Protocol for a Large-Scale Multi-Sample Registered Replication Study of the Theory of Planned Behavior

Title

Testing the Replicability of the Theory of Planned Behavior: A Large-Scale Multi-Sample Registered Replication Study

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Overview

Identifying the determinants of social behavior, and the specific processes by which the determinants relate to behavior, are important in the development of theory to predict social behavior. Predicting behavior also has utility for organizations and stakeholders interested in developing effective interventions and strategies to promote behavior change. The theory of planned behavior (Ajzen, 1991) is a prominent social psychological theory developed to predict social behavior. The theory derives its assumptions from theories of attitude and social cognition (Albarracín & Johnson, 2019; Eagly & Chaiken, 1993; Fishbein, 1967), and focuses on predicting intentional behavior from sets of beliefs about future behavioral engagement. The theory has been tested in over 2000 studies, and over 30 meta-analytic syntheses. Cumulative findings indicate its efficacy in accounting for variance in behaviors across multiple domains. However, considerable unresolved heterogeneity in effects has been observed, which could be attributable to methodological artifacts or genuine variability across contexts, behaviors, and populations. In addition, some theory predictions, particularly interactions among constructs, have not been tested and replicated consistently. The current project will conduct a large-scale replication of the theory in general population and student samples adopting an identical protocol and measures. The result of the study will be a series of data sets testing theory predictions analyzed by meta-analytic structural equation modeling.

Rationale

A central premise of the theory is that intentions are the most proximal predictor of behavior. Intention is a motivational construct that reflects individuals' readiness to pursue a target behavior. Intentions are a function of three sets of belief-based constructs that summarize individuals' personal, social, and control related judgments with respect to performing the target behavior. Attitudes are positive and negative evaluations of performing the behavior (based on beliefs whether or not the target behavior has utility, is affectively fulfilling, and consistent with values). Subjective

52   norms are individuals' perceived social pressure to engage in the target behavior,
53   based on perceptions of significant others' approval or disapproval of their future
54   participation in the target behavior. Perceived behavioral control, or perceived self-
55   efficacy, is individuals' beliefs that they have the capacity to perform the behavior,
56   based on beliefs about the perceived presence or absence of factors that can facilitate
57   or impede performance of the behavior in question. Intentions are expected to
58   completely mediate effects of attitudes, subjective norms, and perceived behavioral
59   control on intentions. The effect of intention on behavior, however, is said to depend
60   on actual control over performance of the behavior. When perceived behavioral
61   control accurately reflects actual behavioral control (e.g., genuine facilitating factors
62   and barriers or obstacles), it can serve as a proxy for actual control to predict the
63   extent to which individuals are able to enact or follow through on their intentions. In
64   this case, perceived behavioral control will moderate the intention-behavior
65   relationship, such that individuals with high perceived control will be more effective in
66   acting on their intentions than those who have low perceived control.
67
68   Attitude, subjective norm, and perceived behavioral control are assessed by
69   means of reflective indicators, often referred to as direct measures. These direct
70   measures are proposed to be predicted by corresponding sets of specific beliefs with
71   respect to future behavioral engagement. An expectancy x value approach is invoked,
72   such that the effect of a belief on its respective direct measure is a function of belief
73   strength and its associated value. Measures of the belief-based constructs are
74   therefore formative indicators and are often referred to as indirect measures of the
75   theory's main predictors. Attitudes are a function of individuals' judgements that the
76   behavior will lead to specific outcomes, behavioral beliefs, and the value attached to
77   those outcomes, outcome evaluations. Subjective norms are proposed to be
78   determined by individuals' judgments of specific salient referents' approval or
79   disapproval of their participation in the behavior, normative beliefs, and the extent to
80   which they value the referents' judgement, motivation to comply. Perceived behavioral
81   control follows from individuals' judgments of the presence of facilitating and impeding
82   factors with respect to performing the behavior, control beliefs, and the power of each
83   of these factors. Each belief is multiplied by its respective value component when
84   predicting the direct attitude, subjective norm, and perceived behavioral control
85   measures. The probability and value components ensure that the relative importance
86   of each belief to the target behavior is accounted for in the prediction. The
87   multiplicative composites of the belief-value are expected to account for substantial
88   variance in their respective direct measures.
89
90   Tests of the key predictions of the theory often adopt prospective correlational
91   designs, with the intention, attitude, subjective norm, and perceived behavioral control
92   constructs measured at an initial time point with follow-up measures of behavior
93   (Ajzen, 1991; Conner & Sparks, 2015). Constructs are assessed using multi-item
94   psychometric scales with close correspondence in the content of the measures (Ajzen,
95   2002). Behavior is measured using suitable means to observe behavior, or via self-
96   report. Correspondence in measurement between the measure of the theory
97   constructs and measures of intention and behavior are a pre-requisite for effective
98   prediction (Ajzen, 1991). Measures of the constructs and behavior should correspond
99   in terms of the target toward which the action is directed, the action to be performed,
100   the context in which the action is to be performed, and the time frame in which the
101   behavior will be performed in the future. Research testing the theory frequently adopt
102   confirmatory analytic approaches such as path analysis and structural equation

