behaviour measure
Study 1	215	13.84 (.38)	50.7%	School students	UK	5 weeks	Ajzen and Fishbein (1980) four items measured on 7-point scales	Bagizzi and Kimmel (1995) and Godin and Shephard (1985) through 3 items measured on 6-point frequency scales	Bagizzi and Kimmel (1995) single items measured on 6-poitn frequency scale
Study 2	106	19.16 (1.96)	50.8%	University students	UK	4 weeks (13.11%)	Ajzen and Fishbein (1980) four items measured on 7-point scales	Bagizzi and Kimmel (1995) and Godin and Shephard (1985) through 3 items measured on 6-point frequency scales	Bagizzi and Kimmel (1995) single items measured on 6-point frequency scale
Study 3	85	14.17 (.97)	47.1%	School students	UK	5 weeks (2.3%)	Ajzen and Fishbein (1980) four items measured on 7-point scales	Bagizzi and Kimmel (1995) and Godin and Shephard (1985) through 2 items measured on 7-point frequency scales	Bagizzi and Kimmel (1995) two items measured on 6-point frequency scale
Study 4	208	14.21 (.89)	50%	School students	UK	5 weeks (5.3%)	Ajzen and Fishbein (1980) four items measured on 7-point scales	Bagizzi and Kimmel (1995) and Godin and Shephard (1985) through three items measured on 6- and 7-point frequency scales	
	N	Age	Gender split (female)	Sample	Nationality	Time gap/ attrition	Intention measure	Behaviour measure	Past behaviour measure
Study 5	92	18.13 (4.98)	46.4%	University students	US	8 weeks (58.9%)	Ajzen and Fishbein (1980) single items measured on 7-point scale	Bagizzi and Kimmel (1995) single items measured on 6-point frequency scale	Bagizzi and Kimmel (1995) single items measured on 6-point frequency scale
Study 6	234	23.50 (7.21)	52.1%	University students	UK	2 weeks (2.13%)	Ajzen and Fishbein (1980) single items measured on 7-point scale	Open-ended question measuring number of days exercised the previous two weeks	
Study 7	418	17.97 (5.06)	56.8%	School students	UK	5 weeks (16.7%)	Ajzen and Fishbein (1980) three items measured on 7-point scale	Bagizzi and Kimmel (1995) single item measured on 6-point frequency scale	
Study 8	109	24.45 (6.60)	62%	Young adults	US	5 weeks (25.34%)	Ajzen and Fishbein (1980) three items measured on 7-point scale	Godin and Shephard (1985) single item measured on 6-point frequency scale	Bagizzi and Kimmel (1995) single item measured on 6-point frequency scale
Study 9	1649	13.79 (.88)	61.9%	School students	Singapore	10 weeks (8.10%)	Ajzen and Fishbein (1980) three items measured on 7-point scale	Godin and Shephard (1985) single item measured on 6-point frequency scale	
	N	Age	Gender split (female)	Sample	Nationality	Time gap/ attrition	Intention measure	Behaviour measure	Past behaviour measure
Study 10	222	14.68 (1.47)	53.2%	School students	UK	5 weeks	Courneya and McAuley (1995) and Ajzen and Fishbein (1980) four items measured on 7-point scale	Godin and Shephard (1985) single item measured on 7-point frequency scale	Bagizzi and Kimmel (1995) single item measured on 6-point frequency scale
Study 11	93	13.99 (.80)	61.3%	School students	Greece	5 weeks (23.1%)	Courneya and McAuley (1995) and Ajzen and Fishbein (1980) four items measured on 7-point scale	Godin and Shephard (1985) single item measured on 7-point frequency scale	Bagizzi and Kimmel (1995) single item measured on 6-point frequency scale
Study 12	132	13.32 (.47)	47.3	School students	Singapore	5 weeks	Courneya and McAuley (1995) and Ajzen and Fishbein (1980) four items measured on 7-point scale	Godin and Shephard (1985) single item measured on 7-point frequency scale	Bagizzi and Kimmel (1995) single item measured on 6-point frequency scale
Study 13	103	16.32 (1.12)	54.4	School students	Poland	5 weeks	Courneya and McAuley (1995) and Ajzen and Fishbein (1980) four items measured on 7-point scale	Godin and Shephard (1985) single item measured on 7-point frequency scale	Bagizzi and Kimmel (1995) single item measured on 6-point frequency scale

Note. Attrition rates are presented in parenthesis. We could not estimate attrition rates for Studies 1, 10, 12, and 13 because there were no available data.

