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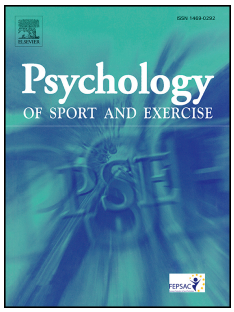

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Self-Determination Theory Informed Research for Promoting Physical Activity: Contributions, Debates, and Future Directions

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Abstract

In this review we evaluate the applications of self-determination theory (SDT) research to promote motivation for physical activity (PA) and exercise. The evidence suggests that SDT-informed interventions are often effective at changing health behaviors, including PA/exercise, and associated health outcomes. The effect sizes are small to moderate and are often mediated by increases in autonomous motivation (primarily), interpersonal support for basic psychological needs, and competence need satisfaction. We also identify conceptual debates within the SDT literature and between SDT and other literatures, and discuss their relevance with respect to PA. We particularly focus on tripartite conceptualizations of interpersonal styles and psychological needs, whether there are more than three basic psychological needs, and the use of financial incentives and competition to promote PA. Our review also provides future conceptual and methodological directions for future SDT-based research, building on advances in technology (e.g., generative Artificial Intelligence and Large Language Models) and the broader field of behavioral science (e.g., optimization designs, system-level interventions, behavior change intervention ontologies).

Keywords: narrative review, tripartite model, behavioral science, motivation, financial incentives, competition

Motivation is a highly popular and cited topic (Smolinski et al., 2024) in the field of sport and exercise psychology. Research on exercise and physical activity (PA) promotion has utilized a plethora of theories and models of motivation and behavior change; most of these were originally developed in the fields of social and health psychology, as well as in behavioral economics. Amongst these theoretical perspectives, self-determination theory (SDT; Ryan & Deci, 2017) has received considerable empirical attention. In a recent handbook on SDT, Ntoumanis and Moller (2023) identified "health" as the primary domain for applications of SDT, amongst many others (e.g., education, workplace). Within the health literature, PA and exercise have been focal targets, with significant and growing outputs. For instance, a search using the database Scopus reveals that inputting the terms "self-determination theory" and "physical activity" or "exercise" results in 142 outputs in 2013-2014, whereas in 2023-2024 the outputs have doubled (287).

In our review, we aim to a) provide a high-level description of the theory (more comprehensive overviews can be found in two somewhat recent SDT books by Ryan, 2023, and Ryan & Deci, 2017), b) evaluate evidence on the applications of this theory to exercise and PA psychology research (covering both structured exercise classes and leisure time recreational PA, but not physical education or sport settings), c) identify conceptual debates within the SDT literature and between SDT and other literatures; some of these debates are outside the field of exercise psychology but could have potential implications for research within this field, d) provide future conceptual and methodological directions for future SDT-based research, building on advances in technology and the broader field of behavioral science,. Although exercise has been defined as a subtype of PA that is planned, structured and repetitive (Caspersen et al., 1985), many of the studies we include in our review have used the terms PA and exercise interchangeably. When differentiation between the two terms was unclear in the reviewed studies, we used the terminology adopted by those studies.

A Concise Overview of the Major SDT Propositions and Constructs

SDT is a macro-theory of motivation, organized in six mini-theories (Ryan, 2023). The latter describe how motivational factors at the individual and social-contextual levels work synergistically to affect changes in motivation-related outcomes in terms of behavior, cognition, and affect. A basic premise of SDT is that more positive outcomes (e.g., goal persistence, cognitive engagement, well-being) are experienced when individuals have high self-determined (autonomous) motivation (Ryan et al., 2022). Autonomous motivation captures regulatory styles that reflect enjoyment/interest (intrinsic motivation), alignment with one's identity (integrated regulation), and perceived usefulness of the target behavior (identified regulation). In contrast to autonomous motivation, controlled motivation as well as lack of motivation (amotivation) are linked to maladaptive outcomes (e.g., dropout, ill-being, cognitive interference). Controlled motivation also captures multiple regulatory styles that reflect inner pressures and ego involvement (introjected regulation) or external pressures and contingent rewards (external regulation).

How can we promote autonomous motivation and, hence, more positive outcomes? According to SDT propositions, the satisfaction of three basic psychological needs for autonomy, competence, and relatedness is a key for foresting autonomous motivation. Such satisfaction can be self-driven (e.g., see research on "need compensation" or "need crafting"; Dalgas et al., 2024; Laporte et al., 2021) or can be fostered in social environments that are need supportive. There are a number of behaviors and interpersonal processes that define need supportive social environments. Two recent expert consensus papers have identified the defining behaviors of need support. The first paper (Teixeira et al., 2020), proposed a classification of 21 motivation and behavior change techniques (MBCTs) that can be used in SDT-informed interventions in the health context. Examples of such techniques include provision of a meaningful rationale (autonomy support), showing unconditional regard (relatedness support), and setting optimally challenging goals (competence support). The second paper (Ahmadi et al., 2023) identified a classification system of 35 behaviors that teachers can use to be need supportive, drawing mainly from SDT but also from other theories. Given that

both expert consensus papers reviewed somewhat similar literatures, there is a partial overlap in the identified need supportive strategies.

What is unique about the Ahmadi et al. (2023) paper is that it also identified 22 behaviors that could be need thwarting. Examples include teachers using pressuring language (autonomy thwarting), publicly presenting critical feedback (competence thwarting), or being sarcastic (relatedness thwarting). Need supportive and thwarting behaviors (as well as need satisfaction and need frustration and motivational regulations), have been examined as composite orthogonal variables or independent need-specific variables, or have been combined using profile scores. Additionally, multidimensional scaling has been used to plot need-supportive and thwarting behaviors on a circumplex model (Aelterman & Vansteenkiste, 2023). The identification of need thwarting behaviors is important, as they are likely to result in feelings of frustration of the three basic psychological needs. In turn, need frustration has been linked to controlled motivation, amotivation, and maladaptive motivation-related outcomes (Bhavsar, Ntoumanis, et al., 2020).

Besides need supportive and need thwarting social environments, the satisfaction or frustration of the three psychological needs has been linked in the SDT literature with two more key variables: goal content (also described as “life aspirations”) and causality orientations (Ryan et al., 2022). In terms of goal content (reflecting the “what” of behavior change as opposed to the “why”, which is captured by research on autonomous and controlled motives for goal pursuit; see Sezer et al., 2024), a distinction has been made in the exercise and PA psychology literature between intrinsic (e.g., social affiliation, health management, skill development), and extrinsic (image and social recognition) goals (Sebire et al., 2008). Studies of goal content in exercise and beyond, using the same person-centered and variable-centered approaches as for other SDT variables, have shown that intrinsic goals are conducive not only to psychological need satisfaction but also to well-being. In contrast, extrinsic goals have been linked to need frustration and ill-being (Bradshaw et al., 2023). In terms of causality orientations, namely, individual differences in propensities to focus on external

cues or inner capacities, SDT research has differentiated between autonomous, controlled, and impersonal orientations (Ryan & Deci, 2017). Individuals with autonomous orientation feel choice with respect to their interactions with others, those with controlled orientation focus on internal or external contingencies and rewards, whereas those with impersonal orientation feel lack of control over their lives. Autonomy and control/impersonal orientations have been positively linked with autonomous and controlled forms of motivation, respectively, across different life domains (Hagger & Hamilton, 2021). In PA research, autonomous orientation has also been linked to need satisfaction and controlled orientation to need frustration (Behzadnia, 2021).

Conclusions

In short, the SDT view is that adaptive behavioral, affective, and cognitive outcomes are more likely to be observed when individuals are motivated by autonomous motives and intrinsic goals, experience psychological need satisfaction, have an autonomous orientation, and operate in social environments that are need supportive. In contrast, maladaptive outcomes should be manifested when individuals are motivated by controlled motives or are amotivated, have extrinsic goals, experience psychological need frustration, have a controlled or impersonal orientation, and operate in social environments that are need thwarting (Ryan et al., 2022).

An Overview of the Evidence on the Applications of SDT in Exercise and PA Psychology

A plethora of research designs have been employed in the SDT literature to study motivation in diverse PA settings and samples. These designs range from interviews (Thal et al., 2024) and case studies (Kang et al., 2021) to surveys (Rocchi et al., 2023) longitudinal studies (Ng et al., 2013) and randomized controlled trials (Silva et al., 2011). Due to space constraints, this section focuses on the evaluation of these applications from systematic reviews and meta-analyses. A number of these reviews has been published in the last decade, some of which are specific to exercise and PA, and others which examine diverse health behaviors, amongst them, exercise and PA.

Reviews within the PA/exercise literature

The first systematic review on the applications of SDT for exercise and PA promotion was a narrative review of 66 studies with adult populations by Teixeira et al. (2012). These authors reported that there was a consistent pattern of positive relations between autonomous motivation and exercise behavior, with a trend suggesting that identified regulation was a stronger predictor of exercise adoption and intrinsic motivation was more important for the prediction of exercise maintenance. Teixera et al. explained this trend by suggesting that cognitive factors (e.g., instrumental attitudes) are substantially involved in decisions for initiating exercise, but maintenance of exercise behavior is more likely when the exercise activities are enjoyable. As expected, for the average participant, the relations of exercise behavior with external regulation and amotivation were either negative or null. Interestingly, the associations between introjected regulation and exercise behavior were mixed, with both positive and negative signs being reported. This mixed pattern could stem from the way introjected regulation has been assessed sometimes in SDT literature, with unidimensional scales that conflate approach and avoidance tendencies. Conceptually, avoidance forms of introjection are predicted to be more maladaptive than approach ones, and this has been also shown empirically in studies in which the two forms of introjection have been separated (Bieg et al., 2024). The mixed pattern of results may also be due to internal pressures and feelings of guilt being predictors of short-term, but not long-term, behavior change (e.g., Silva et al., 2011). Lastly, of the three psychological needs, competence satisfaction was more strongly and consistently associated with exercise behavior; the associations pertaining to the other two needs were either positive or null, although none were negative. These results are not surprising, given that many types of exercise and PA require skill acquisition and potentially skill mastery, are self-initiated in adult populations, and might be carried out without the support from others (e.g., solo weight training, running, or rock climbing).