103 modeling, which enables simultaneous tests of the predicted direct and indirect effects
104 among the theory constructs (Bamberg, Ajzen, & Schmidt, 2003; Godin, Valois,
105 Shephard, & Desharnais, 1987), and has also enable tests of alternative formulations
106 of the models, such as the use of formative and reflective indicators (Hagger &
107 Chatzisarantis, 2005; Heiny, Ajzen, Schmidt, & Leonhäuser, in press; Rhodes,
108 Blanchard, & Matheson, 2006).
109
110   The TPB has been applied to predict a wide range of behaviors in multiple
111 populations and contexts, and the empirical findings have been synthesized in
112 numerous meta-analyses across multiple behaviors and contexts (Armitage & Conner,
113 2001b), as well as for specific behaviors and domains such as health behavior
114 (McEachan, Conner, Taylor, & Lawton, 2011), physical activity (Hagger,
115 Chatzisarantis, & Biddle, 2002; Symons Downs & Hausenblas, 2005a), condom use
116 (Albarracín, Johnson, Fishbein, & Muellerleile, 2001), alcohol consumption (Cooke,
117 Dahdah, Norman, & French, 2016), and eating behaviors (McDermott, Oliver, Iverson,
118 & Sharma, 2016). Many of these meta-analyses have adopted confirmatory analytic
119 approaches using the synthesized relations among the theory constructs enabling
120 tests of theory predictions across multiple studies, such as meta-analytic path
121 analyses or structural equation modeling (Albarracín et al., 2001; Hagger, Chan,
122 Protogerou, & Chatzisarantis, 2016; Hagger et al., 2002; Hagger, Polet, & Lintunen,
123 2018; McEachan et al., 2016). Such tests provide evidence for the relative strength or
124 effect size of the relations among the theory constructs and the prediction of behavior,
125 and also enables estimation of the true variability (after correction for attenuation due
126 to measurement error) in these predicted effects across the literature. Research
127 adopting these approaches have demonstrated substantive, non-zero effect sizes for
128 the effects of intentions on behavior, effects of the attitude, subjective norm, and
129 perceived behavioral control constructs on intention, and the indirect effects of these
130 constructs on behavior mediated by intentions (Albarracín et al., 2001; Hagger, Chan,
131 et al., 2016; Hagger et al., 2002). Research has also demonstrated the contribution of
132 belief-based indirect measures of attitudes, subjective norms, and perceived
133 behavioral control on the direct measures of these constructs (Armitage & Conner,
134 2001b). Taken together, these analyses have provided support for theory predictions
135 across multiple studies for different behaviors, contexts, and populations.
136
137   Despite the support offered by syntheses of tests of theory predictions across
138 multiple studies, a number of outstanding issues that may limit the generalizability of
139 the findings have been identified. All of the analyses have shown substantive
140 heterogeneity in the size of the effects among theory constructs (Albarracín et al.,
141 2001; Hagger, Chan, et al., 2016; Hagger et al., 2002; McEachan et al., 2011). While
142 the analyses provide important information on the expected effect sizes among theory
143 variables that would be expected in the 'average' study, and that the effects are non-
144 zero, the high heterogeneity means that the actual effects could vary substantially.
145 Indeed, the theory posits that the relative contribution of the attitude, subjective norm,
146 and perceived behavioral control constructs to the prediction of intention will vary
147 across behaviors and contexts, but it does not make specific predictions. Empirically, it
148 has been found that the relative contribution of constructs depends on a number of
149 moderator variables. For example, research has demonstrated that subjective norms
150 are more likely to account for variance in intentions for certain behaviors such as bone
151 marrow donation (Bagozzi, Lee, & Van Loo, 2001), risk behaviors (McEachan et al.,
152 2011; Park, Klein, Smith, & Martell, 2009), and safe sex behaviors (McEachan et al.,
153 2011), while attitudes are likely to be the predominant predictor for behaviors like

154   physical activity (Hagger et al., 2002) and dietary behaviors (McDermott et al., 2015).
155   Therefore, the heterogeneity observed in the average effect size of theory constructs
156   on intentions in meta-analyses is likely to be due to moderator variables, including the
157   nature of the target behavior. Even meta-analyses of studies on the same target
158   behavior demonstrate considerable heterogeneity, and this may be due to other
159   moderators but may also be due to variations of types of behavior within the
160   behavioral category. For example, physical activity comprises many different
161   behaviors such as formal exercise or sports, informal or incidental activities like
162   walking or occupational physical activity. Such analyses seldom account for these
163   micro-level variations, but they may have substantive impact on effects among theory
164   constructs.
165
166   There is also likely to be variability in the degree of control individuals perceive
167   they have over performing the target behavior. In cases where individuals have full
168   actual and perceived control over the behavior, the theory should, strictly speaking,
169   reduce to the theory of reasoned action, the predecessor of the theory of planned
170   behavior. However, research demonstrates that individuals seldom perceive they have
171   complete control over their behavior, and as with attitudes, effects of perceived
172   behavioral control on intentions often vary across behaviors and contexts (Giles &
173   Cairns, 1995; Kraft, Rise, Sutton, & Røysamb, 2005; Rich, Brandes, Mullan, &
174   Hagger, 2015). Similarly, the direct effect of perceived behavioral control on behavior
175   often differs across behaviors and populations, suggesting that the extent to which
176   measures of perceived control reflect actual control over behavior varies (Hagger et
177   al., 2002; McEachan et al., 2011; Rich et al., 2015). However, verifying the extent to
178   which perceived behavioral control reflects actual control is quite difficult in
179   observational studies. Furthermore, improving participants' precision in estimating
180   their actual control is also difficult, as their estimates may be subjectively accurate with
181   respect to their personal capabilities, but may not reflect genuine external constraints.
182
183   Relatively little research has tested the moderating effects of perceived
184   behavioral control on the intention-behavior relationship (e.g., Ajzen, 1991; Armitage &
185   Conner, 2001b; Steinmetz, Davidov, & Schmidt, 2011; Yang-Wallentin, Schmidt,
186   Davidov, & Bamberg, 2004). For example, Armitage and Conner indicated that fewer
187   than 30% of the studies in their meta-analysis tested the interaction effect. Summaries
188   of research have demonstrated inconsistent findings, with some studies finding
189   statistically significant interaction effects and others no effects or even negative effects
190   (Armitage & Conner, 2001a; Yang-Wallentin et al., 2004). Yang-Wallentin suggested
191   that the inconsistencies could be attributed to the type of analysis used and that
192   among studies that used analyses correcting for attenuation due to measurement
193   error, the interaction effect was positive and statistically significant. However, to date
194   research syntheses of the interaction effects have relied on a 'vote count' method,
195   which may bias interpretations because it does not correct for methodological artifacts
196   and relies on statistical significance (Hunter & Schmidt, 2004). There is currently no
197   meta-analytic synthesis of research examining the interaction effect. A possible
198   reason for this lack of analysis is that testing interaction effects using meta-analytic
199   techniques requires access to the zero-order effects of the interaction terms used in
200   regression analyses. Such data are almost never presented in research articles
201   testing interaction effects. The meta-analyst would, therefore, require access to the
202   raw data for these studies in order to compute the required interaction terms. Gaining
203   access to these data sets through requests to the original authors may yield access to
204   some datasets, but this may be a relatively small sample of studies relative to the

