The future of health behaviour change interventions: Opportunities for open science and personality research

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Introduction

Understanding self-regulation processes is a central concern for promoting health, wellbeing and longevity. Over many decades scientists have attempted to understand the architecture of self-regulation and its associated mechanisms and processes. Moreover, within this context numerous theoretical models have been developed to facilitate the identification of the key determinants of health behaviours in order to provide suitable targets for intervention. As a result, there has been an explosion of research investigating the effectiveness of health behaviour change interventions. However, what are we to make of these findings? This special issue entitled 'Understanding and predicting health behaviour change: A contemporary view' represents an important advance in understanding the "state of the art" with regards to health behaviour change interventions applied to a range of different behaviours (e.g., chronic disease medications, Wilson et al., 2020; unhealthy risk-taking behaviours, Protogerou, McHugh, & Johnson, 2020), health conditions (e.g., cardiovascular disease, Suls et al., 2020; chronic disease conditions; Hennessy, Johnson, Acabchuk, McCloskey, and Stewart-James, 2020) and contexts (e.g., high versus low social class groups, race/ethnicity, Alcántara et al., 2020; early childhood and adolescence, Miller, Lo, Bauer, & Fredericks, 2020). The special issue ends with a look to the future with examples of how machine learning and natural language processing methods may advance the behaviour change interventions evidence base (Wallace et al., 2020). In this commentary, I outline two critical issues that came to mind when reading this collection of papers. The first relates to the reproducibility of meta-analyses and the principles of Open Science. The second deals with the need to examine the role of personality and individual differences in the context of health behaviour change interventions and self-regulation processes.

The parent meta-review by Hennessy et al. (2020) sets the scene for the special issue overall and for the associated meta-reviews. However, it also raises a number of fundamental issues not only for self-regulation intervention research in the area of chronic disease, but also for health behaviour change research more broadly. Hennessy and colleagues highlight the relatively low quality of reviews in this area (e.g., reviews satisfied less than 50% of the items using the AMSTAR 2 assessment tool) as well as highlighting the inconclusive evidence in terms of which intervention components are consistently important. Similarly, in the sub meta-reviews, Wilson et al. reported variable quality of meta-analyses of interventions targeting self-regulation on adherence to chronic disease medication (AMSTAR 2 item completion – M= 50%; range 31-65%) and Protogerou et al. showed that only four (26.67%) of the meta-analyses included in their meta-review satisfied at least 50% of the AMSTAR 2 quality criteria. Finally, Suls et al. (2020) reported that, on average, the meta-analyses included in their review achieved 56.5% completion of AMSTAR 2 quality items (range 31-88%). Taken together, these findings suggest that there is substantial room for improvement in the conduct and reporting of meta-analytical syntheses of health behaviour change interventions. In addition, they also point to concerns about the veracity of the conclusions of meta-analyses in this area. Another important issue relates to the reproducibility of meta-analyses and the extent to which they are conducted in line with the principles of Open Science – an issue I turn to next.

Open Science

Science, and not just psychological science, is undergoing a renaissance. It is an exciting time for psychology, and it is great that we, as a discipline, have been leading the way. This renaissance has been prompted by a number of developments: Most notably was the publication of the Open Science Collaboration (2015) paper estimating the reproducibility of psychological science. This large scale investigation attempted to replicate 100 experimental and correlational studies from three leading journals. The findings were stark; less than 40% of psychology studies were replicated. More recently, another large investigation (the Many Labs 2 project) found that only 14 of 28 classic and contemporary studies replicated (Klein et al., 2018). In addition, these failures to replicate did not appear to be attributable to sample diversity. Numerous factors have been proposed to explain these low levels of replication including low statistical power, hypothesizing after the results are known (HARKING), p-hacking and other questionable research practices (see Munafo et al., 2017 for further discussion). As a consequence, the renaissance in psychology has prompted a new approach to the scientific process known by the umbrella term, Open Science. The aim of Open Science is to increase openness, integrity and reproducibility in scientific research. It is hoped that it will propel psychological researchers forward by improving scientific practice and trigger new ways of working that will ultimately improve the robustness of our evidence base (Norris & O'Connor, 2019).