1.2. Overview of the study and hypothesis

The purpose of the present study was to examine differential effects of unfavourable and favourable intentions on physical activity participation. Based on research stemming from the attitude strength literature (Doorn et al., 2007; Theodorakis, 1994; Tormala & Petty, 2004), we hypothesised that the effects of unfavourable intentions on measures of physical activity participation would be much smaller than corresponding effects of favourable intentions. At analytic level, this hypothesis is confirmed if the functional relationship between intentions and physical activity is convex (Doorn et al., 2007; Edwards, 1994). We examined this hypothesis by analysing data from 13 samples that were sourced from published and unpublished studies.

In the present study, we also controlled for past behaviour in studies that actually measured this variable. This is because previous meta-analytic studies have shown that past behaviour accounts for some of the effects that intentions exert on physical activity participation (Hagger et al., 2002; McEachan et al., 2011). Hence, it can be argued that our hypothesised differential effects of favourable and unfavourable intentions on physical activity participation may be spurious and due to past behaviour (Ganzach, 1997). However, in the present study, we did not expect past behaviour to completely attenuate the relationship between intentions and physical activity because its effects on physical activity tend to be independent from corresponding effects of intentions (Hagger et al., 2002). Despite this, we statistically controlled for the effects that past behaviour may exert on physical activity in order to provide a more precise estimate of effects of intentions on physical activity participation.

2. Method

2.1. Participants and procedure

Data consisted of 13 samples sourced from two published and 11 unpublished studies. The datasets were obtained from authors' personal files. We utilised all of the relevant published and unpublished studies that the authors had access to. Studies were included in the analysis if they employed a prospective design aiming to predict participation in leisure-time physical activities from physical activity intentions or past behaviour. Studies targeted samples from different countries such as UK, USA, Poland, Greece, Singapore or Australia. Sample sizes of the studies ranged from 85 participants (Study 3) to 1649 participants (Study 9). Participants were school students, university students or young adults with mean age ranging from 13.32 years (Study 12) to 24.5 years (Study 8). The time gap between measurement of past behaviour or intentions and physical activity participation ranged from two weeks (Study 6) to 10 weeks (Study 9), but in the majority of the studies, there was a 5-week time gap between measures. In all studies, physical activity intentions were measured through methods proposed by Ajzen and Fishbein (1980) or Courneya and McAuley (1995). Past behaviour was measured through modified versions of methods introduced by Godin and Shephard (1985) or methods employed by Bagizzi and Kimmel (1995).

2.2. Measures

Intentions. Studies that employed Ajzen and Fishbein's (1980) method measured intentions through items asking participants to report the extent to which they intended to engage in leisure-time physical activities. An example item was: "I am determined to engage in physical activities for at least 45 min at a time, 4 times per week during my leisure-time, over the next 5 weeks'. This item was measured on a 7-point scale ranging from (1) 'strongly disagree' to 'strongly agree' (7). Studies using Courneya and McAuley's (1995) method employed similar stem items. However, participants' responses were recorded on open-ended scales or frequency scales aiming to capture the frequency with which participants intended to engage in physical activities during leisure time. An example item was: "I intend to engage in physical activities for at least 45 min at a time over the next 5 weeks". This item was measured on a 7-point frequency scale ranging from (1) 'not at all' to (7) 'every day'. The alpha reliabilities of measures of intentions were satisfactory ranging from 0.74 to 0.93 except for studies that measured intentions through single items (see Table 1).