205   number of tests and may not be sufficient to enable a high-powered test of the
206   interaction effects in meta-analytic synthesis. This therefore presents a considerable
207   challenge to researchers aiming to provide an estimate of the size and variability of
208   the predicted interaction effects among theory constructs. Accrual of a large number of
209   data sets testing the intention x perceived behavioral control interaction would permit
210   such an analysis and afford the opportunity to compute an unbiased test of the
211   interaction effect using meta-analytic synthesis.

213   Other methodological factors may also determine the strength of effects among
214   constructs in the theory across studies. For example, imprecision and level of
215   compatibility in the measures of theory constructs are two critical moderators that are
216   likely to affect the relative strength of the predicted effects. Ajzen (1991, 2002)
217   highlighted the imperative of compatibility in measures of the attitude, subjective norm,
218   perceived behavioral control, and intention constructs, and measures of behavior, in
219   the initial formulation of the model. Standardized guidelines exist outlining how to
220   develop measures of the theory constructs that correspond in terms of target, action,
221   context, and time (Ajzen, 2002). Although some behaviors do no permit compatibility
222   for all of these elements, fulfilling the requirement is likely to enhance behavioral
223   prediction. Indeed, limited research has demonstrated that greater compatibility leads
224   to larger effects, consistent with Ajzen's contention (Courneya, 1994). Ensuring full
225   correspondence in measures used will minimize method variance in studies and
226   maximize precision in estimates of effects among theory variables.

228   A related issue is the observed variability in the effect sizes of the belief-based,
229   indirect measures of attitudes, subjective norms, and perceived behavioral control on
230   their respective direct measures. Again, degree of correspondence between the direct
231   and indirect measures is likely to be a salient moderator. The issue is made more
232   complex by the possibility that value estimates such as outcome evaluations,
233   motivation to comply, and power of control factors are likely to vary as well as the
234   expectancy component, exacerbating variability. In addition, the content of the beliefs
235   identified is also a critical determinant of the size of the effects of indirect on direct
236   measures. Ajzen (2002) advocates eliciting the readily accessible beliefs, referents,
237   and control factors pertinent to the behavior and sample of interest using an open-
238   ended belief-elicitation procedure. Belief measures are subsequently developed from
239   the most frequently elicited responses. This ensures that the measures of beliefs with
240   respect to the target behavior are likely to closely correspond to those held by the
241   target population. While there is some potential for unique, idiosyncratic beliefs to be
242   identified, use of the modal beliefs will encompass the beliefs relevant to a large
243   proportion of the population. Examining behavior as a potential moderating factor of
244   the effects of the indirect measures on direct measures may assist in explaining some
245   of the variability in these relations across studies, but variability in the salient beliefs
246   used may vary across studies even within a particular behavior. A resolution might be
247   to develop indirect measures based on belief elicitation across multiple samples. Such
248   an approach will likely identify the salient beliefs that are common to most populations.
249   This will facilitate greater precision in the indirect measures and may reduce variability
250   in effects of these measures on the direct measures.

252   In addition to variability in the effect sizes of the predicted relations among the
253   theory constructs associated with different behaviors and contexts, variability may also
254   be attributed to sample-specific characteristics. Although large-scale tests of the
255   theory on randomly-selected samples have been conducted (e.g., Wankel, Mummery,

256 Stephens, & Craig, 1994), most research examining theory hypotheses have tended
257 to be conducted in 'convenience' samples that are neither randomly selected nor
258 stratified according to key demographic characteristics. However, there is also
259 research suggesting that the cultural norms endorsed by particular groups, within and
260 across national boundaries, may moderate effects among theory components. For
261 example, research has suggested that the relative contribution of attitudes and
262 subjective norms to the prediction of intention varies, depending on the cultural norms
263 or orientations of the sample. Groups endorsing an interdependent or collectivist
264 orientation, where group goals tend to be prioritized above those of the individual, tend
265 to exhibit larger effects of subjective norms on intentions, relative to attitudes (Bagozzi
266 et al., 2001; Heiny et al., in press; Van Hooft & De Jong, 2009), while attitudes have
267 larger effects on intentions among those endorsing an independent or individualist
268 orientation relative to subjective norms. Similarly, research has suggested that a
269 significant minority of individuals tend to base their intentions on subjective norms
270 (Trafimow & Finlay, 1996). Taken together, it would be important to account for
271 variability in these orientations when estimating the relative contribution of the theory
272 of planned behavior constructs on intentions.
273
274   There is likely to be variability in the measures used and means adopted to
275 collect data on the TPB constructs. For example, there is considerable variability in the
276 numbers of items used, the extent to which items correspond with measures of
277 intentions and behavior, the format of the response scales used, and wording and
278 phrasing of the items. These variations present challenges when attempting to
279 evaluate the extent to which variability in theory effect sizes can be attributed to
280 methodological artefacts or attributed to systematic differences due to moderator
281 variables. Standardization of methods and collection of data from samples with
282 demographic profiles that are more closely matched with those of the general
283 population may yield more precise, less variable estimates of effects among theory
284 constructs.
285
286   A final issue that has not been sufficiently explored within the TPB is the extent
287 to which causal effects posited by the theory are in the predicted direction, i.e.
288 attitudes, subjective norms, and perceived behavioral control determine intentions,
289 and intentions produce the observed behavior. A further issue is the importance of
290 examining long-term prediction while modeling change in the theory constructs. Some
291 researchers have suggested, for example, that just as attitudes may determine
292 intentions, forming and holding intentions toward a target behavior may have the
293 function of informing subsequent attitudes. Previous research has identified reciprocal
294 effects among the theory constructs (Liska, 1984), while others have supported the
295 directional effects and found only reciprocal relations among the determinants of
296 intentions, e.g., perceived behavioral control correlating with attitudes (Hagger,
297 Chatzisarantis, Biddle, & Orbell, 2001). Furthermore, researchers have demonstrated
298 that model predictions hold even after controlling for stability in longitudinal designs
299 measuring all theory constructs at two or more points in time (Hagger et al., 2001;
300 Reinecke, Schmidt, & Ajzen, 1996). The current study enables a unique large-scale
301 test of these relations by collecting data on the key theory constructs at two points in
302 time.
303
304 **Present Study**
305