A limitation of the Teixeira et al. (2012) review was that it was narrative in nature with limited quantitative evidence, mainly in the form of “vote counting”. More recent reviews on the

applications of SDT to PA used meta-analytic methods. We interpret the effect sizes from these reviews using recent benchmarks proposed for psychology research (Funder & Ozer, 2019). Unlike Teixeira et al., these reviews also included studies from sport and/or physical education, but without testing for moderation across different PA contexts. Hence, the results of these reviews are not directly comparable due to differences in populations and settings. Manninen et al. (2022) reviewed experimental applications of SDT in organized exercise, sport, and physical education settings. The 38 included studies showed that these interventions had positive but small effects on intrinsic motivation (g = 0.29) and identified regulation (g = 0.23) and a negative small effect on external regulation (g = -0.16) and amotivation (g = -0.14). Their effects on integrated regulation (g = 0.08) and introjected regulation (g = 0.03) were inconsequential. Mossman et al. (2024) meta-analytically synthesized any study design that reported associations between autonomy support and other SDT variables in sport or exercise. The findings from 131 independent samples showed that autonomy support (perceived or observed) by significant others (fitness instructor, coach) was positively and strongly associated with all types of autonomous motivation, with the satisfaction of all three psychological needs, and with introjected regulation (small effect size). However, autonomy support was unrelated to external regulation and was negatively related to amotivation (small effect), as well as to the frustration of all three psychological needs (large effects). No evidence was found that these effects were moderated by culture or age. Also, there was no evidence of publication bias in the included studies.

Reviews within the Health Psychology Literature

All four of the meta-analyses presented in this section had somewhat different eligibility criteria (and hence their results are not directly comparable), but broadly speaking, they were interested in whether SDT-informed interventions are successful in changing SDT constructs and/or health behaviors and health outcomes (e.g., blood pressure, mental health indices). By far, the most frequently targeted health behavior in all four meta-analyses was PA/exercise (and in some cases,

also physical education). Less frequently targeted health behaviors included smoking cessation, alcohol consumption, diet, and dental hygiene. Some of these reviews also tested process models of change and/or examined the effectiveness of MBCTs, as well as behavior change techniques (e.g., goal setting) based on classifications proposed by Michie et al. (2013) and Hardcastle et al. (2017).

Gillison et al. (2019) reported the analysis of 74 interventions which showed that these had large effect sizes in terms of changes in autonomy support (g = 0.84), autonomy (g = 0.81) and competence (g = 0.63) need satisfaction, medium effect size for autonomous motivation (g = 0.41), and small for relatedness (g = 0.28). The effects pertaining to controlled motivation were, unfortunately, not analyzed. Moderation analysis showed no differential effects as a function of intervention duration. In terms of MBCTs and BCTs, Gillison et al. reported that individual techniques had limited independent impact on outcomes, leading the authors to suggest that SDT-informed interventions should use a combination of these techniques.

Extending the Gillison et al. (2019) meta-analysis, Ntoumanis et al. (2021) examined the effects of 73 SDT-based interventions not only on autonomous motivation and need satisfaction, but also on need support, controlled motivation, amotivation, health behavior, and physical and psychological health. Further, the impact of such interventions was assessed separately at the end of the intervention period and at the latest follow-up of each included study. The findings for autonomous motivation and need satisfaction were similar to those of Gillison et al., albeit smaller in size. The effects of the interventions on perceptions of need support were large to very large, indicating that experimental manipulations of the need supportive features of the social environment were successful. However, the reductions in controlled motivation and amotivation were rather small, indicating that more work is needed to identify how such interventions can help not only to increase autonomous motivation but also reduce non-autonomous forms of motivation. For health behaviors the effect sizes were moderate in size, but for physical and psychological effects the effects were small. Further, meta-regressions showed that increases in autonomous motivation and

need support at the end of the intervention were associated with positive changes in health behaviors at follow-up (there were too few studies to examine the effects of SDT variables at intervention end on psychological and physical health at follow-up). Taken together, these findings imply that to experience benefits in health outcomes, health behaviors need to be maintained over an extended period of time, and that such behavioral maintenance is facilitated by autonomous motivation and need supportive social environments.

Ntoumanis et al. (2021) also examined MBCTs and BCTs used in the included intervention studies. They found that some MBCTs moderated intervention effects; for instance, provision (vs absence) of a meaningful rationale was associated with larger effect sizes in autonomy satisfaction, need satisfaction, and psychological health. The number of BCTs used in the intervention was positively associated with autonomous motivation levels (but not with other SDT constructs). However, no distinct pattern emerged connecting specific BCTs to either physical or psychological health outcomes. One conclusion from this review was that there was considerable variation in intervention duration and intensity, highlighting a need in the literature to test and identify optimal content for SDT interventions (see also Future Directions below). Furthermore, there was a noteworthy absence of data on the cost-effectiveness of these interventions, as well as comparative effectiveness with other interventions; such data are especially important for policymakers. Ntoumanis et al. also suggested that future interventions should assess their impact on perceptions of need thwarting and need frustration.

Sheeran et al. (2020) identified 56 SDT-informed interventions in the health domain. The sample-weighted average effect size on all behaviors was d_+= .23, similar to the one by Ntoumanis et al. (2021) at follow-up (g= .28). For PA in particular, the effects were d_+ = .25 for overall activity, d_+= .23 for self-reported, and d_+= .29 for device-assessed. In a follow-up analysis with 67 studies, Sheeran et al. (2021) identified that increases in autonomous motivation, and to a lesser extent in competence satisfaction/perceived competence, led to medium size changes in health behaviors

(similar results for the effects of these two mediators on physical and mental health were reported in an older meta-analysis by Ng et al., 2012). In contrast, the effects on health behaviors were far smaller when studies reported no increases in these two key mediators (autonomous motivation and competence). There was no evidence that increases in both mediators resulted in synergistic effects. These results are partially in line with those by Ntoumanis et al. in showing the important role of autonomous motivation for sustained behavior change. However, Ntoumanis et al. also identified perceptions of need support as crucial mediators; these were not assessed by Sheeran et al. (2021). Also, in Ntoumanis et al. competence satisfaction did not emerge as a longitudinal mediator of behavior change, potentially due to its overlapping variance with perceived need support.

Conclusions

Taken together, the meta-analyses reported in this section indicate that SDT-informed interventions are effective in changing health behaviors, including PA/exercise, and associated health outcomes. The effect sizes are moderate to small and are mediated by increases in autonomous motivation (primarily) and in composite need support and/or competence need satisfaction. Is it easy to train individuals, such as fitness instructors, to be need supportive? This is not an easy question to answer, as there are numerous factors that determine the degree to which individuals in position of authority or expertise will be receptive to need supportive interventions. These factors range from contextual (e.g., pressures from colleagues, resource or time constraints) to personal (e.g., personality, beliefs about need support) to perceptions of others' motivation and competence (for a comprehensive review of the various antecedents of need support, see Matosic et al., 2016). Hancox et al. (2018) presented a rare example of a qualitative study, using interviews and self-reflective diaries, of successes and challenges that fitness instructors experienced in implementing need supportive strategies in group exercise classes, following a training program they received. Such studies are important in informing the design, content, and implementation of SDT-based training

programs, and could complement studies presenting classifications of need supportive behaviors (Ahmadi et al., 2023; Teixeira et al., 2020).

Conceptual Debates within SDT and Between SDT and Other Literatures

While SDT has shown promise in terms of PA promotion and health behavior change in general, there are a number of active debates within the SDT literature, as well as between SDT and other literatures from the field of motivation. In this section, we will discuss four such debates. The first two debates are within the SDT literature and refer to: 1) tripartite conceptualizations of interpersonal styles and psychological needs, and 2) whether there are more than three basic psychological needs. The other two debates concern contrasting views between SDT and other perspectives on motivation with regard to the: 3) use of financial incentives and 4) use of competition to promote behavior (e.g., PA) change. This is not an exhaustive list of debates; for instance, there are debates on the universality of the three psychological needs, the relative importance of each, and the assessment of SDT constructs using different approaches (e.g., bifactor modeling, exploratory structural equation modeling, latent profile analysis). Interested readers are referred to recent SDT books (Ryan, 2023; Ryan & Deci, 2017) for more information on these topics.

Tripartite Conceptualizations of Interpersonal Styles and Psychological Needs

The dominant view within the SDT literature of interpersonal styles is that of a dualistic model. Need supportive (the label ‘autonomy supportive’ was used previously) styles are often contrasted with need thwarting (controlling) styles. A recent meta-analysis in education (Howard et al., 2024) showed that the correlations between each pair of support and thwarting were modest (autonomy r =-.27; competence r =-.31; relatedness r =-.47); in other words, the average amount of shared variance was about 13%. Similarly, a dualistic model of psychological needs is currently the dominant view within the SDT literature (Bartholomew et al., 2011; Vansteenkiste & Ryan, 2013), distinguishing between the satisfaction and frustration of the three psychological needs. More

recently, tripartite conceptualizations have been proposed for both interpersonal styles and psychological needs (Ntoumanis, 2023; Reeve et al., 2023). These conceptualizations have been tested in sport, education, and the workplace, and to a limited extent in exercise settings (see Figure 1).

In terms of interpersonal styles, suggestions have been made to consider 'need indifferent' styles, in addition to supporting and thwarting ones. For instance, Bhavsar et al. (2019) advocated the usefulness of distinguishing between coach interpersonal styles that are thwarting and actively suppress others' psychological needs (e.g., pressure, intimidation), and styles that are "passive" or "indifferent" to the psychological needs (e.g., being chaotic or unresponsive to others). For instance, Bhavsar et al. argued that while a chaotic coaching style is unpredictable and may not help athletes develop their skills or achieve their goals, it does not actively block their psychological needs. Hence, a chaotic style is a need *indifferent* (neglectful) rather than a need *thwarting* style. Bhavsar et al. constructed a scale that assesses these three styles and provided evidence for nomological validity in the context of sport.

In terms of structured exercise, Quested et al. (2018) developed an observational scale to assess changes in need support, thwarting, and indifferent styles displayed by fitness instructors, as the result of participating in a SDT informed intervention. Example items in this observational scale are criticizing, belittling, devaluing, or dismissing exercisers' views (need thwarting), talking in ways that are motivationally "empty" (e.g., "keep going"; need indifferent), and taking time to listen and be responsive to the exercisers' needs (need supportive). Quested et al. reported that observers, blinded to the study's hypotheses, were able to detect significant changes in instructors' use of all three behaviors, with supportive ones increasing and thwarting and indifferent ones decreasing over the 12-week intervention period. This tripartite conceptualization of interpersonal styles has been also examined in the work context, using both variable (factor analysis) and person-centered (latent profile analysis) approaches by Huyghebaert-Zouaghi and colleagues (2023, 2025). Reeve et al.