Physical activity participation. Studies that employed Bagizzi and Kimmel's (1995) method or modified versions of Godin's leisure-time exercise questionnaire provided participants with definitions of vigorous physical activity and leisure-time developed by Godin and Shephard (1985). In addition, the majority of studies using Bagizzi and Kimmel's (1995) method or Godin and Shephard's (1985) modified method recorded responses on 6-point, 7-point or 9-point frequency scales ranging from (0 or 1) "not at all" to (6, 7 or 8) "most of the days per week". An exception was Study 6 in which responses were recorded on an open-ended scale (see Table 1). However, measures of behaviour differed across studies in two respects.

First, although most studies measured physical activity participation through a single item, some studies assessed physical activity participation through multiple items. Second, the stem items of studies employing Godin and Shephard's (1985) or Bagizzi and Kimmel's (1995) questionnaires were slightly different. Specifically, in studies that employed modified versions of Godin and Shephard's (1985) questionnaire, the stem item(s): (i) prompted participants to 'select' a typical week (7 days) from a specific period from the past (i.e., the previous 5 weeks) and then (ii) report how many times they engaged in vigorous physical activities during that 'selected week'. In contrast, studies employing Bagizzi and Kimmel (1995) method did not prompt participants to consider a typical week from the past. Rather, items stemming from Bagizzi and Kimmel's (1995) method prompted participants to report frequency of engagement in vigorous physical activities in the past. An example item using Godin and Shephard's (1985) modified method was: "Consider a typical 7-day period (a week) from the last 5 weeks. During that 7-day period, how many times did you engage in active sports and/or vigorous physical activities for at least 30 min at a time during your leisure time". This item was measured on a 7-point scale ranging from (1) "not at all" to (7) "all days per week". An example item employing Bagizzi and Kimmel's (1995) method was: "During the last 5-weeks, how many times on average did you engage in active sports and/or vigorous physical activities for at least 30 min at a time during your leisure time". This item was measured on a 6-point scale ranging from (1) "not at all" to (6) "most days per week".

Past behaviour. Measures of past behaviour of studies that employed Bagizzi and Kimmel's (1995) method or modifications of Godin and Shephard's (1985) method provided participants with definitions of vigorous physical activity and leisure-time developed by Godin and Shephard (1985). In addition, the stem items in studies using these methods were almost identical. This is because the stem items stemming from Godin and Sheppard's (1985) method did not prompt participants to consider a typical week from the past during responding. Rather studies using Bagizzi and Kimmel's (1995) method or modified versions of Godin and Shephard's (1985) questionnaire asked participants to report frequency of engagement in vigorous physical activities in the past. The only difference between studies using these two methods was concerned with range of measurement scales (see Table 1). An example item measuring past behaviour was:" How often did you engage in active sports and/or vigorous physical activities during your leisure time the last 6 months". Responses to this item were measured on 6-point scale ranging from (1) "not at all" to (6) "most days per week".

2.3. Analysis

We conducted a series of hierarchical regression analyses that aimed to predict participation in physical activities across the 13 studies.

Following Edwards' (1994) recommendations, measures of intentions and past behaviour were standardised by subtracting the sample mean from participants' responses to measures. In all regression analyses, we estimated main effects of intentions and past behaviour in the first step of the analyses. In the second step of the analyses, we estimated non-linear effects of intentions on physical activity participation by specifying a quadratic term of intentions in the regression equations (Aiken & West, 1991). This quadratic term was calculated by squaring participants' responses to measures of intentions (i.e., I^2). According to Aiken and West (1991), the regression analyses support convex functions if (i) the second step of the analyses improves predictive validity of the regression model and (ii) the regression coefficients on the quadratic terms are positive and statistically significant.

In the current study, we also used the following regression equation, that we obtained in the second step of the hierarchical regression analyses, to plot the convex relationship between intentions and physical activity participation at various levels of intentions (Hayes & Preacher, 2010; Stolzenberg, 1980):

$$PA = \beta_1 I + \beta_2 I^2 + \beta_3 PB + \beta_0 \quad (1)$$

In Equation 1, *PA* represents participants' responses to the questionnaires measuring physical activity participation. The terms *I* and *PB* represent participants' responses to measures of intentions (i.e., I) or past behaviour (i.e., *PB*). The term I^2 is the quadratic term. The coefficients $\beta_1$to β_3 are unstandardized regression coefficients that capture main and quadratic effects associated with variables. The coefficient β_0 is the intercept of the regression equation. It is important to note that, in Equation 1, the coefficients β_1 and β_2 on intentions were estimated at average levels of past behaviour (Hayes & Preacher, 2010). Non-linear relationships were plotted by evaluating Equation 1 for intention scores that indicated increases in intentions by 0.30 units.

