Functional Digital Nudges: Identifying Optimal Timing for Effective Behavior Change

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ABSTRACT

Digital nudges hold enormous potential to change behavior. Despite the appeal to consider timing as a critical factor responsible for the success of digital nudges, a comprehensive organizing framework to guide the design of digital nudges considering nudge moment is yet to be provided. In this paper, we advance the theoretical model to design digital nudges by incorporating three key components: (1) Identifying the optimal digital nudge moment (2) Inferring this optimal moment and (3) Delivering the digital nudge at that moment. We further discuss the existing work and open research avenues.

INTRODUCTION

Thaler and Sunstein [24] suggested that policymakers can design nudges to promote change in behavior among citizens. They defined a nudge as "any aspect of the architecture of choice that changes people's behavior in a way predictable without prohibiting all options or significantly changing their incentives" [24]. Nudges assist in modifying the behavior by changing the way we see things and making a person more sensitive to one option [13]. Consumers accept nudges because they retain their freedom of choice [19]. Exhibiting the low-cost advantage with the potentiality to shape behavior [12],

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KEYWORDS Timing; Digital Nudge; Behavioral change interventions; Nudge moment

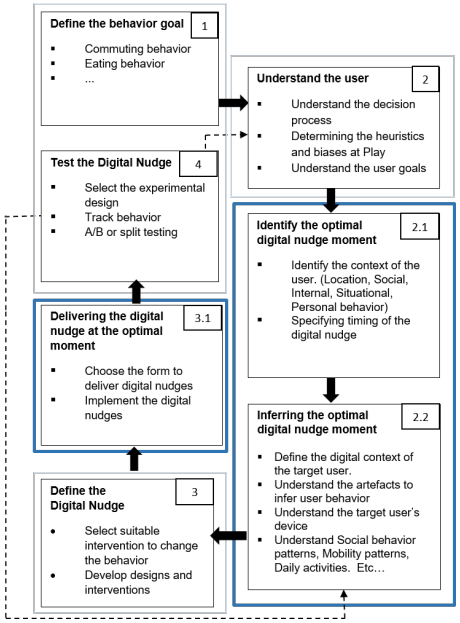

Figure 1: A theoretical model for designing digital nudges for behavior change. Components 1,2,3,4 - from the existing theoretical model by Schneider et al. [20]. Components 2.1, 2.2, 3.1 - added to advance the theoretical framework

government organizations have successfully used nudges in public wellness campaigns [25], such as promoting smoking cessation [5], influencing food choices [28], or promoting pro-environmental consumption behavior [1].

The omnipresence of mobile devices with online communication has enabled the creation of *digital nudges* [3]. These digital nudges use online technologies such as SMS, notifications, mobile applications, and gamification to encourage people to act in the desired way. Research shows that digital nudges can have propelling effect on behavior and influence decisions of the individual [17]. An example of such a nudge is the gamification of physical activity by providing mobile application users with badges and points when they reach specific goals to increase physical activity [2].

However, the success of the receptivity of nudges has shown to be varying depending on their timing [6]. Deploying early nudges could lead to forgetfulness and provision of late nudges could shrink the time available for action [21]. Even though this issue has been raised, identifying the appropriate time to turn a potential digital nudge into what we call a *functional digital nudge*, that is a digital nudge that can effectively change behavior, is mainly an unresolved issue [16]. In this paper, we advocate for the investigation of this issue and propose open research avenues.

DESIGNING FUNCTIONAL DIGITAL NUDGES

Schneider et al. [20] provided a general framework for designing digital nudges. The design process proposed to design digital nudges was similar to the systems development cycle (planning, analysis, design, implementation) - see Figure 1. Step 1 in the cycle was to define the goal - Investigating the organization's goal (e.g., increasing sales, increasing pledges). Step 2 was to understand and recognize user heuristic and biases (availability heuristic, representativeness heuristic). Step 3 was concerned about designing the nudges and Step 4 dealt with testing the nudges. Assessing the significance of the timing of digital nudges, we propose to extend this framework by including three additional components : (1) Step 2.1 identifying the optimal digital nudge moment (2) Step 2.2 inferring the optimal digital nudge moment (3) Step 3.1 delivering the digital nudge at the optimal moment.

