Conclusions about well-being being necessary but not sufficient for resilience may be unwarranted

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Abstract

After conducting necessary condition analysis (NCA), researchers have concluded that a certain, not too low, level of well-being is necessary but not sufficient for a high level of resilience. However, as acknowledged by the developers of the test, NCA only evaluates if the association between two variables is characterized by some unspecified type of non-randomness and not conditions of necessity. The present findings, based on re-analyses of data, indicate a significant necessity effect of resilience on overall well-being, which is not logically compatible with well-being being necessary but not sufficient for resilience. Analyses with an extended version of NCA suggest that the association between overall well-being and resilience is characterized by equal degrees of necessity and sufficiency.

Key words: necessary condition analysis (NCA), necessity, re-analysis of data, resilience, sufficiency, well-being

Introduction

According to rules of logic, if a condition X is necessary but not sufficient for another condition Y, there are no instances where X is absent and Y is present, but there are instances where X is present and Y is absent. Consequently, as there are instances where X is present and Y is absent, if X is necessary but not sufficient for Y, Y cannot, at the same time, be necessary for X. However, as there are no instances where X is absent and Y is present, if X is necessary but not sufficient for Y, Y must, at the same time, be sufficient for X. As an example, if being human is necessary but not sufficient for being Greek, we know that (i) there are no Greeks that are not humans, (ii) there are humans that are not Greeks, (iii) being Greek is not necessary for being human, and (iv) being Greek is sufficient for being human. If condition (ii) is not satisfied, i.e. if all humans are Greeks, this indicates that being Greek is actually necessary for being human and that being human is sufficient for being Greek.

Necessary condition analysis (NCA) is a method that was originally developed to help researchers identify conditions that are necessary but not sufficient for some outcome of interest. According to the logic of the test, the size of the empty space in the upper-left corner when plotting two variables, X and Y, against each other indicates to what degree a low value on X precludes a high value on Y, i.e. to

what degree X is necessary for Y [1] (the calculation of the necessity effect will be illustrated in the Result section, see below). Subsequently, NCA has been extended with a significance test that employs permutations [2]. As an empirical example, after conducting analyses with NCA, Camitan and Bajin concluded that well-being is necessary but not sufficient for resilience [3].

However, there are mounting evidence that NCA does not correctly identify conditions that are necessary but not sufficient for the outcome. Sorjonen and Melin [4,5] have shown that if X is sufficient for Y, X does not need to be necessary for Y for a significant result in NCA, which is in exact contradiction to the originally stated objective of NCA (see also [6]). The developers of NCA have acknowledged that NCA does not assess if X can be assumed to be necessary for Y, and even less if X can be assumed to be necessary but not sufficient for Y. Instead, NCA has been described as a null hypothesis test and a significant finding only indicates that the association between X and Y is characterized by some unspecified type of non-randomness [7]. However, NCA seems inferior to ordinary linear regression analysis for detecting non-random associations [8].

In order to increase the specificity and usefulness of results obtained through NCA, Sorjonen and Melin [5] have proposed an extended version of NCA, where both the degree of necessity and the degree of sufficiency, as well as the difference between these two, are calculated. Degree of sufficiency is operationalized as the size of the empty space in the lower-right corner when plotting the two variables against each other (see the Result section for an illustration). This sufficiency effect of X on Y equals the necessity effect of Y on X. The significance of the difference between degree of necessity and degree of sufficiency can be evaluated through bootstrapping and a significant finding indicates that the association between X and Y is characterized either by a higher degree of necessity than sufficiency (significant positive difference) or by a higher degree of sufficiency than necessity (significant negative difference). A non-significant difference suggests equal degrees of necessity and sufficiency. However, Sorjonen and Melin warn against drawing conclusions about a significant difference unless the stronger effect, either necessity or sufficiency, has been indicated as significant by the permutation test in NCA.

Given the limitations of NCA, the objective of the present study was to evaluate if well-being really can be assumed to be necessary but not sufficient for resilience by re-analyzing the data used by Camitan and Bajin [3]. If this is the case, resilience must not be necessary for well-being. Also the difference between degree of necessity and degree of sufficiency in the association between well-being and resilience will be evaluated with the extended

version of NCA proposed by Sorjonen and Melin [5].

Method

We refer to the original paper by Camitan and Bajin [3] for a more exhaustive description of the sample, the measures, and data collection procedures. In short, well-being and resilience were measured among 533 Filipino adults (age range 18-40, 29% male) in COVID-19 quarantine. Subscales included in the PERMA Profiler, measuring positive emotions, engagement, positive relations, meaning, accomplishment, as well as a composite score measuring overall well-being, were used as measures of well-being. We have not included measures of negative emotions, physical health, and loneliness used by Camitan and Bajin in the present study, as these had no significant necessity effect on resilience (although physical health and loneliness were included in the composite score). Resilience was measured with the Connor-Davidson Resilience Scale.