(2023) have also proposed and tested (in education) a tripartite conceptualization of interpersonal styles along the same lines, using the term ‘neglecting’ as opposed to ‘indifferent’ style.

A tripartite conceptualization has also been advocated for psychological needs, with need *unfulfillment* posited alongside need satisfaction and frustration. Specifically, Bhavsar et al. (2020) referred to need unfulfillment as a state in which psychological needs are neglected. For instance, these authors argued that competence unfulfillment could be evident when athletes practice tasks that are not challenging or relevant enough, relatedness unfulfillment when they have very little in common with fellow athletes, and autonomy unfulfillment when they feel uncertain about their perspectives being valued. However, a scale developed by Bhavsar et al. testing this tripartite conceptualization of psychological needs in sport failed to show discriminant validity. Research along the same lines in the workplace and education (Huyghebaert-Zouaghi et al., 2021, 2024; Reeve et al., 2023) has offered stronger evidence of discriminant validity amongst the three need states of support, thwarting, and fulfillment. Further, these studies showed that both need indifferent styles and need fulfillment (the new variables in the tripartite conceptualizations) add unique variance (in predicting motivation, engagement, and well-being/ill-being outcomes) to the variance accounted for by interpersonal styles and need states from the dualistic conceptualizations. The results of these studies have often been supportive in terms of nomological validity, but not always. For instance, Huyghebaert-Zouaghi et al. (2023, 2025) and Reeve et al. (2023) found that in some cases need indifferent behaviors and/or need unfulfillment to relate as strongly or stronger to ‘harmful’ outcomes compared to need thwarting and need frustration. This is in contrast to theoretical arguments that ‘dark’ colors of motivation (need thwarting and need frustration) are more motivationally damaging that ‘dim light’ colors (Ntoumanis, 2023; Reeve et al., 2023). It is unclear whether these inconsistencies stem from limited research in this area or deeper challenges in conceptualizing and empirically distinguishing nuanced motivational constructs. This question warrants further exploration.

In the field of exercise and PA psychology, research on the potential added value of these tripartite conceptualizations is sparse. Such conceptualizations not only could potentially enrich our conceptual understanding of the "middle ground" of motivation (dim light colors; (Ntoumanis, 2023), but could have potential relevance for intervention work that aims to address "missed opportunities" for optimal motivational functioning at the contextual and personal levels. For example, fitness instructors who are not need-supportive may be more likely to exhibit need-indifferent behaviors (e.g., neglect or lack of interest in their clients) rather than need-thwarting behaviors (e.g., intimidation), as the latter could drive clients away. Therefore, interventions targeting fitness instructors should focus not only on increasing need-supportive behaviors but also on reducing need-indifferent behaviors to foster better motivational outcomes.

Candidate Basic Psychological Needs

In 2020, the journal *Motivation and Emotion* published two special issues on Basic Psychological Need Theory that include in-depth coverage of different candidate basic psychological needs that might be added to SDT's classic three. The editors, Vansteenkiste et al. (2020), outlined a set of key criteria for basic psychological needs that includes five basic criteria (must be psychological, as opposed to physical; must be essential for growth, well-being, and adjustment; must be inherent or evolved due to adaptive advantage; must be distinctive; and must be universal) and four associated criteria (must be pervasive, content-specific, directional, and explanatory). Four articles outlined cases for new candidate needs: novelty-variety (Bagheri & Milyavskaya, 2020), novelty (González-Cutre & Sicilia, 2019), beneficence (Martela & Ryan, 2020), and morality (Prentice et al., 2020). We will focus our attention on novelty and variety, the candidate needs most closely associated with PA/exercise motivation. One feature of PA involves the potential for monotony and repetition; that is, doing the same activity again and again, often with the same schedule (e.g., walking the same route to work each day, or using the same exercise equipment during each visit to the gym). While repetition is often cited as helpful for habit formation, one of its

downsides may be reduced enjoyment. In the context of PA, novelty involves introducing new forms of PA, while variety involves rotating forms of PA.

Sylvester and colleagues have focused on the concepts of *perceived variety in exercise* and *variety support* as a predictors of exercise motivation and behavior without explicitly proposing variety as a new candidate need (Sylvester et al., 2014, 2016, 2018) . In one study involving adults from a community sample (n = 363), Sylvester and colleagues (2014) showed that perceived variety of exercise uniquely predicted exercise behavior 6 weeks later, along with satisfaction of the needs for competence and relatedness. In a follow up study, Sylvester et al. (2016) assessed both variety support and perceived variety in exercise among physically inactive university students (n = 121) assigned to follow a high or low variety support exercise program for 6 weeks. Those in the high variety support group were more adherent, and this association was mediated by perceived variety.

The case for novelty as a new basic psychological need was offered by Gonzalez-Cutre et al. (2020) and was applied to PA/exercise both conceptually and with empirical evidence (González-Cutre et al., 2016; González-Cutre & Sicilia, 2019). González-Cutre and colleagues defined novelty as the experience of something not previously experienced, or something that differs from a person's everyday routines. In 2016, González-Cutre et al. validated a new measure assessing novelty need satisfaction, the six-item Novelty Need Satisfaction Scale (NNSS), operationalized at the global- or person-level (as opposed to the context- or state-level). Factor analysis demonstrated the distinctness of novelty assessed by the NNSS relative to autonomy, competence, and relatedness, and the invariance of a four-factor model across gender and age (Study 1). Study 2 focused on students enrolled in Spanish physical education classes that included two weekly 55-minute sessions of compulsory exercise (n = 1035, M_{age} = 16.20 years). In this sample, novelty predicted intrinsic motivation for exercise independently of the other three psychological needs.

We note that Bagheri and Milyavskaya (2020) proposed the more inclusive concept of "novelty-variety" as a candidate need and found novelty and variety items did not load onto

separable factors in factor analysis. Further, novelty and variety were highly correlated across four life domains (ranging from r = .79 to r = .92).

Although the editors of these two special issues praised the above lines of research on new candidate needs as "promising," leaving the question in each case open, they ultimately concluded that at that point each team had provided "*initial, yet not decisive, evidence for their proposed candidate-needs*" (Vansteenkiste et al., 2020, p. 7). The nine criteria they proposed for establishing a new basic psychological need represent a high threshold –Although none of the studies on novelty, variety, and novelty-variety generated compelling evidence for their exclusion, evaluating several, still unmet, criteria will require additional data that are both costly and complex to collect (i.e., *must be universal* across contexts, populations, and types of activity). In the meantime, novelty-variety seems to uniquely support intrinsic motivation in PA/exercise contexts and is strongly correlated with autonomy and competence experiences.

Using Financial Incentives to Motivate PA/Exercise

Questions related to using financial incentives (if at all; if so, when, how) to motivate behavior change have received considerable attention within the SDT-informed literature. One reason for this significant attention is that the answers to these questions have proven complex; a second reason is that financial incentives are very frequently used in practice, but often in ways that lack nuance. Cognitive evaluation theory (CET), a sub-theory of SDT, addresses questions of when rewards (including financial incentives) will alternatively undermine or support intrinsic motivation (Ryan, 2023). Specifically, when rewards are experienced as controlling, SDT researchers using CET predict that these rewards will undermine people's intrinsic motivation; however, when rewards are well-structured, experienced as informational, and boost perceived competence, SDT researchers predict those rewards will not undermine intrinsic motivation, and have the potential to support it.

Despite ample evidence that using financial incentives can undermine intrinsic motivation and meta-analysis findings that suggest any positive behavioral effects dissipate beyond three months

post-incentive removal (Mantzari et al., 2015), the use of financial incentives tied to PA/exercise behavior change has become quite common, especially in the U.S. and in the context of employer-sponsored health and wellness interventions. This practice accelerated after the passage of the U.S. Affordable Care Act in 2010, which includes tax incentives for employers to offer financial incentives targeting health behaviors. Recent estimates suggest that over 86% of U.S. employers now offer financial incentives for one or more health-related behaviors, including for meeting physical activity goals, joining a gym or exercise intervention, or for attending exercise classes (Moller et al., 2019). Policies promoting their use have helped fuel significant research attention, with many labs explicitly focusing their research on financial incentives targeting health behaviors (e.g., the Center for Health Incentives and Behavioral Economics, CHIBE, at the University of Pennsylvania).

In one review by researchers at the CHIBE, Thirumurthy, Asch, and Volpp (2019) acknowledged the mixed and often disappointing effectiveness of using financial incentives to motivate health behavior change and concluded "that seemingly small choices in how incentives are situated, framed, or deployed can have substantial effects on their success" (Thirumurthy et al., 2019) (p. E1). We agree wholeheartedly with that assessment. However, we were also disappointed that Thirumurthy et al. ignored the potential for small choices to frustrate people's need for autonomy and undermine intrinsic motivation. Instead, Thirumurthy et al. endorsed strategies like increasing both the frequency and amount of incentives ("not being stingy with financial incentives," p. E2). In a response to Thirumurthy et al., we outlined an SDT account for the uncertain effects and potential costs of using financial incentives to motivate health behaviors (Moller et al., 2019). We recommended decreasing the salience or relative centrality of financial incentives, emphasizing their informational value, and carefully considering the interpersonal context for their provision (e.g., using need supportive language and offering rationales to frame them as informational, and selecting "payers" with whom people have established relationships characterized by need support). A recently published set of studies by Saini, Uppal, and Howard, although not focused on PA/exercise,

offers additional support for those recommendations with additional nuance (Saini et al., 2025). Saini et al. demonstrated that perceived salience of performance-contingent financial incentives was negatively associated with intrinsic motivation, and this association (undermining effect) was mediated by autonomy frustration. Additionally, that path was moderated by task type, such that undermining was stronger when tasks were more complex and included novel challenges. However, when financial incentives were non-contingent and the tasks were simple and routine, making the financial incentive more salient (with email reminders) was positively associated with intrinsic motivation (i.e., the opposite of undermining). Given that PA/exercise can also vary considerably in terms of complexity and novelty-variety, future research investing how these factors may moderate the undermining effect in PA/exercise contexts is warranted. That is, if the pattern observed by Saini et al. (2025) in a work context holds in the context of PA/exercise, more salient financial incentives might support intrinsic motivation for simple and mundane forms of PA, while undermining intrinsic motivation for more complex, novel-varied forms of PA. Research suggests the relative salience of financial incentives may also be positively associated with the longevity of the undermining effect. While brief experiments conducted online with Mturk (i.e., crowdsourcing marketplace) workers receiving tiny financial incentives (low salience) found that undermining was short-lived (Goswami & Urminsky, 2017), research involving much larger, performance-contingent financial incentives awarded over multiple years (i.e., athletic scholarships at a Division I university) showed those highly salient incentives were associated with undermined enjoyment for being active via playing recreational sports decades later (Moller & Sheldon, 2019).