Health psychology generally, and behaviour change research (including self-regulation interventions) specifically, are not immune to issues related to replication and reproducibility. Indeed, Hagger and colleagues (2017) have reported that health psychology has paid relatively limited attention to the issues of replication and reproducibility. However, over the last few years, many health psychology researchers have begun to embrace open science practices, engage in large scale replication efforts and recognize the risks of p-hacking and other questionable research practices. In fact, it is important to note that health psychologists and other behaviour change trialists have been early adopters of a number of important Open Science practices such as pre-registering studies on relevant repositories (e.g., https://clinicaltrials.gov/; https://www.isrctn.com/) as well as pre-registering systematic reviews and meta-analyses (https://www.crd.york.ac.uk/PROSPERO/). Nevertheless, there will be many studies included in the meta-analyses described in this special issue that have not been pre-registered and they may be contaminated by questionable research practices. This is not to undermine the conclusions drawn from the reviews here, but instead it may help to explain some of the inconsistent and variable findings observed in this vast and divergent literature base.

Another issue that is worthy of comment relates to the reproducibility of meta-analyses given their central role in meta-reviews. Meta-analyses are the cornerstone of cumulative science. They allow researchers to synthesize evidence across a range of studies of differing sample sizes and outcomes and to draw conclusions about the weight of evidence for the effectiveness of a particular intervention or the size of the association between variables of interest while taking into account publication bias. However, relatively recently, concerns have been raised about the reproducibility of meta-analyses (e.g., Gotzsche, Hrobjartsson, Maric, & Kendal, 2007; Lakens, Hilgard & Staaks, 2016). For example, across 27 meta-analyses, Gotzsche and colleagues attempted to replicate the results of these meta-analyses by independently calculating the standardized mean difference (SMD) from two trials randomly selected from each of the chosen meta-analyses (as well as investigating other data extraction errors). The main findings showed that the authors were unable to replicate at least one of two chosen SMDs in 37% of meta-analyses (N =10) and other errors were reported in 63% of the meta-analyses (N =17). Moreover, they concluded that data extraction in meta-analyses is prone to errors that may actually negate the original conclusions or reverse the findings of the study.

What, therefore, can we do to improve the reproducibility of meta-analyses? Prompted by the work led by Gotzsche and colleagues, Lakens, Hilgard and Staaks (2016) recently published six practical recommendations to improve the reproducibility of meta-analyses. In their own words, they argued that there is "the need to improve the reproducibility of meta-analyses to facilitate the identification of errors, allow researchers to examine the impact of subjective choices such as inclusion criteria, and update the meta-analysis after several years" (p. 1). Their six recommendations are summarized briefly below:

1. Disclose all meta-analytic data (i.e., effect sizes, sample sizes for each condition, test statistics and degrees of freedom etc.),
2. Facilitate quality control by specifying which effect sizes calculations are used and which assumptions are made for missing data,
3. Adhere to established reporting guidelines with the minimum standard being the PRISMA guidelines,
4. Pre-register the meta-analysis protocol and clearly state confirmatory and exploratory analyses,
5. Facilitate reproducibility by allowing others to re-analyse your data (e.g., provide links to data files, script, codes etc.),

6. Recruit expertise as required (e.g., consult a librarian about systematic reviewing and/or a statistician before extracting effect size data).

The scientific publishing landscape has changed substantially as a result of the Open Science movement. An important development is the introduction of Registered Reports (https://osf.io/rr/). The aim of this new type of article is to increase the transparency of science, to allow peer review of research studies before the results are known and, crucially, to guarantee acceptance of the paper (irrespective of the findings following review at Stage 1; known as an In Principle Acceptance, IPA). As a consequence, it is hoped this will help reduce questionable research practice while improving the quality of our research protocols, and over time, it is hoped this will ultimately improve the robustness of our evidence base and the reliability and reproducibility of future meta-analyses and meta-reviews. Another area of research that is likely to improve our understanding of the effectiveness of health behaviour change interventions and self-regulation processes relates to personality and individual differences.

What about the role of personality and individual differences in the context of health behaviour change interventions?