In the present study, analyses were conducted with R 4.1.0 statistical software [9] employing the NCA package [10]. Sufficiency effects of well-being on resilience, operationalized as the size of the empty space in the lower-right corner when plotting variables against each other (see below), were calculated as necessity effects of resilience on well-being (as these two effects are identical). The significance of necessity and sufficiency effects were calculated through 10,000 permutations. Differences between necessity and sufficiency effects were calculated in 10,000 bootstrapped subsamples and the significance of the difference was estimated by calculating a Z-score, and then a corresponding *p*-value, by dividing the mean of the differences by the standard error of the differences.

Results

In Table 1 we see, as already demonstrated by Camitan and Bajin [3], that the well-being variables have a significant necessity effect on resilience. We also see that the sufficiency effect of the five subscale measures of well-being on resilience (= the necessity effect of resilience on these subscales) is non-significant. This might be seen to suggest that well-being is, as concluded by Camitan and Bajin,

necessary but not sufficient for resilience. However, this conclusion is compromised by the fact that the difference between the necessity effect and the sufficiency effect is not significant, except for meaning. Moreover, for the overall well-being composite score the sufficiency effect is significant and the difference between the necessity and the sufficiency effect is very non-significant.

The necessity and sufficiency effects of the overall well-being composite on resilience, as well as the difference between these two effects, is illustrated in Figure 1. In the upper panel, the size of the empty space above the ceiling line in the upper-left corner, as a percentage of the red square given by the lowest and highest values on the two variables, corresponds to the necessity effect ($d = 0.121$) while the size of the empty space below the floor line in the lower-right corner corresponds to the sufficiency effect ($d = 0.137$) which, as stated above, is identical to the necessity effect of resilience on overall well-being. In the bottom panel we see that the frequency distribution of the differences between the necessity effect and the sufficiency effect, calculated in 10,000 bootstrapped subsamples, firmly includes zero, indicating no difference between the two effects.

Discussion

The present findings suggest that the conclusion by Camitan and Bajin [3], that well-being is necessary but not sufficient for resilience, may be unwarranted. We found that resilience had a significant necessity effect on overall well-being and it would be inconsistent with rules of logic if well-being is necessary but not sufficient for resilience at the same time as resilience is necessary for well-being. Instead, analyses with an extended version of NCA, proposed by Sorjonen and Melin [5], indicate that the association between overall well-being and resilience is characterized by equal degrees of necessity and sufficiency.

We suspect that Camitan and Bajin, and maybe also others, may have been duped by the name of the test as well as the content of Dul's [1] original paper (including its title) into believing that NCA analyzes if a condition X can be assumed to be necessary, or even necessary but not sufficient, for an outcome Y. However, as later recognized by the developers,

Table 1. Necessity and sufficiency effects of well-being on resilience, as well as the difference between these two effects.

Well-being variable	Necessity		Sufficiency		Difference	
	<i>d</i>	<i>p</i>	<i>d</i>	<i>p</i>	<i>d</i> (SE)	<i>p</i>
Positive Emotions	0.122	< 0.001	0.056	0.226	0.065 (0.035)	0.069
Engagement	0.085	< 0.001	0.026	0.796	0.062 (0.039)	0.109
Positive relations	0.093	< 0.001	0.068	0.088	0.033 (0.019)	0.080
Meaning	0.117	0.003	0.032	0.474	0.088 (0.021)	< 0.001
Accomplishment	0.121	< 0.001	0.085	0.153	0.035 (0.031)	0.264
Overall well-being	0.121	< 0.001	0.137	0.008	0.000 (0.033)	0.991

Note: The sufficiency effect of well-being on resilience equals the necessity effect of resilience on well-being; *d* = effect size; *p* = significance; SE = standard error.

NCA is only capable of evaluating if the association between X and Y is characterized by some unspecified type of non-randomness [7]. With this in mind, it might be asked if it would not be appropriate to rename the analysis “a randomness test (ART)” or something similar. Then again, ordinary linear regression analysis seems superior to NCA for identifying non-random associations [8].

Conclusions

Resilience has a significant necessity effect, as calculated by necessary condition analysis (NCA), on overall well-being. Consequently, well-being does not seem to be a necessary but not sufficient condition for resilience. Instead, analyses with an extended version of NCA suggest that the

associations between overall well-being and resilience is characterized by equal degrees of necessity and sufficiency. Some researchers still seem to believe that a significant result in NCA (original version) indicates that the analyzed condition is necessary but not sufficient for the outcome. However, as recognized by the developers, NCA (original version) is only capable of evaluating if the association between two variables is characterized by some unspecified type of non-randomness.

Data availability

The empirical data, originally used by Camitan and Banaji [3], is available [here \(link\)](#). The script for the present study is available at Open Science Framework at <https://osf.io/abnj4/>.

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