306   Primary and meta-analytic research has demonstrated that the theory of
307 planned behavior is effective in predicting intention and behavior across multiple
308 behaviors, contexts, and populations. However, research syntheses testing theory
309 relations have identified considerable heterogeneity in the effect sizes of model
310 relationships. Furthermore, previous research syntheses have not tested the
311 moderating effects of perceived behavioral control on theory relations, particularly the
312 intention-behavior relationship, due to the lack of previous research testing these
313 effects and the inherent problems presented in computing the interaction terms
314 necessary to test these effects through research synthesis. In addition, there is also
315 considerable variability in the relative contribution of the indirect measures of the
316 theory constructs on their direct measures. The present study will address these
317 research gaps by conducting a large-scale multi-sample replication of the theory of
318 planned behavior. We aim to keep a number of potential contextual- and sample-
319 related moderating factors constant by focusing on a single behavior: participation in
320 vigorous physical activity according to the definition provided by the World Health
321 Organization (2010), and by conducting the research in a sample with demographic
322 characteristics that closely match those of the general population, as well as in
323 undergraduate university student samples with strict inclusion criteria. In addition, we
324 also aim to evaluate the effects of cultural orientation on relations among the theory
325 constructs by including a measure of independent and interdependent orientations
326 (Singelis, 1994).
327
328   The research will adopt an identical research protocol based on the procedures
329 for developing direct and indirect measures of the theory variables recommended by
330 Fishbein and Ajzen (2010). Specifically, the research will be conducted in two stages:
331 (1) Belief elicitation using an open-ended procedure to identify the salient behavior-
332 specific beliefs from the target population for the development of indirect measures of
333 the theory constructs, and selection of reflective items for the direct measures; (2)
334 Administration of standardized indirect and direct measures of the theory constructs:
335 attitudes, subjective norms, and perceived behavioral control, and intentions, with
336 follow-up measures of the target behavior, vigorous physical activity, taken five weeks
337 later, to test behavioral prediction across a time frame that exceeds the median of four
338 weeks identified in previous meta-analyses (McEachan et al., 2011; McEachan et al.,
339 2016) – the TPB constructs have been shown to have good stability over this time
340 frame (Armitage & Conner, 2001b; Hagger et al., 2001; McEachan et al., 2011); and
341 (3) Measures of the direct measures of the theory constructs: attitudes, subjective
342 norms, and perceived behavioral control, and intentions will also be taken at the
343 follow-up time point to test longitudinal and reciprocal effects among the theory
344 constructs, with measures taken after the measure of behavior in order to preserve the
345 typical two-wave prospective design typically used to test the theory.
346
347   Data will be collected from an online panel of research participants. In addition,
348 self-nominated research teams consenting to participate in the replication will collect
349 data from existing undergraduate cohorts with strict eligibility criteria. Participating
350 research teams will be required to pre-register their protocol and their predictions,
351 follow the research protocol precisely and log any deviations, and submit their data to
352 the principal investigators of the replication (Hagger, Hamilton, Bosnjak, Ajzen,
353 Schmidt) for analysis. The resulting data sets will be used to test the following
354 predictions of the theory using meta-analytic structural equation modeling using a
355 random effects model. As the sample size will be substantial, our predictions will be
356 based on the sizes of the predicted effects and confidence intervals about each effect

357 and not statistical significance, as most effects will likely be statistically significant.
358 Guidance will be provided by previous meta-analytic findings in the physical activity
359 domain (Hagger et al., 2002; Symons Downs & Hausenblas, 2005b). Effect sizes will
360 be evaluated on Cohen's suggested guidelines for small (β = .20), medium (β = .50),
361 and large (β = .70) effect sizes for multiple regression coefficients. All effects are
362 predicted to have a positive sign. Predictions are consistent with those proposed in the
363 original conceptualization of the theory and effect size estimates are based on
364 previous meta-analyses of the theory of planned behavior (Armitage & Conner, 2001b;
365 Hagger et al., 2002; McEachan et al., 2011).

366

367   1. Direct measures of attitude (H1a), subjective norms (H1b), and perceived
368 behavioral control (H1c) will have non-zero effects on intentions, with medium effect
369 sizes expected for H1a and H1c and small effect sizes for H1b.

370

371   2. Intentions (H2a) and the direct measure of perceived behavioral control
372 (H2b) will have non-zero effects on prospectively-measured vigorous physical activity
373 (H2), with a medium-sized effect.

374

375   3. Composite indirect measures of attitude (H4a), subjective norms (H4b), and
376 perceived behavioral control (H4c), based on the belief and value components, will
377 have non-zero effects on their respective direct measures, with medium effect sizes.