3. Results

Table 2 presents results of the hierarchical regression analyses that aimed to predict physical activity participation. As it is shown, the first step of the analysis supported statistically significant effects of intentions on physical activity participation in 8 out of 13 studies in the first step of the analysis. In addition, the second step of the regression analyses pointed out that the addition of the quadratic term, that aimed to capture non-linear effects of intentions on physical activity participation, increased predictive validity of the linear model in 7 out of 13 studies. In 6 out the 13 studies, the regression analysis did not detect a non-linear relationship between intentions and physical activity participation. Most relevant, in accordance with our expectations and previous research (i.e., Doorn et al., 2007), the second step of the analyses supported convex relationships between intentions and physical activity participation in the 7 studies that detected statistically significant quadratic effects. This is because the coefficients on the statistically significant quadratic terms were positive (Edwards, 1994). Further, the regression analyses revealed that the predictive validity of the non-linear model varied across studies. This conclusion is corroborated by changes in the coefficients of determination (R^2) that ranged from 2% in Study 3–11% in Study 8. However, our findings did not corroborate presence of moderators because studies that detected statistically significant convex functions varied in terms of age, nationality, methods used to measure intentions or physical activity participation or time gap between measurement of intentions and physical activity participation.

Figure 1 presents plots of the relationships between intentions and physical activity participation across all studies. As it is shown, the convex functions predicted that changes in intentions from extremely unfavourable to moderate levels were less likely to predict physical activity participation than changes in intentions from moderate levels to levels that indicated extremely favourable intentions. This is because the regression lines were almost flat in the region that indicates unfavourable intentions whereas they monotonically increased in the regions that indicated favourable intentions. For example in Study 7, the convex function predicted that participants who exhibited moderate-level intentions would engage in physical activities 3.49 times per-week ($I = 0$) whereas participants with favourable intentions would engage in the same program 4.62 times per-week ($I = 1.2$). Hence, the increase in physical activity participation when increasing intentions from moderate to favourable was 1.13 times per-week. In contrast, participants with unfavourable intentions were predicted to engage in the program 3.06 times per-week ($I = -1.20$). Hence, the increase in physical activity participation when increasing intentions from unfavourable to moderate was 0.43 times per-week only.

4. Discussion

The present study used non-linear analysis to examine differential effects of unfavourable and favourable intentions on physical activity participation. In partial support of our hypothesis, results provided preliminary evidence in favour of a convex function that supported differential effects of the construct of intentions on physical activity participation in 7 out of 13 studies. Hence, at an empirical level, the current study compares favourably with previous research that demonstrated a convex relationship between attitude extremity and purchase behaviour (Doorn et al., 2007). However, the present study adds to this literature because it actually observed similar convex functions for intentions and in the context of studies that aimed to predict participation in physical activities. Broadly speaking, findings from studies

Table 2
Effects of intentions on physical activity participation.

		Step 1				Step 2				
	N	F	R^2	Intention	Past behaviour	ΔF	ΔR^2	Intentions	Past behaviour	Intention^2
Study 1	215	46.13*	.30	-.01	.56*	.26	.00	.00	.56*	.03
Study 2	106	59.23*	.54	.14	.64*	1.96	.00	.13	.65*	-.10
Study 3	85	53.65*	.57	.13	.65*	4.33*	.02	.19*	.63*	.16*
Study 4	208	51.37*	.20	.45*	_	5.41*	.02	.55*	_	.17*
Study 5	92	36.92	.46	.26*	.49*	6.49*	.03	.50*	.46*	.30*
Study 6	234	11.12*	.05	.21*	_	3.68	.01	.32*	_	.16
Study 7	418	113.04*	.21	.46*	_	7.98*	.02	.45*	_	.12*
Study 8	109	23.83*	.31	.35*	.30*	18.98*	.11	.43*	.27*	.33*
Study 9	1649	177.93*	.10	.31*	_	94.46*	.05	.32*	_	.22*
Study 10	222	35.74*	.25	.21*	.32*	.78	.00	.24*	.31*	.06
Study 11	93	35.91*	.45	.12	.59*	.36	.00	.12	.59*	-.05
Study 12	132	90.24*	.58	.30*	.54*	4.96*	.02	.36*	.48*	.13*
Study 13	103	2.34	.05	-.10	.19	.46	.00	-.18	.18	-.10