Another suggestion offered by (Thirumurthy et al., 2019) was that the potential effectiveness of using financial incentives to motivate health behavior change might be limited to those who are less motivated or amotivated at baseline. We believe this is an open empirical question. Using an SDT-CET perspective, a critical feature related to addressing this question involves differentiating between types of motivation and types of health behavior, considerations absent from Thirumurthy et

al.'s analysis. That said, an SDT-CET guided consideration of this open question might arrive at a similar prediction under some circumstances; those with low overall motivation or amotivation at baseline will (by definition) have less autonomous motivation to be undermined, especially for simple or monotonous activities (e.g., walking the same route or using the same exercise equipment day after day). However, some SDT-guided research has also shown that when physical activities have the potential to become enjoyable over time, salient financial incentives may suppress this potential. A study by Moller et al. (2014) included assessing five different motives for participating in a multi-week behavioral health intervention that included performance-contingent financial incentives for increasing PA (fitness, appearance, competence/challenge, enjoyment, and financial) in a sample of sedentary U.S. adults (n = 204). When controlling for other motives, financial motivation was negatively related to changes in liking PA. In other words, when the relative centrality of financial motivation was low, participants increased their enjoyment of PA during the 3-week intervention that included performance-contingent financial incentives; by contrast, when the relative centrality of financial motivation was high, participants enjoyment of PA was unchanged.

To summarize, an SDT-CET guided consideration of whether and how one might use financial incentives to motivate PA/exercise change is nuanced and requires deliberation of multiple factors, including: the salience of financial incentives relative to other motives, the interpersonal context (whether the payer is need supportive, thwarting, or indifferent), the type of motivation or regulation being promoted (intrinsic vs. external), and the stage and duration of behavior change (initiation vs. maintenance).

Using Competition to Motivate PA/Exercise

If financial incentives are a common tool used to promote PA and exercise, competition is an even more ubiquitous feature. Often the two are combined in the form of competition-contingent financial incentives or rewards. Alternatively, competition can be directly or indirectly promoted in the absence of financial incentives or rewards). For example, many PA tracking technologies (Fitbit,

Apple Watch, Garmin, Peloton, etc.) offer people access to community leaderboards. Without offering tangible rewards or explicitly promoting competition, the mere presence of leaderboards can indirectly promote competition among some participants. Researchers interested in motivating people to be more physically active frequently use leaderboards and many other strategies that directly or indirectly promote competition. The effects of such strategies on motivation and wellbeing are nuanced and complex. For example, a leaderboard that includes only the initials of strangers who've participated asynchronously might be experienced as exclusively informational and increase intrinsic motivation. By contrast, another leaderboard that includes only people who are well known to each other and that appears in a highly visible space (e.g., every co-worker's weekly step counts) might be experienced as ego-involving (controlling) and undermine intrinsic motivation.

Reviewing research on the mixed effects of multiple types of competition across multiple contexts and applying CET, Ryan and Reeve concluded that although competition can in some cases enhance intrinsic motivation, it typically undermines it (Ryan & Reeve, 2024). The primary pathways for undermining include frustrating autonomy and competence, though (as with earning a performance-contingent financial incentive) winning a competition can also be informational and satisfy one's need for competence. Ryan and Reeve thus refer to two alternative types of competition, *informational competition* and *controlling competition*, predicting that informational competition will tend to increase intrinsic motivation, while controlling competition will tend to undermine it. Ryan and Reeve also posit that aspects of competition can either support or thwart the need for relatedness. For example, aspects of the interpersonal context, including a coach/trainer's motivating style and a team's interpersonal climate being need supportive, thwarting, or indifferent, can moderate associations between competition and relatedness need satisfaction. A closely related model of competition developed by Shields and Bredemeier (2009) treats the need for relatedness as focal to how people experience it. They posit that "true competition" involves "striving with"

another person, as such, it is both possible and worthwhile for competitors to form close friendships with each other.

With these SDT-CET guided distinctions between types of competition in mind, we reviewed PA/exercise interventions that have incorporated competition. Despite Reeve's (2023) assertion that competition more often undermines intrinsic motivation, when the design of PA/exercise interventions involving competition where informed by SDT-CET, they tended to promote need supportive competition, increasing intrinsic motivation and PA. For example, an RCT by Prestwich et al. (2017) recruited physically inactive adults in the UK (n = 281) and randomly assigned them to one of three web-based conditions: a control group, a group encouraged to self-monitor their steps and receive basic feedback, and a group encouraged to self-monitor their steps, received basic feedback, plus additional feedback to instigate (need supportive) competition. PA was monitored using pedometers for one-week pre-intervention and for four-weeks during the intervention period. Participants in the (need supportive) competition condition increased their step count more than either the control or self-monitoring only conditions. Further, the effect of competition on PA was mediated by increased goal importance, identified motivation, and intrinsic motivation.

Another PA/exercise study involving competition that was informed by SDT-CET, employed an exergame that required a moderate level of exercise called *Hula Hoop* for the Nintendo Wii (Song et al., 2013). This game detects player's movements (on the Wii Fit board) and translates them into movements of an avatar and corresponding points reflecting relative performance (a novel form of exercise). Song et al. randomly assigned participants (n = 72) to one of two competitive context conditions (competition or no competition) and measured trait-level competitiveness. They found that trait competitiveness moderated the association between competitive exercise context and intrinsic motivation, such that competition was associated with higher intrinsic motivation only among those high in trait competitiveness, but the opposite was found for those low in trait

competitiveness. Competitive context was positively associated with heart rate, but this positive slope was steeper for those high in trait competitiveness. Collectively, Song et al.'s findings speak to the significance of considering individual or group preferences when designing PA/exercise interventions, potentially including opportunities for opting in or out of competition.

Looking across the extant research literature involving the use of competition to motivate PA/exercise, we find introducing competition has frequently increased PA/exercise. However, a closer examination informed by SDT-CET reveals that the type of motivation or regulation promoted by competition (intrinsic vs. external) may depend on the type of competition (need supporting vs. need thwarting), type of PA/exercise (novel vs. mundane), and preferences of the targeted individual or group. Furthermore, considering the type of motivation for PA/exercise promoted by different types of competition may be most important in the longer run, that is, when predicting PA/exercise at follow-up, weeks or months after those competitions have ended.

Conclusions

The tripartite conceptualizations of interpersonal styles and psychological needs represents a relatively recent extension to SDT, and we expect the adoption of this extended conceptualization will continue to spread as more empirical support accumulates. Indeed, research reviewed in multiple contexts, including exercise, education, the workplace, and to a limited extent in sport settings, has already offered strong evidence of discriminant validity when "need indifferent" interpersonal styles and "need fulfillment" are considered. That said, a barrier limiting wider adoption of these tripartite conceptualizations may involve researchers' consideration of added participant burden with additional questionnaire items. A methodological advance that could reduce participant burden and may accelerate the adoption of tripartite conceptualizations in SDT-guided research involves using automated coding of free speech or text in naturalistic settings (e.g., natural language processing) to passively measure these variables. With regard to active debate within the SDT literature concerning new candidate needs, we find the extant evidence compelling that novelty and variety can increase

intrinsic motivation and wellbeing in the context of PA/exercise promotion, even after controlling for experiences of autonomy, competence, and relatedness. In our view, the basic need-defining criteria that may still lack decisive evidence involves establishing essential universality across cultures, domains or activities. Cost is a significant barrier to testing the essential universality of candidate needs. As such, we hope funders and/or international research cooperatives (such as the Psychological Science Accelerator) will support future research designed to resolve this debate.

Finally, with regard to the parallel debates between researchers working with SDT and other perspectives involving (1) the use of financial incentives and (2) competition to promote PA/exercise, we hope to encourage a more nuanced dialogue and shared understanding. SDT-CET guided predictions about how financial incentives and competition will influence motivation and behavior change are complex and require consideration of multiple variables. Attempts to represent SDT-CET guided predictions about financial incentives or competition as binary (good or bad) is a form of straw argument that can be called out and dismissed out of hand, as the founders of SDT-CET have made clear that both financial incentives and competition can alternatively be either need supporting or thwarting depending on numerous factors. Fuller consideration of SDT-CET guided predictions concerning either financial incentives or competition requires consideration of: (1) the interpersonal context, (2) individual differences (e.g., motivational orientation), (3) type of activity (e.g., PA/exercise that is novel and varied vs. mundane) as predictors, and (4) the type of motivation or regulation (e.g., intrinsic vs. external) and timeline or duration of interest (e.g., initiation vs. maintenance) as outcomes.

Future Research Directions

In this last section, we identify some suggestions for future SDT research, stemming from recent advances in technology, methodology, and the broader field of behavioral science.

Leveraging Emerging Technologies

Behavioral health researchers have embraced the use of digital technologies to help promote PA/exercise. This "digital health revolution" has taken numerous forms, including the development of increasingly sophisticated wearable sensors (e.g., biomarkers of exertion, distance traveled), digital gamification of PA (e.g., active video games or exergames), and the provision of social support from fitness coaches and peers using digital communication channels and social networking platforms (Moller et al., 2017). These applications of digital technology to PA/exercise science have sometimes included research informed by motivation science, and SDT specifically. Work led by SDT scholars from design and human computer interaction (HCI) has been especially influential in guiding that work (Peters & Calvo, 2023). Specifically, their Motivation, Engagement and Thriving in User Experience (METUX) model and accompanying scales are frequently used to inform the design of emerging digital health and other technologies. The METUX measure is comprised of five scales for measuring need satisfaction and frustration within five spheres of technology experience (adoption, interface, task, behavior, and life). SDT and the METUX model have been extensively applied to digital game design, including games-for-health (e.g., exergames) and games-for-entertainment (Rigby, 2023).