378

379   4. Direct measures of attitude (H3a), subjective norms (H3b), and perceived
380 behavioral control (H3c) will have non-zero indirect (mediated) effects on
381 prospectively-measured vigorous physical activity via intentions, with small effect
382 sizes.

383

384   5. There will be non-zero interactive effects of intentions and perceived
385 behavioral control on prospectively-measured vigorous physical activity, with larger
386 effects of intentions on vigorous physical activity expected among individuals with
387 higher levels of perceived behavioral control (H5).

388

389   6. There will be non-zero interactive effects of perceived behavioral control and
390 attitudes, and perceived behavioral control and subjective norms on intention, with
391 larger effects of attitude and subjective norms on vigorous physical activity expected
392 among individuals with higher levels of perceived behavioral control.

393

394   7. There will be non-zero interactive effects of self-construals on the effects of
395 attitudes and subjective norms on intentions. The effect size of direct measures of
396 attitudes on intentions is predicted to be larger in participants that strongly endorse
397 independent self-construals (H6a), and the effect size of direct measures of subjective
398 norms on intentions is predicted to be larger among individuals that strongly endorse
399 interdependent self-construals (H6b).

400

401   8. We will also estimate the covariance stability (autoregressive effects) of each
402 of the direct measures of theory constructs (attitudes, subjective norms, perceived
403 behavioral control, intentions) and behavior in a panel design. In addition, we will test
404 reciprocal effects among the theory variables. There will be non-zero effects of direct
405 measures of attitude (H7a), subjective norms (H7b), and perceived behavioral control
406 (H7c) on intentions with small-to-medium effect sizes after controlling for covariance
407 stability. There will also be non-zero effects of physical activity behavior measured at

408 an initial point in time on attitude (H7d), subjective norms (H7e), and perceived
409 behavioral control (H7f), and intentions (H7g) with small-to-medium effect sizes. We
410 will also test reciprocal (cross-lagged) relations among direct measures of theory
411 constructs over time and expect predicted causal directions among theory constructs
412 to hold.
413
414 **Materials**
415
416   The protocol for the proposed replication study will develop standardized direct
417 measures of the theory constructs based on previously published guidelines. In
418 addition, measures of behavioral beliefs, normative beliefs, and control beliefs will be
419 developed from belief elicitation research and used alongside standardized measures
420 of outcome expectancies, motivation to comply, and control belief power to produce
421 indirect measures of the attitude, subjective norm, and perceived behavioral control
422 constructs. The materials for the experiment include:
423
424 1. Standardized direct measures of theory of planned behavior constructs, namely,
425 attitudes, subjective norms, perceived behavioral control, and intentions, and self-
426 report measures of behavior, made available as part of an online survey administered
427 by the online survey software.
428
429 2. Standardized open-ended belief-elicitation questionnaire administered using the
430 online survey software, for use in the first phase of the study.
431
432 3. Standardized indirect measures of attitude, subjective norms, and perceived
433 behavioral control for use in all samples, developed based on the beliefs identified in
434 the elicitation questionnaire administered across all samples in the first phase of the
435 study.
436
437 4. Information statements, consent forms and debrief statements made available as
438 part of the online survey delivered by the online survey software.
439
440 5. Items for participants to self-report salient demographic variables as part of the
441 online survey including gender, age, education, parental education, household income
442 (if applicable), and ethnicity.
443
444 All materials are available on the Open Science Framework project page and
445 PsychArchives.org for the registered replication study.
446
447 **Important:** Participating research teams will be provided with access to the
448 questionnaire using an online questionnaire tool and will have direct access to the
449 survey responses from their participants.
450
451 **Methods**
452
453   *Design*. Phase one of the study will comprise a brief belief elicitation survey and
454 will adopt a single-wave design using surveys with open-ended response options.
455 Phase two of the study will adopt a two-wave correlational, prospective design using
456 surveys containing multi-item scaled measures of study constructs. Direct and indirect
457 measures of theory variables will be administered to participants on an initial data
458 collection occasion, and a self-reported measure of vigorous physical activity

459   administered to the same participants on a second occasion five weeks later. The
460   adoption of standardized measures and use of online survey software are design
461   features aimed at minimizing variability in data collection. Each of the surveys will be
462   piloted among native speakers of the survey language (English for the initial panel
463   survey, see below) to provide precise completion time estimates.

465   *Procedure: Phase 1 Belief Elicitation Survey*. Participants will be recruited from
466   two sources. The first source is an online panel of research participants. Specifically,
467   UK-based participants will be recruited via PsychLab online operated by the ZPID.
468   The second will be undergraduate participants in their first year at University aged 18
469   to 25 years. In the first phase, participants will be sent an email inviting them to
470   participate in "a brief survey on physical activity". The email will contain brief
471   information and an internet address (URL) directing participants to a 'landing' web
472   page controlled by the online survey software. The landing page will comprise a brief
473   study information statement and a consent form. Participants will be required to agree
474   that they have read the information statement and provide consent to participate in the
475   survey before they can navigate further. Participants declining to participate will be
476   directed to an exit web page. Consenting participants will be able to navigate to the
477   first page of the survey, which provides information on how to complete the open-
478   ended questions for the belief-elicitation procedure. Participants' responses will be
479   logged by the online survey software and stored on a cloud-based, password
480   protected repository accessible only to the principal investigators.