Note. In Study 6 the incremental fit index and the standardised regression coefficient on the quadratic term for intentions are statistically significant at p = .056 level.

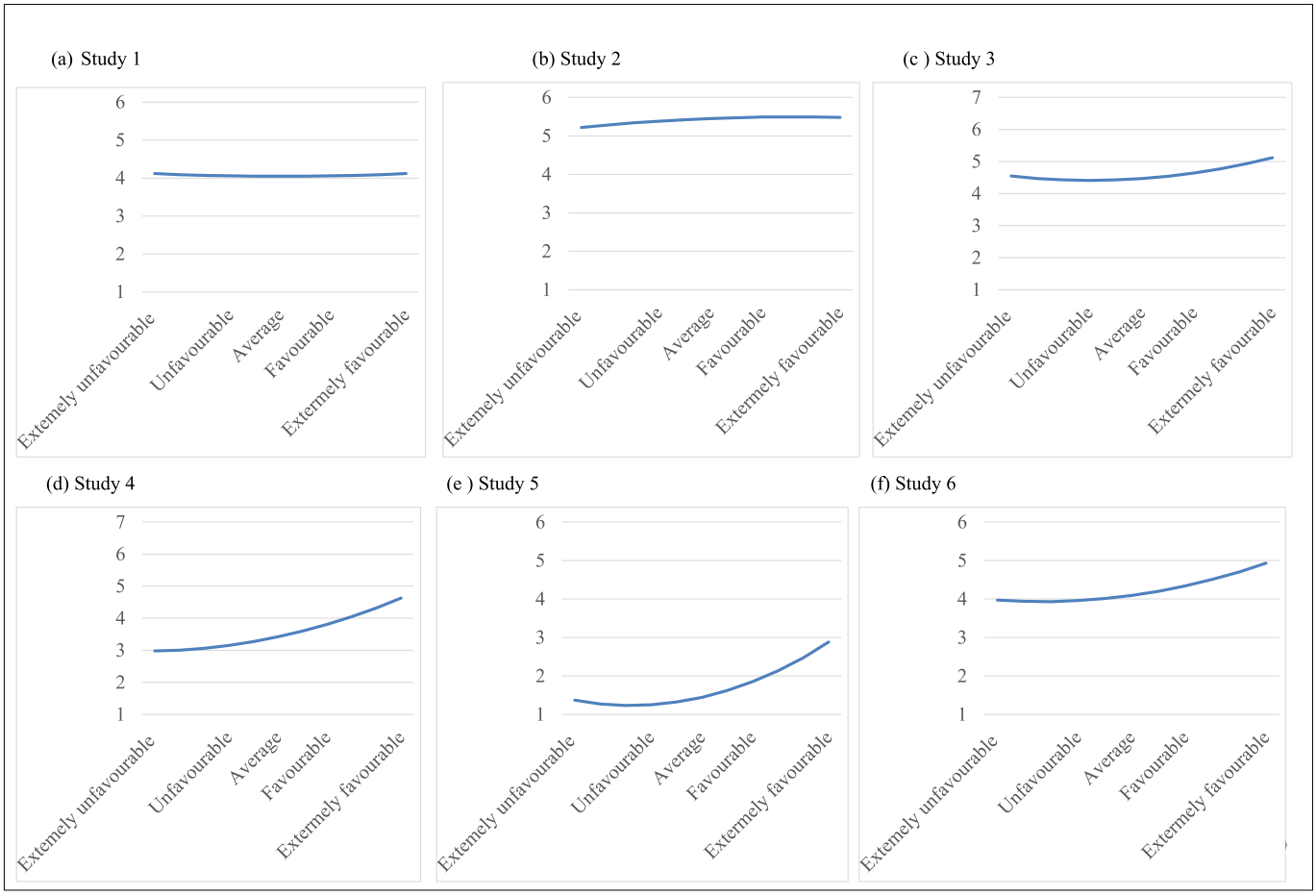

Figure 1. Plots of relationships between intentions and physical activity participation.
Note. In the Figure, intention is set to increase by 0.30 units on a standardised scale ranging from −1.5 to 1.5. The numbers on the top of the curve indicate predicted levels of physical activity participation.

that detected convex functions suggest that intentions are more likely to predict physical activity participation among individuals who exhibit favourable intentions than among individuals who exhibit unfavourable intentions.

Although the current study observed convex relationships between intentions and physical activity participation in 7 out of 13 studies, in 6 out of 13 studies our analysis did not detect a convex function. This variability in study results is important to emphasise as it means that researchers should not expect to always observe a convex or linear function in their studies. On the other hand, however, inconsistency observed in the results of the current studies does suggest that researchers should interpret effects sizes reported by previous primary and meta-analytic studies with care. This is because these effect sizes have been estimated on the basis of linear analysis which by definition does not rule out the alternative hypothesis that intentions relate to physical activity by a non-linear function (Aiken & West, 1991; Ganzach, 1997). For example, it will be precise to conclude, on the basis of the regression coefficients observed in the first step of the regression analysis in Study 6, that intentions predict physical activity participation among individuals who report unfavourable intentions. However, the accuracy of this conclusion is not only corroborated by the statistically significant coefficient on intentions in the first step of the analysis but also by the statistically non-significant coefficient on the quadratic term in the second step of the analysis (Aiken & West, 1991). In contrast, it will be imprecise to reach the same conclusion about unfavourable intentions in Study 3. This is because in this study the second step of the analysis detected a statistically significant coefficient on the quadratic term, supporting a convex relationship between intentions and physical activity participation (Aiken & West, 1991).

