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Review Article

Can functional magnetic resonance imaging studies help with the optimization of health messaging for lifestyle behavior change? A systematic review

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ABSTRACT

Unhealthy behaviors, including smoking, poor nutrition, excessive alcohol consumption, physical inactivity and sedentary lifestyles, are global risk factors for non-communicable diseases and premature death. Functional magnetic resonance imaging (fMRI) offers a unique approach to optimize health messages by examining how the brain responds to information relating to health. Our aim was to systematically review fMRI studies that have investigated variations in brain activation in response to health messages relating to (i) smoking; (ii) alcohol consumption; (iii) physical activity; (iv) diet; and (v) sedentary behavior. The electronic databases used were Medline/PubMed, Web of Science (Core Collection), PsychINFO, SPORTDiscuss, Cochrane Library and Open Grey. Studies were included if they investigated subjects aged ≥10 years and were published before January 2017. Of the 13,836 studies identified in the database search, 18 studies (smoking k = 15; diet k = 2; physical activity/sedentary behavior k = 1) were included in the review. The prefrontal cortex was activated in seven (47%) of the smoking-related studies and the physical activity study. Results suggest that activation of the ventromedial, dorsolateral and medial prefrontal cortex regions were predictive of subsequent behavior change following exposure to aversive anti-smoking stimuli. Studies investigating the neurological responses to anti-smoking material were most abundant. Of note, the prefrontal cortex and amygdala were most commonly activated in response to health messages across lifestyle behaviors. The review highlights an important disparity between research focusing on different lifestyle behaviors. Insights from smoking literature suggest fMRI may help to optimize health messaging in relation to other lifestyle behaviors.

Contents

Abbreviations: PSA, public service announcement; MRI, magnetic resonance imaging; fMRI, functional magnetic resonance imaging; NCD, non-communicable diseases; UK, United Kingdom; USA, United States of America; BOLD, blood oxygen level dependent; PRISMA, preferred reporting items for systematic reviews and meta-analyses; FDA, food and drug administration.

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1. Background

Non-communicable diseases (NCDs) such as cardiovascular disease, cancers and type 2 diabetes are reaching epidemic proportions; accounting for 60% of all deaths worldwide (Warburton et al., 2006). The onset of more than two thirds of all new NCD cases is widely attributed to four specific modifiable risk factors; smoking, excessive alcohol consumption, poor nutritional intake and physical inactivity (Beaglehole et al., 2011). The prevalence for each of these risk factors is staggering with one in five UK adults current cigarette smokers (Office for National Statistics, 2014), over 85,000 alcohol-related deaths annually (National Institute of Alcohol Abuse and Alcoholism, 2017), a rising global body mass index (NCD Risk Factor Collaboration, NCD-RisC, 2016) and only 5% of UK (Chaudhury and Esliger, 2008) and US (Troiano et al., 2008) adults achieving national guidelines. This highlights that effective interventions to promote healthy lifestyles are needed. One approach that has been widely used is public health messaging which has the important advantage of reaching whole populations.

Promoting lower sugar intake, increased regular physical activity (e.g. "Change4Life"), smoking cessation (e.g. "Smoke Free") and minimizing excessive alcohol consumption (e.g. "Know your limits") are common aims of public health campaigns. In addition to these campaigns, point-of-decision prompts (e.g. take the stairs) and on-product packaging (e.g. "Smoking Kills") also presents persuasive micro-level messages which can also reach a wide audience. In particular, pictures of tar-filled lungs and yellow teeth are now commonplace on cigarette packages (World Health Organisation, 2009). These prompts are attributed in part to the reductions in smoking prevalence (Emery et al., 2012; Wakefield et al., 2010). However, ensuring campaigns and the information or images provided are impactful and evidence-based is crucial when implementing these behavior change approaches (Latimer-Cheung et al., 2013). Therefore, to help ensure public health campaigns and point-of-decision prompts are given the greatest chance to succeed in changing behavior, it is important to assess how people respond to them.

Lifestyle behaviors are influenced not only by conscious choices (e.g. choosing to active commute to work) but also by subconscious responses to the environment and stimuli (e.g. emotional responses to a television advertisement or billboard). In order for a decision to be made by the brain, self-related processing must occur which involves the evaluation of environmental stimuli with regards to its personal relevance. Given this, neuroimaging can provide valuable insight into subconscious responses to stimuli by examining regions of the brain and levels of brain activation when individuals view health-related messages. These insights may then be used to bolster the persuasiveness of health messages (Nisbett and Wilson, 1977) and as a result, increase the likelihood of changing behavior (Kaye et al., 2016). Previous research has highlighted that regions within the medial prefrontal cortex of the brain are associated with self-related processing (Lieberman, 2010) with people subsequently reducing time spent sitting when activations within the ventromedial prefrontal cortex were observed (Falk et al., 2015). Predicting behavior change based on neural activity through fMRI offers an interesting brain-behavior link (Falk et al., 2011); highlighting the importance of optimizing the content of health messages as they have a direct effect on how people's brains engage with the health message and whether they ultimately change their behavior. By producing and disseminating health messages that activate brain regions linked with successful behavior change, health campaigns may have greater population-level success and be more cost-effective (Falk et al., 2011; Falk et al., 2010).

2. Methods

The present review aims to systematically review studies that have used fMRI to examine brain activity in response to health messages pertaining to physical activity, sedentary behavior, dietary intake, smoking and alcohol consumption. The aims of the review were to (i) examine stimuli content and modality; (ii) identify activated brain regions in response to stimuli presented and (iii) assess the capacity of fMRI results to predict behavior change. The protocol of this systematic review was developed in accordance with the PRISMA-P guidelines (Moher et al., 2015).

2.1. Search strategy

An electronic search was conducted using Medline/Pubmed; PsychINFO; SPORTDiscus; Web of Science (Core Collection); Cochrane Library; and Open Grey. The reference lists of included records were manually screened for identifying additional relevant records. The electronic database search was conducted on the 10th January 2017. The search strategy was identical across databases but the affiliation field was adjusted for each database (see Electronic Supplementary Material, Table 1). The search strategy used for all databases was: ("functional magnetic resonance imaging" OR "functional MRI" OR fMRI OR "blood oxygen level dependent" OR BOLD OR neuroimaging) AND (smoke* OR smoking OR cigarette OR tobacco OR alcohol OR drink OR "sedentary lifestyle" OR sedentary behavior* OR sedentar* OR sitting OR "physical activity" OR "physical inactivity" OR "activities of daily living" OR fitness OR exercise OR food OR snack OR diet OR eat OR eating OR calorie OR caloric OR campaign OR message OR messaging OR communication OR "mass media" OR PSA OR "public service announcement" OR graphic OR warning OR label OR image OR video).

2.2. Selection criteria and study selection

To be included, identified records had to meet the following criteria: (i) published in English prior to January 2017; (ii) involved human participants aged ≥10 years; (iii) investigated physical activity, sedentary