482   *Procedure: Phase 2 Main Survey*. Participants will be sent an invitation to
483   participate in "a survey on attitudes and beliefs towards physical activity" via email.
484   The email will contain brief information about the study with a URL directing
485   participants to the study 'landing page' hosted by the online survey software. The
486   'landing page' will comprise an information statement providing details of study
487   requirements and expectations, a statement on their rights as a participant, and a
488   consent form, which includes consent to be contacted for the follow-up survey.
489   Participants will be required to confirm their consent before they can navigate further,
490   participants declining to participate will be directed to an exit page. Consenting
491   participants will be directed to the first page of the survey, which provides brief
492   instructions on how to complete the survey items and a definition of the target
493   behavior: vigorous physical activity. Participants are then prompted to complete the
494   survey items, segregated into brief sections. To minimize data loss, a forced response
495   procedure will be used: participants will be required to respond to all items on each
496   page of the survey before they are able to advance to the next page. Responses to
497   each item are logged by the survey software. After completing the survey, participants
498   will be directed to an exit page thanking them for their participation and reminding
499   them that they will be contacted by email to complete the follow-up survey.
500   Participants' anonymity will be protected by assigning each participant with a unique
501   code number will be used to match questionnaires across the two data collection
502   occasions.

504   Participants completing the survey on the first data collection occasion will be
505   sent a second email inviting them to participate in the follow-up survey. The email will
506   direct them to the landing page of the follow-up survey hosted by the online survey
507   software. The page will provide a brief information statement and a reminder of their
508   participant rights. Participants will then be directed to the first page of the survey. On
509   completion participants will be directed to an exit page thanking them for their

510   participation and provided with a plain-language debrief statement outlining the
511   purpose of the research and expected outcomes.

Data Analyses and Predictions

515   The pre-registered predicted effects among the theory constructs will be
516   estimated using meta-analytic structural equation modeling with a random effects
517   model using the data sets collected from the ZPID panel survey and data collected
518   from all participating research teams (Cheung, 2015; Cheung & Hong, 2017). The
519   analysis allows for the simultaneous estimation of each effect using standardized
520   parameter estimates with likelihood-based confidence intervals, estimation of the
521   overall fit of the proposed model with the data, and estimation of the degree of
522   heterogeneity associated with the effects and the true variability after correcting for
523   methodological artefacts using random-effects meta-analysis. In terms of specific
524   hypothesis tests, we will estimate three separate models: (1) a model testing the
525   proposed direct and indirect (mediated effects) among measures of attitude,
526   subjective norm, perceived behavioral control, intentions, and behavior; (2) an
527   identical model including effects of past behavior; (3) a model in which proposed
528   interaction effects are tested: interactions of attitudes and subjective norms with
529   perceived behavioral control on intention, and the interaction of perceived behavioral
530   control with intention on behavior; and (4) an autoregressive panel model testing
531   model effects while controlling for covariance stability and also testing lagged effects
532   for direct measures of theory constructs, this model will not include interaction effects.
533   In addition, we will also test the measurement and factor structures of the models in
534   the full sample including data from both the ZPID panel and student participants, and
535   separately, using conventional and multi-sample confirmatory factor analyses and
536   structural equation modeling. In the event that the factor structure of the measures in
537   the current study do not exhibit good fit with the data in one or more samples,
538   exploratory analyses will be conducted to identify the source of the misspecification,
539   and the discrepancies logged prior to proceeding with hypothesis tests. The multi-
540   sample analysis may provide information on the extent to which effects vary according
541   to the background of particular samples. Finally, we plan on pooling the general
542   population samples and conducting an analysis using Bayes factors for model effects
543   under the null hypothesis i.e. no effect, and specific hypotheses based on effect size
544   estimates and distributions from the most recent meta-analysis applying the TPB to
545   physical activity (McEachan et al., 2011, Table 3). Demographic variables will be used
546   as covariance in the main analyses.

Sample size

550   Phase one data collection will be conducted on small samples drawn from the
551   population of interest. In the case of the ZPID panel sample, this will be a pilot sample
552   drawn from the panel, and in the case of the student samples this will be a pilot
553   sample drawn from each student sample. Previous research has demonstrated that
554   samples of this size are sufficient to elicit modal beliefs for the development of indirect
555   measures (Hamilton, Kirkpatrick, Rebar, White, & Hagger, 2017; Hamilton et al.,
556   2012). The phase one samples will be independent of the sample used in phase two.

558   Two approaches to estimating required sample size for phase two were used,
559   one for each replication. The first estimate was based on expected individual effects in

560 the proposed model, and the second on the overall estimate of the final structural
561 model based on model fit.

563   *Individual effect sizes*. Previous meta-analytic research testing effects among
564 theory of planned behavior variables in physical activity contexts has indicated
565 medium-sized effects for attitude-intention, perceived behavioral control-intention, and
566 intention-behavior relations, with small-to-medium sized effects for the subjective
567 norm-intention and perceived behavioral control-behavior relations. For the sake of
568 conservatism, we therefore assumed a small-to-medium effect size for all model
569 parameters (f^2= .10). We estimate a minimum sample size for a linear multiple
570 regression analysis with statistical power set at .90, alpha set at .01 for a regression
571 model with five predictor variables, including effects on intentions and behavior using
572 the G*Power tool (Faul, Erdfelder, Lang, & Buchner, 2007). This provides a projected
573 minimum sample size of 228 participants matched across data collection points. Given
574 an estimated 20% dropout rate, research teams are recommended to collect data from
575 274 participants in their initial data collection occasion. Data from research teams that
576 fall short of the required number will be included in the final cumulative data analysis
577 using meta-analytic structural equation modeling, such data will be assigned less
578 weight in the analysis. However, we will also conduct sensitivity analyses excluding
579 data from research teams that fail to achieve reach the requisite sample size, to check
580 whether the smaller sample size affects conclusions in hypothesis tests.