IDENTIFYING THE OPTIMAL DIGITAL NUDGE MOMENT (2.1)

In health education research, McBride, Emmons, and Lipkus [14] introduced the notion of *teachable moments* to motivate individuals to change their behavior. A teachable moment has been described as "naturally occurring health events thought to motivate individuals to adopt risk-reducing health behaviors spontaneously." For example, An intervention for smoking cessation for women could be appropriate during the perinatal period [18]. Sunstein mentioned that timing matters for reminder type nudges [23]. For Instance, in an offline setting, Sinning and Gillitzer [21] presented theoretical and empirical evidence on how different timings of nudges had an impact on tax payments. However, the specific payment behavior was investigated in a field experiment using a simple reminder letter

Table 1: Significance of Timing for various digital nudges

Type of digital nudge	Sig.	Delivery Medium
Provision of Information[9]	High	PDA$_{(1)}$
Feedback[4]	High	Mandometer$_{(2)}$
Reminder[8]	High	Mobile Phone$_{(3)}$
Default[10]	Low	Email$_{(4)}$
Game rewards[26]	High	Games$_{(5)}$

Associated goals :
(1) - Better dietary decision making
(2) - Normalize eating behavior
(3) - Increase payment of court fines
(4) - Increase web survey participation
(5) - Create sense of value and accomplishment

Classification of nudge moments	
Categorization	**Dimensions**
Location context	Location, Address, Proximity with non-living things, mobility patterns
Social context	Proximity to living beings, social interactions, etc.
Internal context	Heart rate, moods, emotions, mental health, well-being, etc.
Situational context	Date, Weather, Time, Any event
Personal behavior	Smoking, eating, sleeping, waking up, running, etc.

Figure 2: Classification of nudge moments

and suggested to use early reminders. Nevertheless, this study was confined to tax payment behavior and did not identify a specific nudging sweet spot. From the literature, we grasp the importance of timing to the success of digital nudges beyond reminders. Table 1 presents studies indicating how significant the timing is for various digital nudges.

The studies selected are from diverse disciplines like Information systems, Medical research, Policy Analysis, and Digital games. Besides the research by Intille et al. [9] that concentrated on "Just-in-Time" technology, other studies do not explicitly work on adapting digital nudges with timing. Nevertheless, we infer from studies the importance of timing digital nudges to achieve the goal. For instance, to motivate an incremental dietary behavior change, Intille et al. [9] proposed that the information should be provisioned on a PDA (personal digital assistant) when the user was at the point of purchase (nudge moment). Another study investigated how to modify eating behavior for weight loss in obese adolescents [4]. The researchers provided participants with real-time feedback during meals (nudge moment) to slow down their eating speed.

Open research avenues. In recent work, Meske and Potthoff [16] argued that the timing of nudge is an essential aspect of persuasion and present nudging tools are missing this crucial facet. Furthermore, it is still unclear to which behaviors timing of digital nudges is indispensable. Understanding optimal timing will lead to the identification of *nudge moments*. To simplify the understanding of the nudge moments, we have inferred various contexts from communication studies and classified them as potential dimensions of nudge moments in five categories (Figure 2). A nudge moment can include one or more of these dimensions. For each moment, the nudge could be timed before, during, or after it occurs. Digital nudge designers should implement validation techniques to validate the effectiveness of the digital nudges at different times.

Example scenario. Imagine Tom, a 22-year-old design major. Tom agonizes with his increasing weight. His doctor has suggested maintaining a healthy diet by increasing protein intake and reducing carbohydrates. A nudge moments can be the moment right before Tom decides where to eat at lunch to nudge his restaurant choice to a better option. Another moment would then be right when he receives the menu in a restaurant to nudge his choice to a healthier option. This moment would have a combination of location context (a restaurant), situational context (lunchtime, after entering the restaurant), and behavioral context (sitting down, having received the menu).