Self-regulation processes do not happen in isolation. They happen within individuals who vary in terms of a range of individual differences variables (e.g., personality traits, gender, race/ethnicity) and across different contexts (e.g., high versus low social class, educational settings). Indeed, a myriad of individual differences variables have been identified as important determinants of health behaviours and self-regulation processes. Moreover, these variables are likely to be key moderators of behaviour change interventions. Therefore, the inclusion of the Alcantara et al. (2020) synthesis on the role of social determinants of health in the context of health behaviour change interventions targeting self-regulation was a welcome addition to this special issue. Interestingly, these authors report that 73.5% of social determinants moderator analyses tested heterogeneity of treatment effects by gender, race/ethnicity, and intervention setting. Of course, there are other important individual differences variables that may directly influence health outcomes and are also likely to influence the effectiveness of health behaviour change interventions. There is a substantial body of research that has shown that components of the five-factor model of personality are associated with longevity and health status (e.g., Friedman et al. 1993; Hampson et al., 2007; 2013; Hill et al., 2011; Jokela, 2018; Kern & Friedman, 2008; Shipley et al., 2007; Yannick et al., 2019). However, I will limit my discussion here to conscientiousness as it has been reliably identified as a determinant of a range of health behaviours and the only 'Big Five' factor robustly linked to chronic diseases and mortality across multiple studies (e.g., Bogg & Roberts, 2004; Jokela, 2018; O'Connor et al., 2009). For example, Friedman and colleagues (1993), using data from the Terman Life Cycle Study, reported that childhood conscientiousness predicted longevity and the magnitude of this effect (as a risk factor) was comparable to those from elevated serum cholesterol and systolic blood pressure levels in adulthood. In another study spanning forty years, the mechanisms through which childhood personality traits influence health status in adulthood were assessed (Hampson et al., 2007). Results indicated that conscientiousness influenced health status in adulthood indirectly via educational attainment, healthy eating habits and smoking. Bogg and Roberts (2004) carried out a large meta-analysis of 194 studies, demonstrating that conscientiousness was positively correlated with physical activity and negatively correlated with excessive alcohol use, unhealthy eating, tobacco use, drug use, risky driving, risky sex and suicide. These relationships have also been confirmed in daily diary studies as well as large-scale investigations (Gartland et al., 2014; Green et al., 2016; Kern & Friedman, 2008; O'Connor et al., 2009). Recent research has also shown positive associations between the facets of conscientiousness and objective markers of health status including adiposity, blood markers, physical performance and thickness of brain cortical regions (Lewis et al., 2018; Sutin et al., 2018).

Conscientiousness has been defined as the propensity to follow socially prescribed norms, control impulses and to be goal directed, planful, and able to delay gratification (John

& Srivastava, 1999). Each of the latter variables is likely to influence the effectiveness of health behaviour change interventions and self-regulation processes (see Ferguson, 2013). Indeed, Hennessy and colleagues (2020) identify personalized feedback, goal setting, and self-monitoring as successful intervention components in their meta-review. These key self-regulation interventions align closely with the lower order facets of conscientiousness (industriousness, order, self-control, traditionalism, virtue and responsibility, see Green et al., 2016) and their associated automatic patterns of thoughts, feelings and behaviours. Moreover, one's ability to control one's behaviour and to complete tasks is likely to facilitate the performance of aversive or difficult health behaviours that individuals may or may not be motivated to perform (O'Connor et al. 2009). Early research by Conner et al. (2007) showed conscientiousness moderated the impact of intentions to exercise on exercise behaviour. Similarly, Rhodes, Courneya and Jones (2005) reported conscientiousness to significantly moderate the intention–exercise behaviour relationship, with higher levels of conscientiousness associated with stronger intention–behaviour relationships. Future research might usefully examine how the facets of conscientiousness (as well as other personality traits) influence self-regulation processes. Do individuals high on conscientiousness utilize different strategies to enact their health behaviour intentions? For example, do conscientious individuals formulate clearer plans or simply try harder? In short, are individuals high on conscientiousness better at self-regulation?

Miller et al.'s (2020) 'Big Picture' synthesis highlights the importance of considering developmental factors in health-focused self-regulation interventions and reinforces the need to account for developmental stage when delivering behaviour change interventions. For example, they argue that different developmental considerations are required when delivering self-regulation interventions to children and youth compared to adults. Relatedly, it is developmental fact that people tend to become more conscientious as they get older (Roberts, Walton, & Viechtbauer, 2006), therefore, it is likely that the effectiveness of different behaviour change interventions for self-regulation processes will change over time too. Nevertheless, it is surprising that the moderating effects of key personality factors in health behaviour change intervention research have been relatively underresearched. Indeed, many health-based behaviour change interventions are designed to increase purposeful and planned behaviour (implementation intentions, TPB-based interventions, e.g., O'Connor, Armitage & Ferguson, 2015) and may be effective by changing trait levels of personality, hence the need to assess traits as part of intervention development, delivery and evaluation. In addition, the idea that personality is open to change has led authors such as Roberts and colleagues (2017) to suggest the intriguing possibility that interventions can be developed to change traits such as conscientiousness that may have important health benefits. Roberts et al. (2017) have recently introduced the Sociogenomic Trait Intervention Model (STIM), an intervention to change conscientiousness that is based on behavioural activation theory and is informed by developmental research.