582   *Model fit*. An alternative approach to statistical power is based on overall model
583 fit based on the procedures outlined by MacCallum et al. (1996). This approach
584 assumes that overall fit of the proposed model with the data is indicative of precision
585 of the estimates of the individual effect sizes of the parameters in the model with lack
586 of precision penalized through poorer fit. Using this approach to compute the projected
587 sample size for a meta-analytic structural equation model, computing the desired
588 sample size using RMSEA fit index values from previous meta-analytic structural
589 equation models (Hagger et al., 2018). We used the WebPower analytic tool (Zhang &
590 Yuan, 2018) to calculate power using the MacCallum et al. (1996) method. We
591 specified parameters based on a recent model for the reasoned action approach using
592 meta-analytic structural equation modeling, the selected analytic approach for the
593 current research. The model was estimated based on and RMSEA of 0 for the
594 baseline model and RMSEA of 0.06 for the predicted model, with power set at .90 and
595 alpha set at .01, and 3 degrees of freedom (Hagger et al., 2018). The calculated
596 predicted sample size was 1783 for the meta-analytic structural equation modeling.

598 **Sample Demographics**

600   *ZPID Panel sample*. The demographic profile of recruited participants can be
601 specified by the research team a priori. We will recruit general population samples
602 (approximate N = 1000 matched across time points) of panel members with
603 characteristics that match national averages for gender distribution, income, and
604 education. The recruited samples will, therefore, have demographic profiles that
605 closely match those of the general population, although the samples will not be
606 randomly selected. As the target behavior is vigorous physical activity, participants
607 with physical disabilities, or chronic or acute illnesses or conditions, that prevent them
608 from participating in vigorous physical will not be eligible for inclusion. All participants
609 must be 18 years or older at the time of participation.
610

611 *Student sample*. Participating research teams will be required to recruit
612 participants from first-year undergraduate students aged 18-25 years on the day of
613 participation with approximately equal gender distribution. Our aim was to keep the
614 demographic profile relatively narrow in order to provide a level of control over
615 potential demographic moderators. Identical restrictions on eligibility for participation
616 regarding disabilities and illnesses and conditions for the panel sample will also apply
617 to the student sample.
618
619 *Demographic information*. Participants will also complete measures of key
620 demographic variables including age, gender, highest educational level, household
621 income (if applicable), and ethnicity. Participants will also be prompted to complete a
622 brief series of questions on the impact of the COVID-19 pandemic on physical activity
623 patterns.
624
625 *Language*. As data will be collected in multiple countries, study measures will
626 need to be translated into participants' native language. Survey measures and
627 materials will be developed in English and will need to be translated into the requisite
628 language by fluent bi-lingual translators for data collection. Translation will be
629 conducted using a standardized iterative translation procedure involving a combination
630 of forward- and back-translation procedures in consultation with the principal
631 investigators. The translated versions will be held as separate versions of the survey
632 on the online survey software. These versions will be available for participating
633 research teams collecting student data in these languages. Teams that aim to collect
634 data in other languages will need to translate the materials into the required language
635 using an identical back-translation procedure. These surveys will be stored as
636 separate versions of the survey on the online survey software. Translation procedures
637 will follow recommended guidelines:
638 https://www.sciencedirect.com/science/article/pii/S0020748912000600?via%3Dihub
639

Participating Research Team Expertise

642 Participating research teams are expected to have experience in conducting
643 survey research and have access to a relevant pool of participants that can be
644 contacted by email. They will also be required to secure ethical clearance for their
645 data collection from an appropriate ethical committee or institutional review board.
646 Specific knowledge of the theory of planned behavior and its predictions are desirable
647 but not required. Participating teams are also expected to pre-register their replication
648 using a standardized form on the OSF. Each pre-registration will be expected to follow
649 the central pre-registration, but will also enable each time to provide a list of
650 predictions for their particular replication, independent of the predictions provided by
651 the principal investigators in the main pre-registration. Each of these pre-registrations
652 will be a 'fork' form the main OSF page for the project. This approach is consistent
653 with previous registered replication reports (e.g., Alogna et al., 2014; Eerland et al.,
654 2016; Hagger, Chatzisarantis, et al., 2016).
655

Exclusions

658 Data from participants will be excluded from the final data set if they do not
659 meet inclusion criteria, if they drop out of the study between the first and second data
660 collection occasions, if they fail to complete the survey, or their response profile
661 suggests they did not pay attention to the survey questions, according to attention

662   check questions embedded in the survey. Data from participants dropping out of the
663   study across data collection occasions will be retained for analysis of attrition bias.
664   Participant exclusions and reasons for exclusion will be clearly identified and logged
665   on the OSF page.
666
667   **Data Collation and Statistical Analyses**
668
669   The principal investigators will be responsible for collating the collected data
670   and for data analysis.
671
672   Data from the initial belief elicitation stage for each sample will be downloaded
673   and stored as numeric spreadsheets. The principal investigators will then identify the
674   modal responses for the behavioral, normative, and control beliefs, and develop
675   indirect belief-based measures according to guidelines. Beliefs identified by more than
676   25-30% of participants in the pilot sample will be considered modal and eligible for
677   inclusion (Ajzen & Schmidt, 2020).
678
679   Data from the second phase panel and student replications will downloaded as
680   numeric spreadsheets. Data will be analyzed using the *psych* (Revelle, 2018), *lavaan*
681   (Rosseel, 2012), Mplus (Muthén & Muthén, 2015) and *metaSEM* (Cheung, 2015)
682   packages in R. As the surveys will use a forced response procedure, there should be
683   no missing data.
684
685   Data will be screened for responses indicating that participants had not read or
686   paid sufficient attention to the survey. Basic descriptive statistics for each item in each
687   data set will be generated including estimates of skewness and kurtosis.
688
689   Effects of attrition on study variables across data collection occasions in each
690   data set will be tested using MANOVAs with study constructs as multiple dependent
691   variables and attrition status (dropped out vs. remained in the study at follow up) as
692   the single independent variable. Statistically significant overall attrition effects with
693   non-trivial effect sizes will be followed up with univariate follow-up *F*-tests.
694
695   Main hypotheses in the three proposed models within each sample will be
696   estimated. A maximum likelihood method will be used with overall model fit evaluated
697   using incremental fit indexes: the comparative fit index (CFI) and the non-normed fit
698   index (NNFI), the standardized root mean square residuals (SRMSR), and the root
699   mean square error of approximation (RMSEA). Cut-off values of .90 for the CFI and
700   NNFI, and .08 and .05 for the SRMSR and RMSEA, respectively, will indicate
701   satisfactory model fit. Solution estimates for each latent variable representing a study
702   construct will also be estimated, with factor loadings expected to exceed .70 and
703   average variance extracted for each factor expected to exceed .50. Reliability of
704   measures will be estimated using composite reliability coefficients based on the factor
705   loadings. Interaction effects in the third model will be tested using interaction terms
706   computed using the residual centering approach (Steinmetz et al., 2011).
707
708   Main hypotheses in the three proposed models across the samples will be
709   tested using meta-analytic structural equation modeling (MASEM) using the metaSEM
710   package. The MASEM analysis is conducted in two stages. In the first stage,
711   correlation matrices among the TPB items from individual studies are pooled to form a
712   common covariance matrix using random effects meta-analysis. The analysis