INFERRING THE OPTIMAL DIGITAL NUDGE MOMENT (2.2)

Inferring the timing for the digital nudge implies that designers understand the digital context of the target user concerning software and hardware. As digital devices have become an intrinsic part of our lives, mobile sensing technologies can be employed to interpret user behavior. The mobile phones equipped with sensors can record sociability and mobility behaviors [7]. In a study by Mehl,

Forms to deliver digital nudges	Requisite proximity with the device
Push notifications, SMS	At hand
Vibration, Ringtone	Within reach
In-App notifications	In use
Digital badges	In use
Ambient light/ LED Notifications'	Within reach

Figure 3: Proximity of device with user concerning various forms to deliver digital nudges

Gosling and Pennebaker [15], an Electronically Activated Recorder (EAR) was used to infer users social interaction, daily activities, and mobility patterns. Similarly, Wang et al. [27], inferred the studying behavior of the students using combinations of mobile sensing technologies. For instance, a Microphone to determine if the environment was noisy or silent. An accelerometer can be used to ascertain if the phone is in activity by the user. GPS and WiFi data to ascertain if the student was in the library or study area. Inferring time of the day is trivial for any digital device. However, inferring past/current or future activity as well as context can be challenging. Sensors can help identify certain behaviors, such as sleeping or running, and particular contexts, such as location.

Open research avenues. Using smartphone sensing, researchers have overcome the challenges of traditional methods of inferring behavior. However, it is still a challenge to monitor behavior patterns throughout a day across wide-ranging components of behavioral science. Another research avenue should further investigate how to combine different sensor technologies to operate as behavioral predictors and infer the behavior of user post-intervention. At the same time, the data required for predicting and inferring behaviors should be minimized as privacy is a significant concern.

Example scenario. In the case of Tom, the location context (inside a restaurant) can be inferred with GPS, the situational context (lunchtime, after entering the restaurant) with a clock and a timer, and the behavioral context (sitting down) with a gyroscope and accelerometer. All these sensors are part of any smartphone. However inferring the exact moment when Tom is about to decide what to eat is not trivial (e.g., after receiving the menu). One could imagine that this could be inferred using an RFID chip in the menu which would be activated when Tom is nearby.

DELIVERING THE DIGITAL NUDGE AT THE OPTIMAL MOMENT (3.1)

After inferring the nudge moments, it is crucial to identify a suitable digital form for the delivery of digital nudges. Today various digital devices like smartphones [11] and fitness trackers [22] can leverage digital nudges to steer people in a particular direction using delivery methods such as sound and vibration notifications. Furthermore, user interfaces use banners, badges and other visible icons to draw user attention online. It should be noted that the delivery mode is not limited to personal devices and can include connected and ambient objects (e.g., lights, public displays, connected fridges).

Open research avenues. Even though many delivery methods exist, the form in which digital nudge is most useful for a particular behavior needs further investigation. For instance, In which form will the feedback nudge be most effective on various devices for commuting behavior, through push notification, vibration or text SMS? An understanding of the most effective form of delivery for various digital nudge types for target behaviors will assist in reducing the attempts of trial and error and save the time of nudge designers. In Figure 3, we identify that special attention is needed to be given to the

device's proximity to the self when choosing different forms to deliver digital nudges. In particular, research should investigate unorthodox delivery methods through connected objects which are bound to become more and more present in our homes, cars, and cities.

Example Scenario. In Tom's example, the digital nudge could be to gamify his food consumption by allowing him to track his food intake habits and set his goals. This nudge can be delivered directly through a push notification on his phone when he is about to order. The notification could direct him to his food tracking app. If the menu itself was a connected tablet, it could directly show how each option would affect Tom's score.

CONCLUSION

Digital technologies can harness the power of nudges by making them a useful tool for behavior change. It is important to identify favorable timing of digital nudges by taking advantage of mobile devices and online communication. In this paper, we attempted to provide a framework that could assist in designing timely functional digital nudges and a roadmap of open questions that still need to be addressed. It is relevant to note that the success of several digital nudges relies on their timely delivery. Future research can consider the open research avenues presented in this paper, imparting us with a temporal sweet spot for digital nudging.

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