Looking forward, we expect the still nascent "Generative AI-revolution" will have a growing impact on PA/exercise science, especially in the form of AI-coaches and personal trainers. Such developments will leverage various forms of generative AI, (e.g., using Large Language Models to generate text (Ortega & Cushing, 2024), in addition to customizing the look and sound of future AI-coaches/trainers. In relation to the latter point, the high cost and limited availability of human coaching are limitations that constrain its public health impact and potential for upscaling. To the extent digital coaches/trainers might approximate or even, in some respects, outperform humans, the former's public health impact could be potentially increased. But will SDT-hypothesized strategies developed for use by humans hold (or look different) when used by digital assistants, including those using generative AI and LLMs? A recent conceptual paper by Janssen and

Schadenberg (2024) offers SDT-guided suggestions for the design and study of social robots that support well-being across many different contexts (e.g., for learning, at work, in mental health, and more). The authors acknowledge, however, that "*current literature offers limited insights into how human–robot interactions are related to users' experiences of the satisfaction of their basic psychological needs and thus, to their well-being and flourishing* (pp. 857)." Thinking of the aforementioned MBCTs identified by Teixeira et al.(2020), some MBCTs may be more easily delivered by an AI-coach/trainer than others. This includes social robots asserting either experiencing themselves or understanding others' beliefs and emotional experiences (e.g., "I understand how you feel"; "I feel the same way"). As such, many social robots are introduced with explicit acknowledgements of their limitations and accompanying scripts (e.g., "Keep in mind, I'm a robot. I'm not capable of experiencing emotions like you do"). We expect this limitation related to plausibility is especially relevant to translating MBCTs used to support relatedness (e.g., *Acknowledge and respect perspectives and feelings*), but may also extend to some MBCTs used to support competence (e. g., asserting confidence in the client's ability to change).

These potential limitations of AI-coaches/trainers may be offset by other potential advantages or alternative applications of generative AI. For example, in addition to being less expensive and more available, AI-coaches/trainers may also be customizable in innumerable ways to resemble clients' social identities (age, race, gender), simulating looks, sound, and style of speaking. Media scholars working with SDT have demonstrated that people often form parasocial relationships with people they've never met, including characters from television shows and celebrities, in ways that contribute to relatedness need satisfaction (Sherrick et al., 2022). As such, AI-coaches/trainers customized to resemble a parasocial relationship partners (e.g., a celebrity athlete or coach) may prove especially need supportive. Furthermore, AI-coaches/trainers may eventually be capable of supporting even greater novelty and variety relative to humans, as more and more PA/exercise-specific training data are incorporated into LLMs. At the time of our review, a literature search

uncovered just one publication describing a SDT-guided social robot that used generative AI to provided autonomy support for adult learners (Lu et al., 2023). Albeit being pilot data, the results showed that the robot significantly improved learners' intrinsic motivation for learning. This is an obvious avenue for future SDT research. There will also be opportunities for reciprocal learning between human coaches/trainers and AI, such as using AI-powered natural language processing tools to code whether human coaches/trainers' interpersonal communication styles as need supportive or not (Moller, Patel, et al., 2023; Xu, 2023), or to identify the motivational profile of clients (Fukuoka et al., 2018). Such insights can be used as inputs to strengthen the performance of human coaches/trainers.

Using SDT to Design More Social-Structural Interventions

Reviewing roughly five decades of applied research on SDT, including applications related to PA/exercise, we find that the vast majority of intervention work has targeted either individuals or small groups. Exceptions to this include SDT-guided research on population-level health communication strategies (Martela et al., 2021). The orientation toward intervention at the individual-level is especially prevalent in more individualistic cultures, where responsibility for health choices and outcomes is often placed on individuals, as opposed to communities or policymakers. Numerous factors including cultural and disciplinary may help explain why few health interventions informed by SDT have targeted social-structural factors or policies (Moller, Rigby, et al., 2023). Whatever the reasons, there is growing recognition that social-structural and system-level interventions can have a powerful impact on health behavior and PA/exercise (Albarracín et al., 2024a; Rhodes et al., 2024). This represents both a shortcoming of SDT applications and an opportunity for the future.

A recent, influential study by Albarracin and colleagues (2024) synthesized multidisciplinary meta-analyses of behavior change interventions and found that targeting one social-structural factor, *access*, was associated with the largest effects on health behavior change. Providing

community-level access to affordable, convenient opportunities for PA/exercise aligns well with a foundational MBCT identified by SDT researchers but typically applied at the individual-level -- *providing choice*. Albarracin et al.'s finding is consistent with complementary work by Rhodes and colleagues who recently advanced a systems mapping approach toward understanding social determinants of PA and sedentary behavior in families (Rhodes et al., 2024). SDT-guided work has explored how close personal relationships with friends, family, and romantic others influence health behavior (La Guardia & Patrick, 2014). La Guardia and Patrick reviewed evidence from multiple SDT-guided behavioral health interventions targeting dyads (e.g., a parent and child or romantic couple) as opposed to individuals, finding that targeting dyads can frequently improve efficacy by promoting reciprocal need support between close relationship partners. They also acknowledged that fewer SDT-guided interventions have targeted macro-level social influences, such as public policy, culture, and characteristics of the built and physical environment (e.g., support for active transportation options, such as biking and walking).

Future SDT-guided PA/exercise research would benefit from adopting a systems-level orientation and targeting social-structural factors more intentionally and frequently, in addition to individual-level factors. Shifting toward systems-level research and intervention will require more collaboration with community leaders and policymakers, and consideration of communication strategies that constituents and policymakers are likely to find persuasive (e.g., measuring and reporting system-level outcomes like cost-effectiveness and downstream healthcare utilization; Grelle & Hofmann, 2024).

Some Ideas Based on Conceptual and Methodological Developments in the Broader Field of Behavioral Science

Recent developments in behavioral science could be of potential interest to SDT researchers. For instance, the Human Behavior Change Project (https://www.humanbehaviourchange.org/) has produced several new intervention ontologies. These

ontologies cover diverse topics, from intervention dose and schedule to intervention fidelity and styles of delivery. Each of these ontologies includes a comprehensive list of entities, organized in hierarchies. For instance, the Style of Delivery Ontology (Wright et al., 2023) taps the diverse ways in which an intervention can be communicated to participants. It includes interpersonal behaviors described in the SDT literature (e.g., controlling, autonomy supportive) as well as other non-SDT specific styles (e.g., humorous, using metaphors). Such an ontology can serve as an inspiration for SDT researchers in terms of some of the possible ways in which the communication and content of SDT interventions can be augmented and/or diversified. Further, since these entities are open to ongoing updates, the SDT community can contribute to them (e.g., in terms of the full spectrum of MBCTs). These ontologies can also help SDT researchers to describe in a more consistent way various aspects of their intervention (e.g., intervention schedule, dose, setting, population) by using the unique identifier of each relevant entity included in these ontologies. These identifiers make the entities computer-readable (e.g., the Mechanism of Action Ontology, [Schenk et al., 2024], has such unique identifiers for psychological needs and motivational regulations described by SDT). All these methodological advances can confer several benefits. First, they can help meta-analyses in the SDT field to be more precise with their coding, reducing discrepancies in effect sizes reported for similar studies. Second, machine learning methods can be used to continuously update the meta-analytic estimates, as soon as new relevant studies are published. In a recent meta-review of meta-analytic findings, Ryan et al. (2022) identified 60 meta-analyses in the SDT field. Clearly, this number is not sustainable over time, particularly with the rapid growth of available journals, hence the use of machine learning methods to (semi) automate the evidence synthesis would be necessary in the near future. For an extended discussion, see Howard and Slemp's recent call for a living meta-analysis of SDT research (Howard & Slemp, 2025). The third benefit is that unique identifiers can be used for outcome prediction (e.g., see an example of how machine learning can be used to predict different

smoking cessation rates by adding or removing intervention components: https://pred.hbcptools.org/interface/).

SDT researchers could also benefit from methodologies used in behavioral sciences that are non-existent in the SDT literature. For instance, some of the debates mentioned in the preceding pages can be advanced via adversarial collaboration, whereby researchers with different views on a topic (e.g., on financial incentives for PA promotion) can set up collaborative projects with researchers who have different views (e.g., SDT researchers collaborating with behavioral economists) in an effort to make progress on the understanding of this topic (Rakow, 2022). Also, optimization trials (Collins et al., 2024) have been proposed as prerequisites before randomized controlled trials (RCT). Optimization trials use a variety of designs (e.g., factorial, micro-randomized trials) to select from a list of candidate components (using efficacy, acceptability and, increasingly, affordability criteria) the components that should be included in a future RCT on one or multiple optimization criteria. Given the large number of MBCTs available to SDT researchers, optimization trials can help them design RCTs that are pragmatic and cost-effective for the setting and population of interest.

Conclusions

Reviewing the past SDT literature, we find that the influence of SDT on motivation and PA/exercise science over the last 50 years has been both significant and positive. Significant as evidenced by hundreds of publications and citations, and positive in the sense that PA/exercise promoting interventions can only be considered truly health promoting to the extent that the well-being of participants is also supported. SDT-informed PA/exercise interventions are relatively unique in terms of considering participants' psychological well-being alongside their physical fitness.

In this last section of our review, we humbly offered suggestions for future SDT research related to PA/exercise, stemming from recent advances in technology, methodology, and the broader field of behavioral science. A common theme involves a call to SDT researchers for more continuous

integration of new advances in concepts and methods in behavioral science (e.g., systems-based thinking, intervention ontologies, optimization trials), as well as in technology and related sciences (e.g., HCI, urban planning, public health). Embracing these advances can further strengthen SDT's relevance and impact in the decades to come.

