report

Using N-of-1 methods to study or change health-related behaviour and outcomes: A symposium summary

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N-of-1 methods are increasingly attracting attention as a viable and innovative set of methods in health psychology science. N-of-1 methods focus on changes within an individual (or individual unit e.g. family, hospital) over time and involve repeated measurements to draw conclusions about the individual. N-of-1 methods are advocated by the UK Medical Research Council as methods that can be used to test theories and interventions (Medical Research Council, 2008). They can be used to investigate patterns of individual behaviour and determinants over time and, in contrast to group-based designs that focus on the effect of an intervention *on average*, N-of-1 methods can be used to understand the effect of an intervention on the individual.

Since 2011, the European Health Psychology Society (EHPS) annual conference has featured a symposium dedicated to methods in health psychology. The '5th Methods in Health Psychology Symposium', held at the EHPS annual conference in Cyprus (2015), was on the topic of using N-of-1 methods to study or change health-related behaviour. The symposium aimed to highlight the key features and advantages of N-of-1 methods and how they can be used to address key questions in health psychology science. The purpose of the symposium was to create an interest in the method and discuss areas which currently lack clarity and consensus in regards to the application of N-of-1 methods to health psychology research.

Wayne Velicer (University of Rhode Island) opened the symposium with a strong emphasis on how N-of-1 methods can be used to address research questions that traditional group-based designs cannot. N-of-1 methods provide information about changes in individual behaviour over time which is not well represented in studies using group-based designs. Wayne presented the findings from a study that examined smoking behaviour for a period of 40 days in a group of individuals (Hoeppner, Goodwin, Velicer, Mooney, & Hatsukami, 2008). Analysis of the data at the group level showed that, on average, smoking behaviour decreased over time. However, analysis of the data at the individual level showed that only 12% of the group displayed this smoking pattern. In fact, some smokers had increased their smoking behaviour over time. Wayne highlighted the need for statistical methods for analysing N-of-1 data that can account for potential autocorrelation (i.e. dependency between the data points due to repeated and frequent measurements from the same individual) within the data. Ignoring the existence of autocorrelation in N-of-1 data can have major implications because it results in inaccurate tests of significance and effect size estimates. Furthermore, the study of autocorrelation itself can provide important insights into the function of behaviour over time such as daily and cyclical patterns in health-related behaviours. The dependency in the data can sometimes lead to large autocorrelations, and these have implications for the selection of the statistical method(s) used to analyse N-of-1 data, because the presence of dependency in the dependant variable violates the assumptions of many traditional statistical techniques. Although specialised statistical techniques may be required there is currently no 'gold standard' method of analysis. Wayne concluded that replicating N-of-1 studies across individuals, contexts and settings can

help to identify homogeneous subgroups of individuals with similar health behavioural patterns.

Next, Suzanne McDonald (Newcastle University) presented a summary of findings from a systematic review of N-of-1 methods applied to health behaviour research (McDonald, Quinn, Hobbs, White, & Sniehotta, 2013). The review identified a number of studies using N-of-1 observational and experimental designs to study or change various behaviours including physical activity (PA), treatment adherence, sleep, alcohol consumption, smoking and drug use. Suzanne also presented the findings from a series of N-of-1 natural experiments conducted to understand how PA patterns change during the retirement transition. An N-of-1 design was appropriate because of the considerable heterogeneity in PA trajectories and PA determinants during the retirement transition (McDonald, O'Brien, White, & Sniehotta, 2015). PA, measured continuously by tri-axial accelerometry, and ecological momentary assessments of potential cognitive and affective determinants of PA were collected daily for seven participants approaching retirement. Additional variables of interest were selected by participants and added to the design as potential predictors of their PA. Participants provided data for a continuous period of 4-6 months covering the retirement date and the data were analysed using Auto-Regressive Integrated Moving Average (ARIMA) models (Box & Jenkins, 1970). In this study PA trajectories were found to differ considerably between individuals, with some individuals showing increases in PA levels pre- to post-retirement and others showing decreases in PA levels or no change. The predictors of daily PA also differed between participants and for some individuals predictors of PA changed pre- to post-retirement. The findings showed that the direction, magnitude and predictors of PA change may vary considerably between individuals. At the end of the study the participant's data were discussed with the participant and they were encouraged to take an active role in the interpretation of their data. This

resulted in a shared understanding of the data and facilitated a process of knowledge co-creation about individual behaviour change.