713   produces a pooled matrix representing the average covariance matrix among study
714   variables in the population, with a sampling variance-covariance matrix that represents
715   the known precision estimates of each correlation in the pooled matrix. The first stage
716   yields zero-order correlations corrected for bias using a random effects meta-analytic
717   model among study constructs across studies with 95% likelihood-based confidence
718   intervals. In addition, statistics to evaluate heterogeneity in the effect sizes are also
719   provided: the τ^2 statistic representing the true variability in the effect across studies,
720   and the Q statistic, and the I^2 statistic and its 95% confidence interval which indicate
721   the level of heterogeneity in the effect across studies. In the second stage of the
722   analysis, the pooled correlation matrix is used to estimate the proposed model. As
723   with the single-sample analyses, model fit is evaluated using multiple criteria for
724   goodness of fit: CFI, NNFI, SRMSR, and RMSEA. The model also allows for the
725   computation of indirect effects specified a priori and their 95% likelihood-based
726   confidence intervals. Models testing the proposed direct and indirect effects among
727   theory variables will be tested using the full latent variable approach consistent with
728   the univariate models. However, as interaction effects using latent variables are
729   difficult to compute using MASEM, we will use mean-centered interaction terms based
730   on composite (averaged) variables.

731

732   **Procedure**

733

734   (1) Research teams will be invited to participate in the study via advertisements on
735   listservs and circular email lists. The invitation will provide a brief outline of the main
736   purpose of the study, and provide information requirements for following study
737   protocol, participant recruitment, and data collection. Interested teams will be asked to
738   follow a url to the recruitment web page, which will provide further details and
739   requirements, and a brief application form. Expressions of interest will be vetted by the
740   principal investigators to ensure applicants have sufficient experience and resources
741   to follow the protocol and collect data before the specified deadline. Accepted
742   applicants will be provided with full study protocol and materials and asked to liaise via
743   email or voip conversations with the principal investigators on their progress.
744   Participating teams will be required to develop a page for their replication on the OSF
745   forked to the main OSF page for the project following a standard template and pre-
746   register their predictions. Members of teams completing data collection will be
747   included as co-authors on the final research report and peer-reviewed articles arising
748   from the project (maximum of three co-authors per team).

749

750   (2) Study measures will be translated for use in non-English speaking countries using
751   the stipulated translation procedure. Research teams collecting data other languages
752   will be required to conduct their own translations using the stipulated procedure and
753   make the measures available via the OSF project page for their replication and upload
754   it to the online survey software.

755

756   (3) Each research team will identify an initial sample N ~ 50 of participants from the
757   target population and collect data for the first phase of the study using the belief
758   elicitation survey. A unique url for access to the survey will be provided for each
759   participating research team. Once data collection is complete, the principal
760   investigators will develop indirect measures of theory of planned behavior constructs
761   based on the elicited modal beliefs. This will be done by coding the open ended
762   responses to the elicitation survey into categories of beliefs and values for each TPB
763   construct: attitudes (behavioral beliefs), subjective norm (normative beliefs), and

perceived behavioral control (control beliefs). Beliefs identified by at least 25-30% of the initial sample will be used (Ajzen & Schmidt, 2020). Separate sets of beliefs will be elicited for the panel and student surveys for use in the final questionnaires. The core team will also oversee the translation processes for the materials for non-English speaking participant groups. These will be incorporated into the online survey software. These will be incorporated into the online survey. Participating research teams conducting the replication in other languages will also be required to conduct the translation using the stipulated procedure and provide the final set of indirect measures to the principal investigators for inclusion in the online survey. As differences in the sets of salient beliefs for the target behavior identified in the panel sample and student samples are expected, belief measures will be developed separately for each.

(4) Research teams will then proceed with collecting data on the initial survey in phase two. Collection of phase two data from the ZPID panel will be managed by the principal investigators. Participating research teams will be required to recruit participants by directing them to the study url. Participating teams will be able to keep track of recruited numbers of participants via the online survey software.

(5) After recruiting sufficient numbers of participants for the initial survey, participating research teams will collect follow-up responses from the same participants five weeks later. Numbers of follow-up responses will be monitored in the same way as previously.

(6) The principal investigators will collate responses to the surveys centrally and provide participating research teams with the final data set downloaded from the online survey software. Data analysis will be conducted by the principal investigators and individual and groups results sent to the participating research teams for verification. All data files will be stored on the PsychArchives repository and made available to researchers on request in a GDPR-compliant form.

(7) The final report detailing results from the hypothesis test from the full samples will be developed by the principal investigators. All participating research teams will be given the opportunity to comment on the report prior to publication. All teams will have full access to their own data and the data collected by other participants. The final data sets will be a publicly available resource for testing additional hypotheses and research questions.

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