To summarise, understanding, predicting and changing self-regulation processes will continue to be a central concern for health psychology and related disciplines. There is a real opportunity to improve the robustness of the health behaviour change evidence base by continuing to embrace the principles of Open Science together with investigating how individual differences and personality traits interact with these interventions. Future research should adopt more open, transparent and reproducible scientific practices *and* explore the role of individuals differences variables such as personality in order to provide a fuller understanding of when, where and how self-regulation processes are effective.

REFERENCES

Alcántara, C., Diaz, S. V., Giorgio Cosenzo, L., Loucks, E. B., Penedo, F. J., & Williams, N. J. (2020). Social determinants as moderators of health behaviour change interventions: scientific gaps and opportunities. *Health Psychology Review.*

Bogg, T., & Roberts, B. W. (2004). Conscientiousness and health-related behaviours: A meta-analysis of the leading behavioural contributors to mortality. *Psychological Bulletin*, 130, 887-919.

Friedman HS, Tucker JS, Tomlinson-Keasey C, Schwartz JE, Wingard DL, Criqui MH. (1993). Does childhood personality predict longevity? *Journal of Personality and Social Psychology,* 65, 176–185.

Conner, M., Rodgers, W., & Murray, T. (2007). Conscientiousness and the intention–behaviour relationship: Predicting exercise behaviour. *Journal of Sport and Exercise Psychology*, 29, 518–533.

Ferguson, E. (2013). Personality is of central concern to understand health: Towards a theoretical model for health psychology. *Health Psychology Review*, 7, S32–S70.

Gartland, N., O'Connor, D.B., Lawton, R., & Ferguson, E. (2014). Investigating the Effects of Conscientiousness on Daily Stress, Affect and Physical Symptom Processes: A Daily Diary Study. *British Journal of Health Psychology*, 19, 311-328.

Green, J., O'Connor, D.B, Gartland, N., & Roberts, B.W. (2016). The Chernyshenko Conscientiousness Scales: A New Facet Measure of Conscientiousness. *Assessment*, 23, 374-385.

Gotzsche, P.C., Hrobjartsson, A., Maric, K., & Kendal, B. (2007). Data extraction errors in meta-analyses that use standardised mean differences. *JAMA*, 298, 430-437.

Hagger, M., Peters, G.-J. Y., Heino, M. T., Crutzen, R., & Johnston, M. (2017). The replication crisis in (health) psychology: reflections and solutions. *The European Health Psychologist, 19*(Supp.).

Hennessy, E. A., Johnson, B. T., Acabchuk, R. L., McCloskey, K., & Stewart-James J. (2020). Self-regulation mechanisms in health behaviour change: a systematic meta-review of meta-analyses, 2006-2017. *Health Psychology Review.*

Hampson, S. E., Edmonds, G. W., Goldberg, L. R., Dubanoski, J. P., & Hillier, T. A. (2013). Childhood conscientiousness relates to objectively measured adult physical health four decades later. *Health Psychology, 32,* 925–928.

Hampson, S., Goldberg, L.R., Vogt, T.M., & Dubanoski, J.P. (2006). Forty years on: Teachers' assessment of children's personality traits predict traits predict self-reported health behaviours and outcomes at mid life *Health Psychology,* 25, 57-64.

Hill, P. L., Turiano, N. A., Hurd, M. D., Mroczek, D. K., & Roberts, B. W. (2011). Conscientiousness and longevity: An examination of possible mediators. *Health Psychology, 30,* 536–541.

Jokela, M. (2018). Personality as a determinant of health behaviors and chronic diseases: Review of meta-analytic evidence. In C.D. Ryff & R. F. Krueger (Eds.), *The Oxford Handbook of Integrative Health Science*. Oxford: Oxford University Press.