Given that non-linear relationships between variables can only be ruled out by way of employing non-linear analysis, we advise researchers to always test for non-linear relationships between intentions and physical activity participation in experimental or prospective studies (see also Krantz & Tversky, 1971; Lubinski & Humphreys, 1990). This can achieved by specifying quadratic terms into regression equations (Aiken & West, 1991). By testing for non-linear relationships between intentions and physical activity participation, researchers cannot only obtain information about whether intentions predict physical activity participation among individuals who exhibit favourable intentions but also among individuals who exhibit unfavourable intentions. This additional information about unfavourable intentions is crucial to induct from observations. This is because practitioners and policy makers do not only need to know whether psychological constructs such as intentions predict, and hence motivate, physical activity participation among intenders who are likely to engage in physical activities but also among non-intenders who are most likely to be physically inactive (Sniehotta, Presseau, & Araujo-Soares, 2015).

At first glance, the convex functions observed in the current study may seem to suggest a limitation of theories of intentional behaviour in motivating non-intenders who exhibit extremely unfavourable intentions toward physical activity participation (Ajzen, 1991; Becker, Radius, & Rosenstock, 1978; Rogers, 1983). This is because, according to the convex functions in Figure 1, non-intenders are likely to engage in physical activities if they change their intentions to an at least moderate level (i.e., from $I = -1.5$ to $I = 0$)-a rather challenging amount of change that may be impossible to achieve in an intervention

