Neural Interface Technologies: the behavioural dimension

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With the proliferation of the use of smartphones and apps, has come the advent of the use of technology to drive behavioural change. The two predominant areas in which technology is being used to this effect are in wearable health trackers and smartphone apps. The technology is being used to target a wealth of health outcomes such as physical activity, diabetes and smoking, amongst others (McKay et al. 2018). While, in the case of many of these technologies, there has been much criticism based on the lack of hard evidence of a definable change in health markers (Helf & Hlavacs 2016), one cannot ignore the potential for these technologies to have a prolific effect on health outcomes in the future. Prior to using wearable trackers to monitor biological markers or activity level, the health biomarkers of people during their daily life were monitored through self-reporting. Unfortunately, self-reporting is notoriously unreliable (Prince et al. 2008). A meta-study that examined the relationship between direct measurements and self-reported physical activity found that there was no clear pattern in the difference between the two measures as some people over-estimated and some under-estimated their physical activity levels. However, the widespread use of smartphones and the ease of monitoring through wearables has resulted in the ability to capture quantitative data easily from a large population. With appropriate feedback measures, this can be used to provide information to shift behaviour in the user. This application shifts the locus of control in healthcare from the physician to the individual. The individual can obtain a plethora of information regarding their health biomarkers, in a simplified, accessible format. They can choose when to record the information, what information will be recorded, and who will have access to this information. It provides the individual with a higher degree of agency in the maintenance of their own health. Indeed, this increase in self-efficacy may be one of the key catalysts for the success of this approach in behavioural change. By empowering people to be in control of their own health, they are more likely to have greater motivation to take a more active role in their own healthcare.

Case Study: Nudgeomics

Behavioural change. It's hard. Unfulfilled new year's resolutions despite the best intentions, unsuccessful attempts at weight loss, despite reminders that obesity can radically reduce lifespan. The motivators range from the desirable, such as weight loss, to the imperative, such as cancer. Yet, producing sustainable change in habits remains elusive to many. As noted by Professor Dame Theresa Marteau: "if we ate and drank less, didn't smoke, and were physically more active, 40% of cancers and 75% of diabetes and cardiovascular disease would be avoided" (Marteau 2018). Behavioural change relies on the interplay of two fundamental processes based on dual-process theory (Kahneman 2003); reflective decision making and automatic

decision making. The reflective system requires conscious thought to make a decision, whereas the automatic system can make a decision without effort. People often load their reflective system with the weight of the behavioural change, committing will-power and discipline to brave through the transition to a new habit. Meanwhile, their automatic system is treated as a bystander, despite the fact that it can support behavioural change. For instance, the automatic system responds to a healthier diet with less sugar by having more energy and better sleep. However, the initial response of the automatic system is often sugar cravings, while the body adjusts to reduced spikes in glucose levels. Hence, while a person is making a behavioural change to healthier dietary habits, they are relying solely on their reflective system to manoeuvre through the tough parts. This system is heavily influenced by the transient state of mind at any given point of decision. However, what if a system was used that put weight on both the reflective and the automatic systems from the beginning? What if people used knowledge of their DNA characteristics to influence the decisions they make for their body? What if dietary advice was not so general and actually applied to the individual. And what if the behavioural change did not idealistically rely on people behaving like 'homo-economicus', but rather realistically assumed that as a humans, people often yield to irrational choices.

Nudgeomics is a concept that uses both the reflective and automatic systems. It was first introduced by Professor Chris Toumazou and Dr. Maria Karvela at the KMPG Innovation and Information Protection in Digital Health Conference, on 23 September 2016. Since then, it has been showcased in the World Economic Forum and the New Scientist. In one application, individuals take a saliva test that reveals distinctive characteristics of their DNA. This enables personalised dietary recommendations to be made, which if followed, may trigger a positive physiological response in terms of health and well-being. In other words, the process is designed to support the reflective system through the external nudge of the DNA-based dietary recommendations, and the automatic system by providing an internal nudge in the form of the body's response to following dietary patterns that are in line with one's DNA, together making behavioural change more effective (Figure 1 – right panel). When binary changes are relied on in behaviour, such as substituting a biscuit snack to grapes, efforts to change fail more often than not. This is approaching the change from a digital perspective, either the biscuit or the grapes, 0 or 1. The Nudgeomics approach recognises all the iterative changes that lie between the biscuit and the grapes, by providing more choices. Rather than jumping to the piece of fruit, it zones in on the small incremental change; perhaps a better biscuit? By making incremental small changes, it's possible to nudge people towards a healthier diet, all through providing easier choices. Nudgeomics is a new concept to understand how our biology can influence our decision-making, how our choices should be architected, and how we inherently may express desire or bias for a particular option. Fundamental to the concept of Nudgeomics is the idea that compliance and the perception of a recommendation for our actions is different when the authority comes from within the individual, rather than from an external body nudging them towards a preferred behaviour. Nudgeomics employs a gradual steer towards a better version of oneself, without limiting freedom and inherent desires. Recent meta-analysis on the influence of nudge theory on