References

Aelterman, N., & Vansteenkiste, M. (2023). Need-supportive and need-thwarting socialization: A circumplex approach. In *The Oxford Handbook of Self-Determination Theory* (pp. 236–257). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197600047.013.21

Ahmadi, A., Noetel, M., Parker, P., Ryan, R. M., Ntoumanis, N., Reeve, J., Beauchamp, M., Dicke, T., Yeung, A., Ahmadi, M., Bartholomew, K., Chiu, T. K. F., Curran, T., Erturan, G., Flunger, B., Frederick, C., Froiland, J. M., González-Cutre, D., Haerens, L., … Lonsdale, C. (2023). A classification system for teachers' motivational behaviors recommended in self-determination theory interventions. *Journal of Educational Psychology*, *115*(8), 1158–1176. https://doi.org/10.1037/edu0000783

Albarracín, D., Fayaz-Farkhad, B., & Granados Samayoa, J. A. (2024). Determinants of behaviour and their efficacy as targets of behavioural change interventions. *Nature Reviews Psychology*, 1–16. https://doi.org/10.1038/s44159-024-00305-0

Bagheri, L., & Milyavskaya, M. (2020). Novelty–variety as a candidate basic psychological need: New evidence across three studies. *Motivation and Emotion*, *44*(1), 32–53. https://doi.org/10.1007/s11031-019-09807-4

Bartholomew, K. J., Ntoumanis, N., Ryan, R. M., Bosch, J. A., & Thøgersen-Ntoumani, C. (2011). Self-determination theory and diminished functioning: The role of interpersonal control and psychological need thwarting. *Personality and Social Psychology Bulletin*, *37*(11), 1459–1473. https://doi.org/10.1177/0146167211413125

Behzadnia, B. (2021). The relations between students' causality orientations and teachers' interpersonal behaviors with students' basic need satisfaction and frustration, intention to physical activity, and well-being. *Physical Education and Sport Pedagogy*, *26*(6), 613–632. https://doi.org/10.1080/17408989.2020.1849085

Bhavsar, N., Bartholomew, K. J., Quested, E., Gucciardi, D. F., Thøgersen-Ntoumani, C., Reeve, J., Sarrazin, P., & Ntoumanis, N. (2020). Measuring psychological need states in sport: Theoretical considerations and a new measure. *Psychology of Sport and Exercise, 47*, 101617. https://doi.org/10.1016/j.psychsport.2019.101617

Bhavsar, N., Ntoumanis, N., Quested, E., Gucciardi, D. F., Thøgersen-Ntoumani, C., Ryan, R. M., Reeve, J., Sarrazin, P., & Bartholomew, K. J. (2019). Conceptualizing and testing a new tripartite measure of coach interpersonal behaviors. *Psychology of Sport and Exercise, 44*, 107–120. https://doi.org/10.1016/j.psychsport.2019.05.006

Bhvasar, N., Ntoumanis, N., Quested, E., Thogersen-Ntoumani, C., & Chatzisarantis, N. (2020). Self-determination theory. In D. Hackfort & R.J. Schinke (Eds). *The Routledge International Encyclopedia of Sport and Exercise Psychology*, Vol 1. Routledge, 565-583.

Bieg, S., Thomas, A., Spreitzer, C., & Müller, F. (2024). Exploring the complexity of introjected regulation in self-determination theory. *International Journal of Teaching and Learning Sciences*, 103. https://doi.org/10.47991/2024/IJTLS-125

Bradshaw, E. L., Conigrave, J. H., Steward, B. A., Ferber, K. A., Parker, P. D., & Ryan, R. M. (2023). A meta-analysis of the dark side of the American dream: Evidence for the universal wellness costs of prioritizing extrinsic over intrinsic goals. *Journal of Personality and Social Psychology*, *124*(4), 873–899. https://doi.org/10.1037/pspp0000431

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports, 100*(2), 126–131.

Collins, L. M., Nahum-Shani, I., Guastaferro, K., Strayhorn, J. C., Vanness, D. J., & Murphy, S. A. (2024). Intervention optimization: A paradigm shift and its potential implications for clinical psychology. *Annual Review of Clinical Psychology*, *20*, 21–47. https://doi.org/10.1146/annurev-clinpsy-080822-051119

Dalgas, B. W., Ntoumanis, N., Elmose-Østerlund, K., & Bredahl, T. V. G. (2024). Exploring the process of restoring psychological needs after incidences of frustration and need unfulfillment. *Frontiers in Psychology, 15*. https://doi.org/10.3389/fpsyg.2024.1413963

Fukuoka, Y., Lindgren, T. G., Mintz, Y. D., Hooper, J., & Aswani, A. (2018). Applying natural language processing to understand motivational profiles for maintaining physical activity after a mobile app and accelerometer-based intervention: The mPED randomized controlled trial. *JMIR mHealth and uHealth*, *6*(6), e10042. https://doi.org/10.2196/10042

Funder, D. C., & Ozer, D. J. (2019). Evaluating effect size in psychological research: Sense and nonsense. *Advances in Methods and Practices in Psychological Science*, *2*(2), 156–168. https://doi.org/10.1177/2515245919847202

Gillison, F. B., Rouse, P., Standage, M., Sebire, S. J., & Ryan, R. M. (2019). A meta-analysis of techniques to promote motivation for health behaviour change from a self-determination theory perspective. *Health Psychology Review*, *13*(1), 110–130. https://doi.org/10.1080/17437199.2018.1534071

González-Cutre, D., Romero-Elías, M., Jiménez-Loaisa, A., Beltrán-Carrillo, V. J., & Hagger, M. S. (2020). Testing the need for novelty as a candidate need in basic psychological needs theory. *Motivation and Emotion*, *44*(2), 295–314. https://doi.org/10.1007/s11031-019-09812-7

González-Cutre, D., & Sicilia, Á. (2019). The importance of novelty satisfaction for multiple positive outcomes in physical education. *European Physical Education Review*, *25*(3), 859–875.

González-Cutre, D., Sicilia, Á., Sierra, A. C., Ferriz, R., & Hagger, M. S. (2016). Understanding the need for novelty from the perspective of self-determination theory. *Personality and Individual Differences*, *102*, 159–169. https://doi.org/10.1016/j.paid.2016.06.036

Goswami, I., & Urminsky, O. (2017). The dynamic effect of incentives on postreward task engagement. *Journal of Experimental Psychology: General*, *146*(1), 1–19. https://doi.org/10.1037/xge0000206

Grelle, S., & Hofmann, W. (2024). When and why do people accept public-policy interventions? An integrative public-policy-acceptance framework. *Perspectives on Psychological Science*, *19*(1), 258–279. https://doi.org/10.1177/17456916231180580

Hagger, M. S., & Hamilton, K. (2021). General causality orientations in self-determination theory: Meta-analysis and test of a process model. *European Journal of Personality*, *35*(5), 710–735. https://doi.org/10.1177/0890207020962330

Hancox, J. E., Quested, E., Ntoumanis, N., & Thøgersen-Ntoumani, C. (2018). Putting self-determination theory into practice: Application of adaptive motivational principles in the exercise domain. *Qualitative Research in Sport, Exercise and Health*, *10*(1), 75–91. https://doi.org/10.1080/2159676X.2017.1354059

Hardcastle, S. J., Fortier, M., Blake, N., & Hagger, M. S. (2017). Identifying content-based and relational techniques to change behaviour in motivational interviewing. *Health Psychology Review*, *11*(1), 1–16. https://doi.org/10.1080/17437199.2016.1190659

Howard, J. L., & Slemp, G. R. (2025). *Why we need a living meta-analysis of self-determination theory: An illustration examining temporal changes in need supportive education.* Manuscript submitted for publication.

Howard, J. L., Slemp, G. R., & Wang, X. (2024). Need support and need thwarting: A meta-analysis of autonomy, competence, and relatedness supportive and thwarting behaviors in student populations. *Personality and Social Psychology Bulletin*, 01461672231225364. Advance online publication. https://doi.org/10.1177/01461672231225364

Huyghebaert-Zouaghi, T., Morin, A. J. S., Ntoumanis, N., Berjot, S., & Gillet, N. (2023). Supervisors' interpersonal styles: An integrative perspective and a measure based on self-

determination theory. *Applied Psychology*, *72*(3), 1097–1133. https://doi.org/10.1111/apps.12423

Huyghebaert-Zouaghi, T., Morin, A. J. S., Ntoumanis, N., Thomas, J., & Gillet, N. (2025). Subordinates' perceptions of the need-supportive, need-thwarting, and need-indifferent behaviors used by their supervisors: A person-centered investigation. *Applied Psychology*, *74*(1), e12573. https://doi.org/10.1111/apps.12573

Huyghebaert-Zouaghi, T., Ntoumanis, N., Berjot, S., & Gillet, N. (2021). Advancing the conceptualization and measurement of psychological need states: A 3 × 3 model based on self-determination theory. *Journal of Career Assessment*, *29*(3), 396–421. https://doi.org/10.1177/1069072720978792

Huyghebaert-Zouaghi, T., Ntoumanis, N., Thomas, J., Badré, S., & Berjot, S. (2024). Rethinking students' psychological need states: The unique role of need unfulfillment to understanding ill-being in academic settings. *Stress and Health*, *40*(4), e3379. https://doi.org/10.1002/smi.3379

Kang, H. J., Wang, C. K. J., & Burns, S. F. (2021). A case study to overcome barriers and enhance motivations through experience of a variety of exercises: Theory-based intervention on an overweight and physically inactive adult. *Case Studies in Sport and Exercise Psychology*, *5*(1), 86–94. https://doi.org/10.1123/cssep.2020-0029

La Guardia, J. G., & Patrick, H. (2014). The influence of the social environment on health behavior. In N. Weinstein (Ed.), *Human motivation and interpersonal relationships: Theory, research, and applications* (pp. 299–315). Springer Science + Business Media. https://doi.org/10.1007/978-94-017-8542-6_13

Laporte, N., Soenens, B., Brenning, K., & Vansteenkiste, M. (2021). Adolescents as active managers of their own psychological needs: The role of psychological need crafting in adolescents'

mental health. *Journal of Adolescence*, *88*, 67–83. https://doi.org/10.1016/j.adolescence.2021.02.004

Lu, Y., Chen, C., Chen, P., & Yu, S. (2023). Designing social robot for adults using self-determination theory and AI technologies. *IEEE Transactions on Learning Technologies*, *16*(2), 206–218. IEEE Transactions on Learning Technologies. https://doi.org/10.1109/TLT.2023.3250465

Manninen, M., Dishman, R., Hwang, Y., Magrum, E., Deng, Y., & Yli-Piipari, S. (2022). Self-determination theory based instructional interventions and motivational regulations in organized physical activity: A systematic review and multivariate meta-analysis. *Psychology of Sport and Exercise*, *62*, 102248. https://doi.org/10.1016/j.psychsport.2022.102248

