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To cite this article: Kathrin Cohen Kadosh, Stephen Lisk & Jennifer Y. F. Lau (2016) The Ethics of (Neuro) Feeding Back to the Developing Brain, AJOB Neuroscience, 7:2, 132-133, DOI: 10.1080/21507740.2016.1189979

To link to this article: http://dx.doi.org/10.1080/21507740.2016.1189979

Published online: 18 Jul 2016.
The Ethics of (Neuro) Feeding Back to the Developing Brain

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The recent target article by Nakazawa and colleagues (2016) flags some important ethical issues concerning the use of real-time functional magnetic resonance neuroimaging-based neurofeedback (NF) for clinical intervention. We believe that there is one particular area of research where these ethical concerns are especially critical: with regard to using NF in the developing brain.

With recent advances in paediatric neuroimaging techniques, the imaging of the developing human brain has become a standard procedure—even among clinical groups where there may have been concerns about the acceptability of the scanning environment (Haddad et al. 2013). While this has led to a better appreciation of the substantial development of the human brain throughout the first two decades of life (Tamnes et al. 2013), little progress has been made in translating these insights into applicable interventions that might help make the most of a period of extended plasticity (Cohen Kadosh, Linden, and Lau 2013). We wholeheartedly agree with the authors that NF-based interventions are a welcome, additional intervention approach in a clinical setting. However, we also believe that pediatric NF, which has the potential to boost or interfere with the original establishment of cortical brain networks, faces unique challenges in pediatric populations. In the following, we focus on three main areas of NF: the use of instruction, sham feedback, and target areas, which should be carefully considered before extension into developmental samples.

WHAT IS THE BEST TASK INSTRUCTION?

Previous NF studies have varied as to whether participants were given explicit strategy instructions to regulate their brain responses or whether they had to figure this out on their own—with most opting for the latter (Paret et al. 2014), and only some patient studies suggesting the use of positive mental imagery (deCharms et al. 2005). In our recent study, which was the first to use NF to teach children and adolescents to increase the response in a key emotion regulation region, we asked participants “to think happy thoughts; to think about something that would make them happy” (Cohen Kadosh et al. 2016). The strategy was deliberately kept simple and relatively unconstrained, in order to allow participants across a wide age range (7–17 years) to perform well. Keeping instructions simple may also be important for patient populations, when ability levels to use different strategies are likely to vary significantly. However, we also found that while this instruction worked in the first instance, this lasted only for a couple of runs, with some participants failing to upregulate in the later runs. Understanding the motivational–contextual factors that modulate effective upregulation is crucial. Identifying individual differences in the use of different regulation strategies is also important if we want to enhance the effectiveness of these procedures. In fact, a collection of posttraining feedback across experiments may help us identify any trends in strategy formation/usage and inform us on the most appropriate task instructions to use. From an ethical point of view, we need also to consider whether constraining participants to just one cognitive strategy that might work in the short run and for a particular task may potentially interfere with flexible use of strategies later on. This is nontrivial, as it may very well be that different contexts rely on different strategies and it may be important for young people to keep flexible and to keep an open mind.

The number of trials needed to optimize a regulation strategy may also vary in a child population compared to adults. Too few trials may be detrimental to the formation of coherent and effective strategies. Additionally, ideal feedback delivery schedules may differ for this population; the increased cognitive load of receiving real-time feedback while attempting to learn/formulate a strategy could affect the consolidation of the strategy. Experimenting with delayed and/or intermittent feedback and its effects on strategy learning may allow us to better understand the ideal conditions for effective strategy development in pediatric populations.

IS SHAM FEEDBACK EVER HELPFUL?

In several previous studies, NF designs have also included a sham condition, where feedback is provided from a non-task-related brain region (deCharms et al. 2005; Zotev et al. 2011). Such an approach, while helpful for pinpointing the specificity of the feedback, is problematic in the context of...
pediatric samples. For example, it is difficult to estimate the ethical implications of incorrect or incoherent feedback, when our participants are trying to establish a strategy that works for them. For example, we would be concerned that inconsistent feedback might encourage participants to abandon an otherwise successful strategy, simply because the feedback does not seem to support using it. Similarly, given the developmental changes in recruitment patterns of different brain regions, it is likely that brain regions that are used at an earlier developmental stage are not be necessarily relevant at a later stage (Johnson, Grossmann, and Cohen Kadosh 2009; Johnson, Jones, and Gliga 2015). As a result of this, it would be extremely difficult to find a sham brain region that would support a comparable function at different ages. A possible solution for this problem could be to provide authentic feedback during the regulation conditions and to compare the regulation success against a “dry” regulation baseline (where feedback is not given). In addition, more research should be looking into the transfer effects of NF interventions, such as improvements in cognitive and mental abilities.

Which Regions Should Be Targeted—Current Supporters or Future Key Players?

This problem, which is similar to the task instruction question, is perhaps unique to pediatric populations, although it does apply to some extent also to clinical populations. That is, it is currently unclear whether we should teach our young participants to regulate the response in a brain region that is currently supporting a cognitive function, or whether we should instead teach them to use the correct, mature brain networks that support this ability in typical, mature adults. This may seem less trivial if we look at the developing brain as an adaptive system, where the networks of brain regions that support cognitive abilities change interactively as a result of ongoing brain maturation and cognitive development (Cohen Kadosh and Johnson 2007; Johnson, Grossmann, and Cohen Kadosh 2009). Hence, the temporary use of an alternative brain network during development can be considered both logical and adaptive, and it remains to be determined whether NF should target these current supporters instead of future players. This is also relevant for clinical populations, where brain networks may well have specialized in a different way that is most adaptive for the individual. In the latter case, the ethical implications of attempting to shape brain networks toward more typical functioning are particularly important to consider.

In sum, it is exciting to think that we could have at our hands a novel and effective tool to shape the responsiveness of the developing brain in childhood and adolescence. Developmental NF may help us to entrain helpful and adaptive brain responses and possibly avert maladaptive response patterns, especially in populations at risk of developing a psychological disorder. In addition, developmental NF could be used to preempt the manifestation of a behavioral disorder by exploring whether these developmental neural precursors can be changed. It can also easily accommodate individual differences that are due to differences in age, gender, or ability level and that are reflected in the activation of slightly different brain regions. Moreover, only functional magnetic resonance imaging (fMRI)-based NF will allow us to target individually tailored brain areas and networks, which once targeted are presumably more amenable to change. In sum, while it is currently not yet possible to answer conclusively how NF will eventually guide training programs, this nevertheless represents an exciting and potent research approach that can provide much insight into plasticity and changes in the developing brain.

Acknowledgments

This work was supported by the European Commission FP7 Braintrain grant (602186) (JL, KCK) and an MRC studentship (MR/K50130X/1) to SL.

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