Kern, M. L., & Friedman, H. S. (2008). Do conscientious individuals live longer? A quantitative review. *Health Psychology, 27,* 505–512.

Klein, R. A., Vianello, M., Hasselman, F., Adams, B. G., Adams, R. B., Jr., Alper, S., … Nosek, B. A. (2018). Many Labs 2: Investigating Variation in Replicability Across Sample and Setting. *Advances in Methods and Practice in Psychological Science*, *1*, 443–490.

Lakens, D., Hilgard, J., & Staaks, J. (2016). On the reproducibility of meta-analyses: six practical recommendations. *BMC Psychology*, 4: 24.

Lewis, G.J., Dickie, D.A., Cox, S.R., Karama, S., Evans, A.C., Starr, J.M., Bastin, M.E., Wardlaw, J.M., & Deary, I.J. (2016). Widespread associations between trait conscientiousness and thickness of brain cortical regions. *Neuroimage*, 176, 22-28.

Munafò, M. R., Nosek, B. A., Bishop, D. V., Button, K. S., Chambers, C. D., Du Sert, N. P., . . . Ioannidis, J. P. (2017). A manifesto for reproducible science. *Nature Human Behaviour, 1*(1), 0021.

Miller, A. L., Lo, S., Bauer, K. W., & Fredericks, E. M. (2020). Considering developmental factors in health-focused self-regulation interventions. *Health Psychology Review.*

Norris, E., & O'Connor, D.B. (2019). Science as behaviour: Using a behaviour change approach to increase uptake of Open Science. *Psychology and Health*, 34, 1397-1406.

O'Connor, D.B., Conner, M., Jones, F., McMillan, B., & Ferguson, E. (2009). Exploring the benefits of conscientiousness: An investigation of daily stressors and health behaviours. *Annals of Behavioral Medicine*, 37, 184-196.

O'Connor, D.B., Armitage, C.J., Ferguson, E. (2015). Randomized test of an implementation intention-based tool to reduce stress-induced eating. *Annals of Behavioral Medicine*, 49, 331-343.

Open Science Collaboration. (2015). Estimating the reproducibility of psychological science. *Science, 349*(6251), aac4716.

Protogerou, C., McHugh, R. K., & Johnson, B. T. (2020). Effectiveness of self-regulation interventions to reduce unhealthy risk-taking behaviours: a meta-review of evidence syntheses. *Health Psychology Review.*

Rhodes, R,E., Courneya, K.S., & Jones, L.W. (2005). The theory of planned behaviour and lower-order personality traits: Interaction effects in the exercise domain. *Personality and Individual Differences*, 38, 251–265.

Roberts, B. W., Hill, P. L., & Davis, J. P. (2017). How to change conscientiousness: The sociogenomic trait intervention model. *Personality Disorders: Theory, Research, and Treatment, 8*, 199-205.

Roberts, B. W., Walton, K. E., & Viechtbauer, W. (2006). Personality traits change in adulthood: Reply to Costa & McCrae (2006). *Psychological Bulletin, 132,* 29-32.

Shipley, B.A., Weiss, A., Der, G, Taylor, M.D., & Deary, I.J. (2007). Neuroticism, extraversion, and mortality in the UK health and lifestyle survey: A 21-year prospective cohort study. *Psychosomatic Medicine*, 69, 923-931.

Suls, J., Mogavero J. N., Falzon, L., Pescatello, L, S, Hennessy, E. A., & Davidson, K. (2020). Health behaviour change in cardiovascular disease prevention and management: meta-review of behaviour change techniques to affect self-regulation. *Health Psychology Review.*

Sutin, A. R., Stephan, Y., & Terracciano, A. (2018). Facets of conscientiousness and objective markers of health status. *Psychology & Health, 33*, 1100-1115.

Wilson, T. E., Hennessy, E. A., Falzon, L., Boyd, R., Kornish, I, M., & Birk, J. L. (2019). Effectiveness of interventions targeting self-regulation to improve adherence to chronic disease medications: A meta-review of meta-analyses. *Health Psychology Review.*

Yannick S., Sutin, A.R., Luchetti, M., & Terracciano, A. (2019). Facets of conscientiousness and longevity: Findings from the Health and Retirement Study. *Journal of Psychosomatic Research*, 116, 1-5.