Nicola O'Brien (Newcastle University) presented the findings from a series of N-of-1 studies comparing a biomedical, a psychological, and an integrated model of activity and activity limitations to predict walking within individuals with osteoarthritis (O'Brien, Philpott-Morgan, & Dixon, 2015). Most theories of behaviour describe the behaviour of an individual yet are rarely tested at the individual level using N-of-1 designs (Johnston & Johnston, 2013). The study also tested the effectiveness of a data-driven walking intervention. Diary methods were used to assess impairment (pain, pain-on-movement, joint stiffness), cognitions (intention, self-efficacy, perceived controllability) and walking (pedometer step count) in four individuals with osteoarthritis twice-daily over 12 weeks. An AB intervention design was used, where the A phase represented a six week period of measurement prior to the implementation of the intervention and the B phase represented a six week period of measurement after the implementation of the intervention. The intervention was a walking intervention individually tailored to target the factors which were found to predict the individual's walking behaviour during the A phase. Simulation modelling analysis tested relationships between predictors and walking behaviour using cross-correlations and the effect of the intervention for each individual was evaluated by testing differences between the means of the two phases while accounting for identified autocorrelation. Multiple regression analyses examined the predictive ability of the three models. Cognitions were better, more consistent within-individual predictors of walking than impairment. More specifically, the integrated and psychological models, which recognise a role for cognitions in predicting behaviour, accounted for substantially more variance in walking than the biomedical model. In this case the individually-tailored intervention did not significantly increase

walking in any participant. However, the study demonstrated the possibility of using N-of-1 methods as a tool to personalise interventions to individuals based on the unique determinants of their behaviour.

Finally, Falko F. Sniehotta (Newcastle University) presented the findings from a series of N-of-1 randomised controlled trials (RCTs) investigating differential response to interventions targeting increased bouts of PA or reduced sedentary time in individuals with Type II Diabetes. The study design was informed by a previous study which investigated the differential effects of two distinct behaviour change techniques (self-monitoring and goal-setting) to increase walking in normal and overweight adults (Sniehotta, Presseau, Hobbs, & Araujo-Soares, 2012). Intervention and control phases were randomly allocated to different days. Seven participants wore an accelerometer measuring PA for 6 months. The intervention conditions included either a daily prompt designed to increase PA, a prompt designed to reduce sedentary time or a control condition. No prompts were delivered on days following either PA or sedentary prompts to examine the nature of carryover effects (i.e. the effect of an intervention condition carrying over into subsequent days). Participants were also prompted daily to complete ecological momentary assessments of potential cognitive and affective determinants of PA and sedentary behaviour. Bootstrapped time series analyses assessed the effect of each type of prompt for each individual over time and tested for the presence of carryover effects in non-intervention days. Each participant varied in their response to the interventions targeting PA and sedentary time with some responding better to intervention days targeting PA and others responding better to intervention days targeting sedentary time. This study demonstrated how N-of-1 RCT designs can provide a rigorous test of interventions at the individual level. Using methods that provide information about individual response is important, particularly if intervention response is likely to be

heterogeneous (Davidson, Peacock, Kronish, & Edmondson, 2014). N-of-1 RCTs can also be used to test specific intervention components (e.g. behaviour change techniques) and can help to identify the most effective combinations, sequences and doses of intervention components for achieving sustained behaviour change (McDonald, Araujo-Soares, & Sniehotta, 2016).

Karina W. Davidson (Columbia University) closed the symposium with a message about how important N-of-1 methods are to the field of health psychology. Specifically, she discussed that although between-subject RCTs are the sine qua non of causal inference, they are not without limitations. Health psychology or behavioural treatments tested in a conventional RCT offer the same treatment to all participants in the intervention group. And, we regularly find that while some benefit from the treatment, others derive no benefit and yet others may even be harmed. And, such a finding can occur even when the average treatment effect is large, and of clinically meaningful and significant benefit—to the hypothetical 'average' participant. This range of benefit (or in some cases harm) available for the actual participants is called the heterogeneity of treatment effect. N-of-1 RCTs offer a low-cost, more precise means by which to overcome some of these limitations, particularly by allowing for the quantitative examination of heterogeneity of treatment effects, and by allowing for individualization of treatment. They can only be used when a treatment is reversible, and the outcome is varying, and can be assessed on a regular basis. This, it turns out, are conditions that are true for many of the symptoms health psychology seeks to treat. Testing our behavioural and psychological reversible interventions first inside an N-of-1 RCT design is a vital methodological advance for health psychology. It allows us to determine for whom a treatment works, and if it should be tailored, rather than presented generically. Only when the heterogeneity of treatment effect is small—a rare occurrence in our field—should we move back to conventional,

between-subjects RCTs.

Summary

The 5th Methods in Health Psychology symposium highlighted the key features and advantages associated with N-of-1 methods and underscored a number of novel opportunities for future research. N-of-1 methods can be used to test theories about individual behaviour and to identify the best interventions for individuals. Furthermore, N-of-1 methods can be used as a tool to develop highly tailored and personalised interventions which are adapted to address the specific needs and preferences of individuals. N-of-1 research can capitalise on the rapid developments in technology and sampling methods that enable investigators to obtain reliable, valid and unobtrusive measurements of behaviour and symptoms from individuals over time (Dallery, Cassidy, & Raiff, 2013; Shiffman, Stone, & Hufford, 2008). The use of N-of-1 methods can make a substantial contribution to many debates within the field and we hope that the symposium sparked interest and enthusiasm for the use of N-of-1 methods in future health psychology research.

Further reading

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