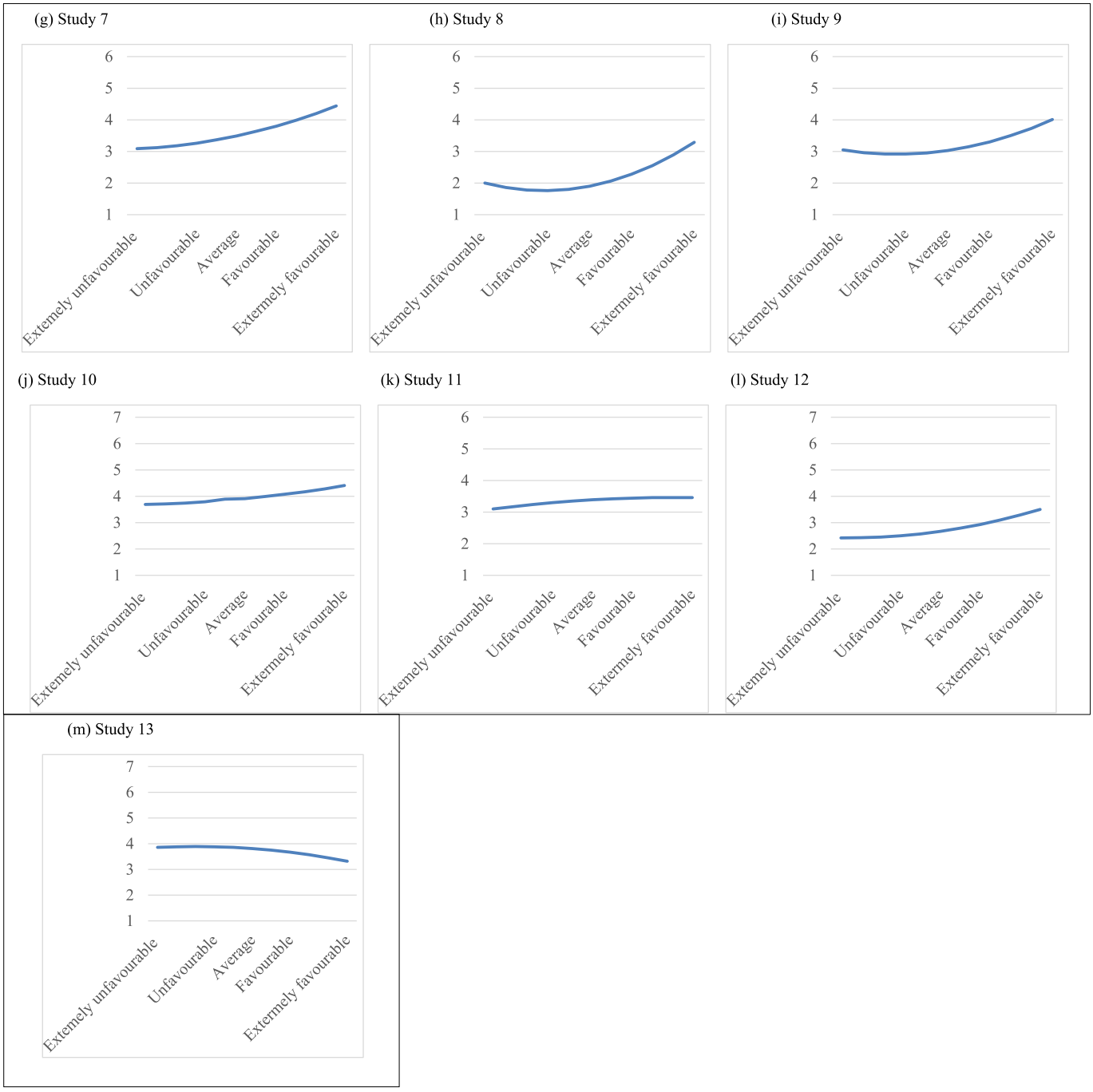

Figure 1. (*continued*)

program. This may also be considered as a general limitation of these theories because practitioners are more interested in promoting physical activity participation among non-intenders who are more likely to be physically inactive than among intenders who are more likely to be physically active. However, we think that it may be premature to conclude that findings of the present study support a limitation of theories of intentional behaviour because our studies did not always detect a convex function.

In addition, whether or not a statistically significant convex function supports a limitation of theories of intentional behaviour depends on whether interventions that are informed by these theories instigate large changes in intentions among individuals who exhibit extremely unfavourable intentions. Broadly speaking, our findings suggest that relatively larger changes in intentions are needed in participants who report, at baseline, unfavourable intentions toward physical activity compared to participant who report moderate or favourable intentions toward physical activity. Accordingly, we advise researchers and practitioners to expose participants, who report unfavourable intentions toward physical activity, to intervention programs for longer periods of time than participants who report favourable intentions toward physical activity.