Mantzari, E., Vogt, F., Shemilt, I., Wei, Y., Higgins, J. P. T., & Marteau, T. M. (2015). Personal financial incentives for changing habitual health-related behaviors: A systematic review and meta-analysis. *Preventive Medicine*, *75*, 75–85. https://doi.org/10.1016/j.ypmed.2015.03.001

Martela, F., Hankonen, N., Ryan, R. M., & Vansteenkiste, M. (2021). Motivating voluntary compliance to behavioural restrictions: Self-determination theory–based checklist of principles for COVID-19 and other emergency communications. *European Review of Social Psychology*, *32*(2), 305–347. https://doi.org/10.1080/10463283.2020.1857082

Martela, F., & Ryan, R. M. (2020). "Distinguishing between basic psychological needs and basic wellness enhancers: The case of beneficence as a candidate psychological need": Correction. *Motivation and Emotion*, *44*(1), 134–134. https://doi.org/10.1007/s11031-020-09823-9

Matosic, D., Ntoumanis, N., & Quested, E. (2016). Antecedents of Need supportive and controlling interpersonal styles from a self-determination theory perspective: A review and implications for sport psychology research. In Raab, M., Wylleman, P., Seiler, R., Elbe, A.M., and Hatzigeorgiadis, A., (Eds.), *New Perspectives on Sport and Exercise Psychology* (pp. 145-180). Elsevier. https://doi.org/10.1016/B978-0-12-803634-1.00007-8

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M. P., Cane, J., & Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine*, *46*(1), 81–95. https://doi.org/10.1007/s12160-013-9486-6

Moller, A. C., Buscemi, J., McFadden, H. G., Hedeker, D., & Spring, B. (2014). Financial motivation undermines potential enjoyment in an intensive diet and activity intervention. *Journal of Behavioral Medicine, 37*(5), 819–827. https://doi.org/10.1007/s10865-013-9542-5

Moller, A. C., Merchant, G., Conroy, D. E., West, R., Hekler, E., Kugler, K. C., & Michie, S. (2017). Applying and advancing behavior change theories and techniques in the context of a digital health revolution: Proposals for more effectively realizing untapped potential. *Journal of Behavioral Medicine*, *40*(1), 85–98. https://doi.org/10.1007/s10865-016-9818-7

Moller, A. C., Ntoumanis, N., & Williams, G. C. (2019). Financial incentives may influence health behaviors, but do we end up with less than we paid for? A self-determination theory perspective. *Annals of Behavioral Medicine*, *53*(11), 939–941. https://doi.org/10.1093/abm/kaz038

Moller, A. C., Patel, H., Legate, N., Shu, K., Frieder, O., Malhotra, T., & Kapoor, S. (2023). *Developing automated methods for classifying 2-way communication patterns: Exploring governments' Covid-related autonomy supportive vs. Controlling communication styles and constituent reactions on Twitter*. 8th International Self-Determination Theory Conference, Orlando, FL.

Moller, A. C., Rigby, B., & Oliver, E. (2023, December 18). *Self Determination Theory & Health Policy Workshop Post Script*. https://selfdeterminationtheory.org/self-determination-theory-health-policy/

Moller, A. C., & Sheldon, K. M. (2019). Athletic scholarships are negatively associated with intrinsic motivation for sports, even decades later: Evidence for long-term undermining. *Motivation Science*. https://doi.org/10.1037/mot0000133

Mossman, L. H., Slemp, G. R., Lewis, K. J., Colla, R. H., & O'Halloran, P. (2024). Autonomy support in sport and exercise settings: A systematic review and meta-analysis. *International Review of Sport and Exercise Psychology*. https://www.tandfonline.com/doi/full/10.1080/1750984X.2022.2031252

Ng, J. Y. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-determination theory applied to health contexts: A meta-analysis. *Perspectives on Psychological Science, 7*(4), 325–340. https://doi.org/10.1177/1745691612447309

Ng, J. Y. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Stott, K., & Hindle, L. (2013). Predicting psychological needs and well-being of individuals engaging in weight management: The role of important others. *Applied Psychology: Health and Well-Being*, *5*(3), 291–310. https://doi.org/10.1111/aphw.12011

Ntoumanis, N., & Moller, A. C. (2023). Facilitating health behavior change: a self-determination theory perspective. In R. M. Ryan (Ed.) *The Oxford Handbook of Self-Determination Theory* (2nd ed) (pp. 777-800). Oxford University Press. https://doi.org/10.1016/bs.adms.2022.11.002

Ntoumanis, N., Ng, J. Y. Y., Prestwich, A., Quested, E., Hancox, J. E., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Lonsdale, C., & Williams, G. C. (2021). A meta-analysis of self-determination theory-informed intervention studies in the health domain: Effects on motivation, health behavior, physical, and psychological health. *Health Psychology Review*, *15*(2), 214–244. https://doi.org/10.1080/17437199.2020.1718529

Ortega, A., & Cushing, C. C. (2024). Design of a temporally augmented text messaging bot to improve adolescents' physical activity and engagement: Proof-of-concept study. *JMIR Formative Research*, *8*, e60171. https://doi.org/10.2196/60171

Peters, D., & Calvo, R. A. (2023). Self-determination theory and technology design. In R. M. Ryan (Ed.), *The Oxford handbook of self-determination theory* (pp. 978–999). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197600047.013.49

Prentice, M., Jayawickreme, E., & Fleeson, W. (2020). An experience sampling study of the momentary dynamics of moral, autonomous, competent, and related need satisfactions, moral enactments, and psychological thriving. *Motivation and Emotion*, *44*(2), 244–256. https://doi.org/10.1007/s11031-020-09829-3

Prestwich, A., Conner, M., Morris, B., Finlayson, G., Sykes-Muskett, B., & Hurling, R. (2017). Do web-based competitions promote physical activity? Randomized controlled trial. *Psychology of Sport and Exercise*, *29*, 1–9. https://doi.org/10.1016/j.psychsport.2016.11.003

Quested, E., Ntoumanis, N., Stenling, A., Thogersen-Ntoumani, C., & Hancox, J. E. (2018). The need-relevant instructor behaviors scale: development and initial validation. *Journal of Sport & Exercise Psychology*, *40*(5), 259–268. https://doi.org/10.1123/jsep.2018-0043

Rakow, T. (2022). Adversarial collaboration. In W. O'Donohue, A. Masuda, & S. Lilienfeld (Eds.), *Avoiding questionable research practices in applied psychology* (pp. 359–377). Springer Nature. https://doi.org/10.1007/978-3-031-04968-2_16

Reeve, J. (2023). Competition can enhance motivation—But typically undermines it. In M. Bong, J. Reeve, & S. Kim (Eds.), *Motivation Science* (1st ed., pp. 165-170). Oxford University Press. https://doi.org/10.1093/oso/9780197662359.003.0028

Reeve, J., Jang, H.-R., Cheon, S. H., Moss, J. D., Ko, H., & Jang, H. (2023). Extending self-determination theory's dual-process model to a new tripartite model to explain diminished

functioning. *Motivation and Emotion, 47*(5), 691–710. https://doi.org/10.1007/s11031-023-10019-0

Rhodes, R. E., Banik, A., Szczuka, Z., Aulbach, M. B., DeSmet, A., Durand, H., Gatting, L., Green, J., Hillison, E. Z., Masaryk, R., Radtke, T., Rigby, B. P., Schenkel, K., Warner, L. M., Jones, C. M., & Luszczynska, A. (2024). Extending our understanding of the social determinants of physical activity and sedentary behaviors in families: a systems mapping approach. *Journal of Physical Activity and Health, 1*, 1–16. https://doi.org/10.1123/jpah.2024-0113

Rigby, C. S. (2023). Flourishing in digital environments: The case for self-determination theory as a beneficial framework for individuals, industry, and society. In R. M. Ryan (Ed.), *The Oxford handbook of self-determination theory* (pp. 1000–1019). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197600047.013.50

Rocchi, M. A., Wilson, P. M., Sylvester, B. D., Guerin, E., Shi, Z., & Sweet, S. N. (2023). Toward brief tools assessing motivation for exercise: Rationale and development of a six- and 12-item version of the Behavioral Regulation in Exercise 3 (BREQ3) Questionnaire. *Sport, Exercise, and Performance Psychology*, *12*(3), 205–227. https://doi.org/10.1037/spy0000321

Ryan, R. M. (2023). *The Oxford Handbook of Self-Determination Theory*. Oxford University Press.

Ryan, R. M., & Deci, E. L. (2017). Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness. *New York: Guilford Publishing*.

Ryan, R. M., Duineveld, J. J., Di Domenico, S. I., Ryan, W. S., Steward, B. A., & Bradshaw, E. L. (2022). We know this much is (meta-analytically) true: A meta-review of meta-analytic findings evaluating self-determination theory. *Psychological Bulletin, 148*(11–12), 813–842. https://doi.org/10.1037/bul0000385

Ryan, R. M., & Reeve, J. (2024). Chapter 11. Intrinsic motivation, psychological needs, and competition: A self-determination theory analysis. In S. M. Garcia, T. Avishalom, & A. J.

Elliot (Eds.), *The Oxford Handbook of the Psychology of Competition* (pp. 240–264). Oxford University Press.