dietary habits showed an average increase in healthier food choices of 15.3% as a result of nudge interventions (Arno & Thomas 2016).
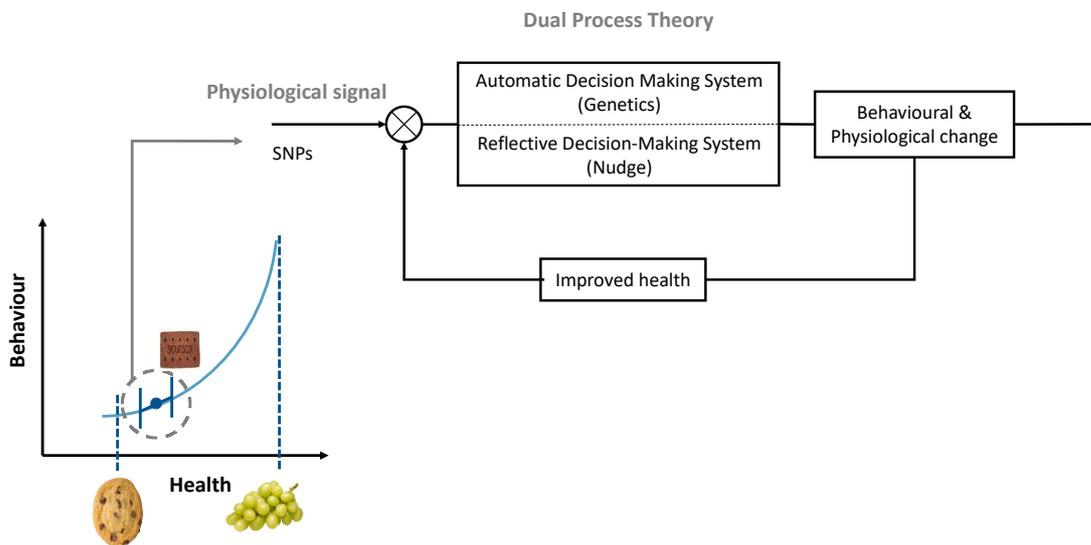

Figure 1: Left panel: Modelling behaviour as analogue health provides a more nuanced model than a binary model of change. For many, making the binary change of a biscuit to a piece of fruit will fail in times of craving. By providing more choices at each incremental point of decision across the curve through the Nudgeomics method, an individual can gradually iterate towards a healthy behaviour in an easier, more sustainable way. Right panel: The Nudgeomics region of the curve combines nudge theory and nutrigenetics to harness both aspects of the dual process theory of decision making. The physiological signal - ie - SNPs in the case of dietary changes, forms the input signal to determine the external nudge for DNA-based dietary recommendations (reflective decision making). It also influences the internal nudge of the body responding positively to foods that are eaten in line with the information encoded in the DNA (automatic decision making). A behavioural change that results in healthier dietary patterns may induce physiological change, which will provide a feedback system via improved health. This could be, for example, through improvement in macro-nutrient profiles, and reduced cravings.

Nudgeomics is a closed loop system that supports self-management and promotes healthy physiological change in the body with both an internal and external nudge. It uses the internal nudge of DNA (via SNPs), to inform the external nudge of DNA-based dietary guidelines. Rather than approaching behavioural change from a digital perspective, healthy choices are being compressed into a series of small incremental changes. The aim is to deliver this system on a global scale and, using the principles of nudge theory, guide people with a "DNA nudge" to make better choices, with the real potential to generate a profound and long-term impact on health and wellbeing.

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