Unfortunately, there are no intervention or experimental studies that have been specifically designed to examine utility of theories of intentional behaviour in instigating favourable intentions among physically inactive individuals who express exceedingly unfavourable intentions towards physical activity. Given this lack of evidence, we advise researchers to not 'treat' the low predictive validity of unfavourable intentions in studies that observed a convex functional

relationship between intentions and physical activity participation as a limitation of theories of intentional behaviour but rather as a plausible boundary condition that delineates when exactly the construct of intentions is more likely to predict and motivate physical activity participation and when it is not. Thus, the onus of examining whether a convex function reflects a limitation of theories of intentional behaviour 'falls' on practitioners and future studies that may wish to examine whether interventions that are based on theories of intentional behaviour are effective in 'shifting' intentions from unfavourable to favourable levels.

In a similar vein, findings of the present study should not discourage researchers from using the construct of intentions in their research or favour other theoretical frameworks that predict physical activity participation among non-intenders. For example, there is considerable evidence to suggest that additional factors that are not included in theories of intentional behaviour predict physical activity participation over and above intentions (Conner, McEachan, Lawton, & Gardner, 2016; Hagger et al., 2002). This evidence has also led some researchers to conclude that theories of intentional behaviour are not sufficient in terms of capturing all antecedents of physical activity participation (Sniehotta et al., 2015). Further, studies have shown that additional factors that are not included in theories of intentional behaviour increase effectiveness of unfavourable and favourable intentions in predicting physical activity participation. For example, using linear modelling, Lippke, Ziegelmann, and Schwarzer (2005) demonstrated that self-efficacy beliefs predicted physical activity participation among individuals who exhibited unfavourable intentions (see also Marshall & Biddle, 2001).

Arguably, research that establishes effects of additional factors on physical activity participation is essential for theoretical progress to be made in physical activity research because it reveals that it is possible to motivate non-intenders to engage in physical activities by intervening on additional factors. However, the present study suggests that effects associated with additional factors should be re-evaluated. This is because additional factors may not predict physical activity participation in the context of an analysis that captures non-linear effects associated with intentions (Ganzach, 1997). Given that it is unknown, at the moment, whether additional factors increase non-linear effects of intentions on physical activity participation, we encourage researchers to continue 'treating' the construct of intentions as a key determinant of physical activity participation. Additionally, researchers can demonstrate that additional factors augment predictive validity of unfavourable intentions if they predict physical activity participation over and above models that estimate non-linear effects of intentions on physical activity participation.

Finally, it will be remiss to not mention limitations of the current study and provide directions for future research. The present study did not examine whether intentions related to moderate or light forms of physical activity by a convex function. This is because our studies assessed vigorous, rather than, light or moderate forms of physical activity. In addition, all studies measured physical activity through self-report measures. Hence, it is important to replicate current findings by using more objective measures of physical activity participation that capture light or moderate forms of physical activity. Further, in the current study, we assume that the convex relationship between intentions and physical activity participation is due to the fact that the construct of intentions captures properties of attitude strength. However, our study did not show which particular dimensions of attitude strength induce the convex relationship between intentions and measures of behaviour because we did not measure attitude strength. Although considerable evidence suggests that the construct of intentions can be 'treated' as a proxy measure of attitude strength, we think that it is important to examine whether attitude extremity or other dimensions of attitudes strength induce the convex relationship between intentions and behaviour.

In conclusion, the current study observed a convex relationship between intentions and physical activity participation in 7 out of 13 studies. Broadly speaking, findings from studies that detected convex functional relationships suggest that intentions predict engagement in vigorous forms of physical activity if and only if they are endorsed at levels that indicate favourable intentions. Intentions are less likely to predict physical activity participation when they are unfavourable. The contribution of this study to the extant literature is that it identifies a new boundary condition of the construct of intentions that asserts that, in some samples and some of the times, intentions predict physical activity participation provided that they are endorsed at high levels.

Declarations of interest

None.

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