Saini, M., Uppal, N., & Howard, J. L. (2025). Perceived financial incentive salience and its undermining effect: A moderated-mediation model. *Journal of Occupational and Organizational Psychology*, *98*(1), e70000. https://doi.org/10.1111/joop.70000

Schenk, P. M., Wright, A. J., West, R., Hastings, J., Lorencatto, F., Moore, C., Hayes, E., Schneider, V., Howes, E., & Michie, S. (2024). An ontology of mechanisms of action in behaviour change interventions. *Wellcome Open Research*, *8*, 337. https://doi.org/10.12688/wellcomeopenres.19489.2

Sebire, S. J., Standage, M., & Vansteenkiste, M. (2008). Development and validation of the goal content for exercise questionnaire. *Journal of Sport & Exercise Psychology*, *30*(4), 353–377. https://doi.org/10.1123/jsep.30.4.353

Sezer, B., Riddell, H., Gucciardi, D. F., Sheldon, K. M., Sedikides, C., Vasconcellos, D., Jackson, B., Thøgersen-Ntoumani, C., & Ntoumanis, N. (2024). Goal motives, approach/avoidance appraisals, psychological needs, and well-being: A systematic review and meta-analysis. *Motivation Science.* Advance online publication. https://doi.org/10.1037/mot0000366

Sheeran, P., Wright, C. E., Avishai, A., Villegas, M. E., Lindemans, J. W., Klein, W. M. P., Rothman, A. J., Miles, E., & Ntoumanis, N. (2020). Self-determination theory interventions for health behavior change: Meta-analysis and meta-analytic structural equation modeling of randomized controlled trials. *Journal of Consulting and Clinical Psychology*, *88*(8), 726–737. https://doi.org/10.1037/ccp0000501

Sheeran, P., Wright, C. E., Avishai, A., Villegas, M. E., Rothman, A. J., & Klein, W. M. P. (2021). Does increasing autonomous motivation or perceived competence lead to health behavior

change? A meta-analysis. *Health Psychology*, *40*(10), 706–716. https://doi.org/10.1037/hea0001111

Sherrick, B., Hoewe, J., & Ewoldsen, D. R. (2022). Using narrative media to satisfy intrinsic needs: Connecting parasocial relationships, retrospective imaginative involvement, and self-determination theory. *Psychology of Popular Media*, *11*(3), 266–274. https://doi.org/10.1037/ppm0000358

Shields, D. L., & Bredemeier, B. L. (2009). *True Competition: A Guide to Pursuing Excellence in Sport and Society*. Human Kinetics.

Silva, M. N., Markland, D., Carraça, E. V., Vieira, P. N., Coutinho, S. R., Minderico, C. S., Matos, M. G., Sardinha, L. B., & Teixeira, P. J. (2011). Exercise autonomous motivation predicts 3-yr weight loss in women. *Medicine and Science in Sports and Exercise*, *43*(4), 728–737. https://doi.org/10.1249/MSS.0b013e3181f3818f

Smolinski, A., McIntyre, O., Martin, D., & Martin, J. J. (2024). An imperfect list of eminent sport and exercise psychology researchers. *Kinesiology Review*, *13*(4), 521–535. https://doi.org/10.1123/kr.2024-0024

Song, H., Kim, J., Tenzek, K. E., & Lee, K. M. (2013). The effects of competition and competitiveness upon intrinsic motivation in exergames. *Computers in Human Behavior*, *29*(4), 1702–1708. https://doi.org/10.1016/j.chb.2013.01.042

Sylvester, B. D., Jackson, B., & Beauchamp, M. R. (2018). The effects of variety and novelty on physical activity and healthy nutritional behaviors. In A. J. Elliot (Ed.), *Advances in motivation science* (pp. 169–202). Elsevier Academic Press. https://doi.org/10.1016/bs.adms.2017.11.001

Sylvester, B. D., Standage, M., Ark, T. K., Sweet, S. N., Crocker, P. R., Zumbo, B. D., & Beauchamp, M. R. (2014). Is variety a spice of (an active) life?: Perceived variety, exercise

behavior, and the mediating role of autonomous motivation. *Journal of Sport and Exercise Psychology*, *36*(5), 516–527. https://doi.org/10.1123/jsep.2014-0102

Sylvester, B. D., Standage, M., McEwan, D., Wolf, S. A., Lubans, D. R., Eather, N., Kaulius, M., Ruissen, G. R., Crocker, P. R. E., Zumbo, B. D., & Beauchamp, M. R. (2016). Variety support and exercise adherence behavior: Experimental and mediating effects. *Journal of Behavioral Medicine*, *39*(2), 214–224. https://doi.org/10.1007/s10865-015-9688-4

Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *The International Journal of Behavioral Nutrition and Physical Activity*, *9*, 78. https://doi.org/10.1186/1479-5868-9-78

Teixeira, P. J., Marques, M. M., Silva, M. N., Brunet, J., Duda, J. L., Haerens, L., La Guardia, J., Lindwall, M., Lonsdale, C., Markland, D., Michie, S., Moller, A. C., Ntoumanis, N., Patrick, H., Reeve, J., Ryan, R. M., Sebire, S. J., Standage, M., Vansteenkiste, M., … Hagger, M. S. (2020). A classification of motivation and behavior change techniques used in self-determination theory-based interventions in health contexts. *Motivation Science*, *6*(4), 438–455. https://doi.org/10.1037/mot0000172

Thal, S., Graham, C., Ntoumanis, N., Myers, B., Bright, S., Jones, J., & Quested, E. (2024). Fostering physical activity motivation at substance use disorder treatment facilities: A qualitative study grounded in self-determination theory. *Mental Health and Physical Activity*, *27*, 1–10. https://doi.org/10.1016/j.mhpa.2024.100650

Thirumurthy, H., Asch, D. A., & Volpp, K. G. (2019). The uncertain effect of financial incentives to improve health behaviors. *JAMA*, *321*(15), 1451–1452. https://doi.org/10.1001/jama.2019.2560

Vansteenkiste, M., & Ryan, R. M. (2013). On psychological growth and vulnerability: Basic psychological need satisfaction and need frustration as a unifying principle. *Journal of Psychotherapy Integration*, *23*(3), 263–280. https://doi.org/10.1037/a0032359

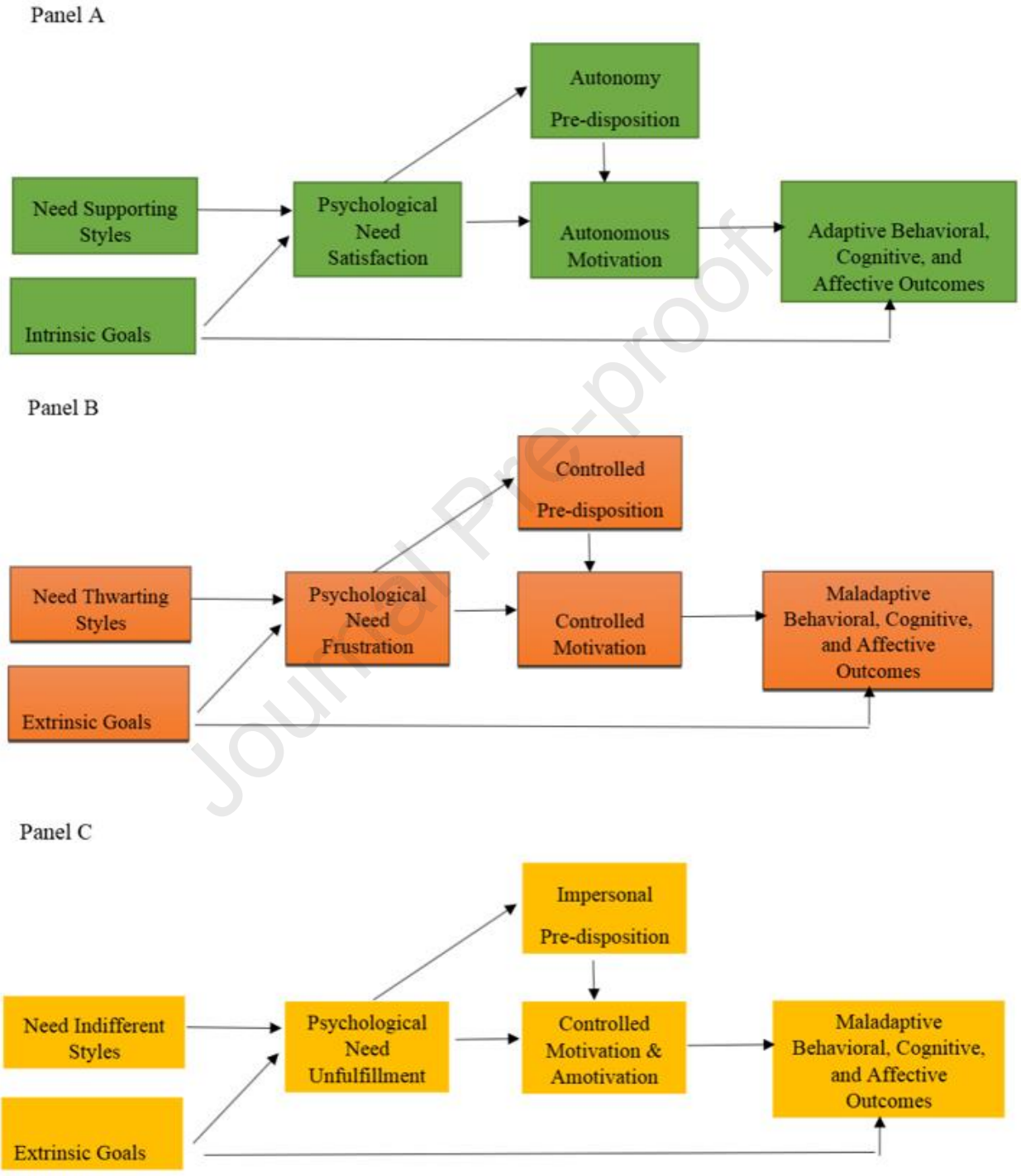
Vansteenkiste, M., Ryan, R. M., & Soenens, B. (2020). Basic psychological need theory: Advancements, critical themes, and future directions. *Motivation and Emotion*, *44*(1), 1–31. https://doi.org/10.1007/s11031-019-09818-1

Wright, A. J., Zhang, L., Howes, E., Veall, C., Corker, E., Johnston, M., Hastings, J., West, R., & Michie, S. (2023). Specifying how intervention content is communicated: Development of a Style of Delivery Ontology. *Wellcome Open Research*, *8*, 456. https://doi.org/10.12688/wellcomeopenres.19899.1

Xu, Z. K. (2023). *The language styles of organismic integration and basic psychological needs: A natural language processing (NLP) application in SDT research*. 8th International Self-Determination Theory Conference, Orlando, FL.

Figure 1

A Flow Chart Illustrating a Bright Motivational Sequence (in Green Color, Using a Traffic Sign Analogy; See Panel A), a Dark Motivational Sequence (in Red; Panel B), and a Dim Light Sequence in Amber (Panel C).



Note: This figure is available at https://osf.io/fzxwj/ under a CC-BY4.0 license and can be freely reproduced.

We critically review debates within the SDT literature and between SDT and other literatures

We identify suggestions for future SDT research stemming from advances in technology

We also identify opportunities for SDT research based on new developments in behavioral science

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: