Neuropsychological Rehabilitation
An International Journal
ISSN: 0960-2011 (Print) 1464-0694 (Online) Journal homepage: www.tandfonline.com/journals/pnrh20

Research digest

Robin Green & Gary Turner

To cite this article: Robin Green & Gary Turner (2010) Research digest, Neuropsychological Rehabilitation, 20:2, 306-311, DOI: 10.1080/09602010903172239

To link to this article: https://doi.org/10.1080/09602010903172239

Published online: 30 Nov 2010.

NEUROPSYCHOLOGICAL REHABILITATION
2010, 20 (2), 306–311

Psychology Press
Taylor & Francis Group

Research digest

Robin Green[1], and Gary Turner[2]
[1]*Toronto Rehabilitation Institute, Toronto, Canada;* [2]*Helen Wills Neuroscience Institute, University of California, Berkeley, USA*

GROWING EVIDENCE FOR THE INFLUENCE OF MEDITATION ON BRAIN AND BEHAVIOUR

There is extensive evidence that the developing human brain and the brain actively recovering from injury have the capacity for experience-dependent neuroplastic change; however, the evidence for such neuroplasticity in the *healthy adult* brain is more limited. The possibility of improving a healthy (or stable, recovered) adult brain has significant clinical implications, including optimising intact areas of functioning to offset impairments in other areas, and increasing reserve capacity to provide prophylactic benefits against ageing or future neurological disorders (Satz, 1993; Stern, 2002). One area of research in experience-dependent neuroplasticity that has been receiving a great deal of attention over the past decade is meditation. Meditation is of clinical interest as it represents one of the few examples of experience-dependent neuroplasticity for higher order in healthy adults for higher cognitive functions. Meditation has also been shown to beneficially affect autonomic nervous system function (Newberg & Iverson, 2003) and affect regulation (Creswell, Way, Eisenberger, & Lieberman, 2007). Moreover, meditation is an intervention that can be self-administered, obviating transportation and cost factors that can be barriers to treatment. Thus, meditation is a treatment modality for neurorehabilitation with marked potential, although it is yet to be widely employed. The aims of this digest are to provide an introduction to meditation research, to discuss some of

Although we scan a number of journals, finding good papers of relevance to neuropsychological rehabilitation is not always an easy task and we would be happy to be sent or pointed to any papers that readers of this journal consider useful, interesting or even controversial.

Contact details: Jonathan.Evans@clinmed.gla.ac.uk; andrew.bateman@ozc.nhs.uk; and levine@psych.utoronto.ca; gary.ucb@gmail.com; and green.robin@torontorehab.on.ca

http://www.psypress.com/neurorehab DOI:10.1080/09602010903172239

the implications of meditation for neurorehabilitation, and to suggest areas for future research that would be of relevance to practitioners of neurorehabilitation.

Several recent empirical examinations of meditation in healthy subjects have demonstrated significant effects in the domains of sustained attention (Valentine & Sweet, 1999), attentional alerting and orienting (Bishop et al., 2004; Jha et al., 2007; Wenk-Sormaz, 2005), and mental and behavioural flexibility (Bishop et al., 2004; Wenk-Sormaz, 2005). Neuroimaging investigations have begun to elucidate the neural correlates of these behavioural changes, providing confirmation of the neuroplastic changes associated with meditation. In a recent such study using functional imaging methods, group differences were observed during meditation in a cross-sectional examination of novice, moderately practised, and expert meditators (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007). The authors reported a pattern of functional brain activation in brain regions typically associated with sustained attention, and the relationship between meditation expertise and activation followed an inverted U-shaped function. In activated regions – including areas of frontal-parietal cortex, hippocampus and primary visual cortices – moderately experienced meditators demonstrated greater brain activation than non-meditators. However, functional response was lowest in the *most* experienced meditators. The authors suggested that functional brain networks were initially over-activated, but became increasingly efficient and thereby less active, with extensive training.

Neuroimaging studies employing structural methods have also found measurable effects of meditation in healthy adults. In a seminal study, Lazar and colleagues (2005) observed increased cortical thickness in anterior insular regions in highly experienced meditators. The finding was subsequently replicated by Holzel et al. (2008), who additionally observed dose-dependent increases in grey matter density in the anterior insula (right side), as well as regions of left inferior temporal gyrus and right hippocampus. Anterior insular cortex has been associated with interoceptive awareness in numerous functional neuroimaging reports (Critchley, 2004). Thus, neuroplastic changes may be associated with the meditation practice of attending to endogenous body states, such as monitoring of breathing. Supporting this notion, Vestergaard-Poulsen et al. (2009) reported increased density of grey matter in brain stem areas associated with such endogenous states, including the medulla oblongata and reticular formation in experienced meditators relative to age-matched non-meditators.

Taken together, these findings from the meditation literature suggest that structural and functional neuroplastic changes underlie the specific behavioural gains associated with meditative practice, and moreover, that there is a dose-response effect. (Davidson, 2003; Lutz, Slagter, Dunne, & Davidson, 2008).

What are the implications of these findings for rehabilitation?

Benefits to rehabilitation depend in part upon the generalisability of these changes – namely measurable cognitive/emotional improvements outside of the meditation context. To date, the extent of transfer has yet to be clearly established. For example, Anderson, Lau, Segal, and Bishop (2007) enrolled participants in an eight-week meditation programme and found significant improvements in self-reports of emotional well-being relative to a waiting-list control group. Yet, on standard neuropsychological measures of attention, the authors observed no differences between the two groups. Similarly, McMillan, Robertson, Chorlton, and Brock (2002) found no significant improvements in attentional functioning in a sample of traumatically brain-injured subjects following a brief meditation intervention. These findings stand in contrast to reports of successful transfer (e.g., Jha, Krompinger, & Baime, 2007; Wenk-Sormaz, 2005; Valentine & Sweet, 1999). Thus, further research is needed to demonstrate the extent of generalised behavioural benefits from meditation. Studies employing both neuropsychological measures and more ecologically valid tools examining quality of life and community reintegration (in patient samples) would be of particular value for neurorehabilitation purposes.

While the behavioural benefits of meditation are as of yet unclear, examples of structural change associated with prophylactic benefits are compelling, albeit preliminary. Pagnoni and Cekic (2007) recently examined whether meditation moderated the impact of ageing on sustained attention performance and on grey matter volume. As expected, both sustained attention and grey matter volumes were inversely related to age in a group of healthy, non-meditators, consistent with previous findings in healthy ageing (Chao & Knight, 1997; Raz et al., 2005). However, in the meditation group, age-related correlations with attention and brain volume were not observed, suggesting that neuroplastic changes resulting from meditation practice may have provided a neuro-protective buffer against the impact of age-related cognitive decline and volume loss. The study was correlational and subjects were self-selected to group, however. Therefore, an alternative explanation for the findings in the Pagnoni and Cekic (2007) study, as the authors point out, is selection bias, with higher functioning and/or healthier individuals practising meditation. Thus, a replication of these important findings in a randomised control trial would be valuable.

To be of clinical utility, a number of practical questions regarding the structuring of a meditation intervention will need to be addressed. For example, can benefits be accrued over time-courses that are clinically practicable (e.g., weeks to months), and what is the optimum duration of meditation practice in minutes/day and total length of intervention that would produce clinically meaningful change? While early reports often examined expert meditators who had practised meditation over many years, some authors have demonstrated structural changes and behavioural improvements following short-duration training interventions (Draganski et al., 2004; Jha et al., 2007). A related question is whether people must continue to meditate to maintain any accrued benefits or whether neuroplastic changes are transient. To date, there appear to be no data speaking directly to this question. Studies examining maintenance of benefits after cessation of meditation would be of value, therefore.

Still another very important question is whether different types of meditation confer different outcomes. There are at least two broad schools of meditation: Concentrative meditation entails the selective focus on a single object of attention, such as respiration or a repetitive mantra, and has been the focus of several recent studies (Brefczynski-Lewis et al., 2007; Lazar et al., 2005; Pagnoni & Cekic, 2007). Open-awareness or open monitoring, in contrast, entails non-selective attention to all aspects of awareness, and the monitoring of one's attention in a non-directive, metacognitive way. Open-awareness meditation encompasses mindfulness-based stress reduction, which has received perhaps the most extensive empirical attention with respect to brain and behavioural change (Anderson et al., 2007; Farb et al., 2007; McMillan et al., 2002; and, see Lutz et al., 2008, for a full review of these meditation techniques). In our review of the literature, we were unable to uncover any reports directly comparing these approaches with respect to neuroplastic changes (but see Valentine & Sweet, 1999, for an early report contrasting the impacts of the techniques on sustained attention performance), and this will be an important future research direction.

Finally, we have discussed meditation largely in the context of the healthy brain. Research into the mechanisms by which meditation induces reorganisation, increases cortical thickness and improves behaviour in normal control models could help to determine whether and how meditation might be used ultimately as an intervention to promote recovery of damaged regions of the brain after injury or to slow degenerative processes that have already begun.

In sum

At this early stage of research, there have been no reports of harm caused by meditation, and clinical and anecdotal findings suggest an array of objectively measurable and subjectively experienced benefits. Further research is needed, however, to understand more fully the impact of meditation on behaviour outside of the meditation context, to determine the optimum content and structure of interventions and, to determine the potential benefits of meditation for neurological populations, whether deteriorating, recovering, or stable.

Acknowledgements

We wish to thank Brenda Colella and Le-Anh Ngo-Chiang for their valuable contributions to the manuscript.

REFERENCES

Anderson, N. D., Lau, M. A., Segal, Z. V., & Bishop, S. R. (2007). Mindfulness-based stress reduction and attentional control. *Clinical Psychology and Psychotherapy*, *14,* 449–463.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., et al. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, *11,* 230–241.

Brefczynski-Lewis, J. A., Lutz, A., Schaefer, H. S., Levinson, D. B., & Davidson, R. J. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. *Proceedings of the National Academy of Sciences*, *104*(27), 11483–11488.

Chao, L. L., & Knight, R. T. (1997). Prefrontal deficits in attention and inhibitory control with aging. *Cerebral Cortex*, *7*(1), 63–69.

Creswell, J. D., Way, B. M., Eisenberger, N. I., & Lieberman, M. D. (2007). Neural correlates of dispositional mindfulness during affect labeling. *Psychosomatic Medicine*, *69*(6), 560–565.

Critchley, H. D. (2004). The human cortex responds to an interoceptive challenge. *Proceedings of the National Academy of Sciences*, *101*(17), 6333–6334.

Davidson, R. J. (2003). Seven sins in the study of emotion: Correctives from affective neuroscience. *Brain & Cognition*, *52*(1), 129–132.

Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., & May, A. (2004). Neuroplasticity: Changes in grey matter induced by training. *Nature*, *427*(6972), 311–312.

Farb, N. A., Segal, Z. V., Mayberg, H., Bean, J., McKeon, D., Fatima, Z., et al. (2007). Attending to the present: Mindfulness meditation reveals distinct neural modes of self-reference. *Social Cognitive and Affective Neuroscience*, *2*(4), 313–322.

Holzel, B. K., Ott, U., Gard, T., Hempel, H., Weygandt, M., Morgen, K., et al. (2008). Investigation of mindfulness meditation practitioners with voxel-based morphometry. *Social Cognitive and Affective Neuroscience*, *3*(1), 55–61.

Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. *Cognitive, Affective, & Behavioral Neuroscience*, *7*(2), 109–119.

Lazar, S. W., Kerr, C. E., Wasserman, R. H., Gray, J. R., Greve, D. N., Treadway, M. T., et al. (2005). Meditation experience is associated with increased cortical thickness. *Neuroreport*, *16*(17), 1893–1897.

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, *12*(4), 163–169.

McMillan, T. M., Robertson, I. H., Chorlton, E., & Brock, D. (2002). Brief mindfulness meditation training for attentional problems after traumatic brain injury: A randomised control treatment trial. *Neuropsychological Rehabilitation*, *12,* 117–123.

Newberg, A. B., & Iverson, J. (2003). The neural basis of the complex mental task of meditation: Neurotransmitter and neurochemical considerations. *Medical Hypotheses*, *61*(2), 282–291.

Pagnoni, G., & Cekic, M. (2007). Age effects on gray matter volume and attentional performance in Zen meditation. *Neurobiology of Aging*, *28*(10), 1623–1627.

Raz, N., Lindenberger, U., Rodrigue, K. M., Kennedy, K. M., Head, D., Williamson, A., et al. (2005). Regional brain changes in aging healthy adults: General trends, individual differences and modifiers. *Cerebral Cortex*, *15*(11), 1676–1689.

Satz, P. (1993). Brain reserve capacity on symptom onset after brain injury: A formulation and review of evidence for threshold theory. *Neuropsychology*, *7*(3), 273–295.

Stern, Y. (2002). What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society*, *8*(3), 448–460.

Valentine, E. R., & Sweet, P. L. G. (1999). Meditation and attention: A comparison of the effects of concentrative and mindfulness meditation on sustained attention. *Mental Health, Religion & Culture*, *2*(1), 59–70.

Vestergaard-Poulsen, P., van Beek, M., Skewes, J., Bjarkam, C. R., Stubberup, M., Bertelsen, J., et al. (2009). Long-term meditation is associated with increased gray matter density in the brain stem. *Neuroreport*, *20*(2), 170–174.

Wenk-Sormaz, H. (2005). Meditation can reduce habitual responding. *Alternative Therapies in Health and Medicine*, *11*(2), 32–58.