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Letters

Training attentional processes

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In the current issue, Tang and Posner [1] review some of the latest research on attention-related interventions that the authors separate into 'attention training' (e.g. computer based exercises), and 'attention state training' (e.g. integrative body-mind training, exposure to nature). What is common to these two types of training is their ability not only to improve trained processes, but also to have effects that transfer to other, non-trained processes and abilities. These findings are very exciting with a wide range of applicability.

Although the authors' [1] distinction between the two types of interventions is interesting, we would like to propose an alternative view on how to integrate these findings into a testable model that explains how the different training regimens interact (Figure 1). Furthermore, we propose a research agenda to test this model.

First, we believe that all the training interventions discussed by Tang and Posner [1] (mindfulness-based training, integrative body-mind training, exposure to nature and the cognitive exercises) focus on attentional processes. However, there could be aspects of attention that are tapped differentially by the different training regimens. Therefore, it might be more appropriate to express the differences in training in terms of practicing a specific attentional process as in the contrast between cognitive exercises versus restoring attentional processes with exposure to natural environments (meditation might also have similar effects, but meditation combines resting and focusing which complicates its classification as either a strengthening process or a resting process). Exercise regimens help strengthen directed or top-down attentional mechanisms via practice, whereas restoration regimens bolster directed attention mechanisms by allowing them to rest (consistent with Kaplan's attention restoration theory [2]). Another distinction we see is that exercise regimens are more active or controlled, whereas restorative regimens are more passive or automatic. Yet another contrast between these two views is that exercise regimens might increase neural activation in cognitive control regions, whereas restorative or passive regimens might decrease activation in these same areas. In summary, we believe that it could be more profitable to discuss these different interventions in terms of a distinction between exercise versus rest rather than a distinction between 'state' and 'non-state' attentional training.

Although these different interventions lead to many similar improvements, the processes altered by these different regimens (strengthening versus restoring) could also lead to some differential effects. For example, strengthening regimens might help focus attention, whereas restorative regimens might broaden attention and facilitate reflection.

A future research agenda that stems from this view would involve experiments in which participants rest directed attentional processes by interacting with nature [3] but also challenge their directed attention processes by mental exercises such as dual n-back training [4]. The research question addressed by such experiments is whether the cognitive improvement seen in both intervention approaches is underadditive, additive or overadditive. That is, do rest and exercise have separable or interactive effects? Another issue is whether the positive effects of one intervention (e.g. dual n-back training) can be undone by the wrong value of another intervention (e.g. exposure to a non-restorative environment). This issue is part of the larger issue of whether the context of an intervention matters, where that context is defined by other environmental variables and also by interindividual differences in intervention efficacy.

We should also note that the examples discussed here, and those by Tang and Posner [1], are not the only training regimens that were found to improve cognitive functioning: musical education [5], social interactions [6], exercise [7], glucose [8] or antioxidant [9] consumption have all been shown to improve performance. Therefore, future research should also examine the mechanisms that are common and unique amongst all of these training procedures and identify mediators and moderators (e.g. motivation, interest or affect) that might be relevant to the design of optimal cognitive interventions.

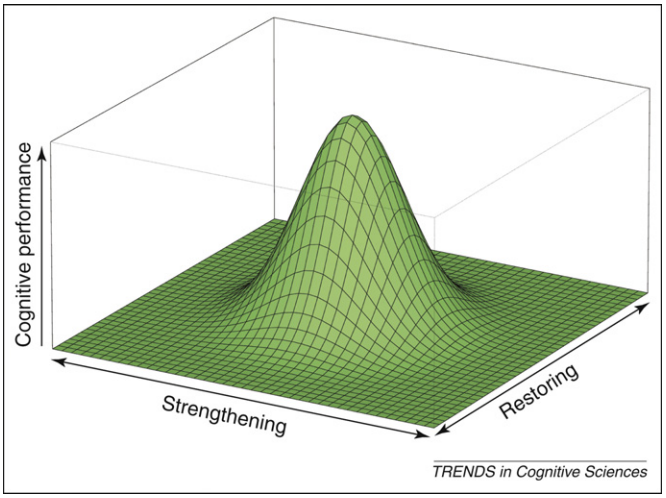

Figure 1. Hypothetical relationship between intervention approaches that focus on exercising attentional processes versus those that aim to restore attentional processes. Best cognitive performance might be obtained at an intermediate level of activity and rest.

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Letters Response

Response to Jaeggi *et al.*: Exploring training methods

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We welcome the interesting contribution of Jaeggi, Berman and Jonides [1] to our discussion of methods to alter attention. As we stated explicitly in our article [2], our goal is to facilitate discussion in this novel field.

The distinction between 'rest' and 'exercise' that Jaeggi *et al.* [1] propose is interesting, and certainly, restoration of attention is an important goal and might be a good way of conceptualizing the effects of exposure to nature. We continue to believe in the importance of employing the distinction between attention training (AT) and attention state training (AST) methods because we believe that AST methods are not merely a means of restoration, but a group of methods that improve the efficiency of attention. State changes are a common and important process for improving behavior and performance in animals and humans [3,4]. Integrative body-mind training (IBMT) qualifies as a state change rather than merely restoration because it is effective after rest and after stressful tasks. However, unlike AT, AST involves more than specific strengthening of a particular brain network, instead, it integrates and coordinates body and mind to improve attention and self-regulation. This seems to involve a state of increased central and autonomic nervous system interaction which would be very different from what is expected from AT methods.

It would be useful, as the authors suggest, to have an empirical method to determine how training should be classified. Using the argument developed by Sternberg [5], two tasks that share a common mechanism would produce a statistical interaction; if there was no common mechanism (e.g. they were independent statistically), they would show additivity. For example, if methods such as exposure to nature and meditation, when applied together, produced a statistical interaction, one might argue that they have a common mechanism and should be put into the same category. If the two are additive, the argument would be that they should be classified separately. For instance, Jaeggi *et al.* [1] argue that meditation might interact with both nature exposure and AT tasks, whereas we think that IBMT would not interact with AT. This approach to determining how training could be classified would involve the additive factors method commonly applied in cognitive studies to examining common mechanisms. Additive factors have proven to be a useful method, but this approach does have limitations, particularly with complex processes such as those involved in training [6].

A different but compatible method would be to use brain imaging to show which training methods involve similar brain networks. As suggested previously, and in our paper [2], we think that IBMT is a kind of state training and because it involves mental and bodily processes, it might activate both the central and peripheral nervous system. This is quite different from what has been found with training methods such as the use of working memory tasks [7].

It is also important to note, as Jaeggi *et al.* [1] have, that there are other methods that might influence cognition. For example, both aerobic exercise [8] and music education [9] have been shown to alter cognitive processes. However, the goal of our article [2] was to deal with methods designed specifically to train attention. It might well be that all of these methods also target attention, but it is equally possible that they involve other cognitive processes. As conclusive evidence regarding the processes targeted by these methods is still lacking, we chose not to discuss them in our contribution.

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