The Nudge Deck: A Design Support Tool for Technology-Mediated Nudging

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ABSTRACT
The idea of *nudging* - that subtle changes in the ’choice architecture’ can alter people’s behaviors in predictable ways - was eagerly adopted by HCI researchers and practitioners over the past decade. Yet, the design of effective nudging interventions is far from trivial, with theoretical knowledge being unstructured, with over a hundred cognitive biases found online, and inaccessible to practitioners during design meetings. We present the design and evaluation of the *Nudge Deck*, a card-based, design support tool that provides actionable knowledge for the design of technology-mediated nudges. The tool was evaluated through two case studies where 58 participants were asked to design nudging interventions, in the contexts of physical activity promotion and misinformation mitigation, with and without the cards. We report on how the cards enhanced designers’ self-efficacy, and led to more theoretically grounded, creative and appropriate for the context, ideas.

Author Keywords
Nudging; Behavior Change; Persuasive Technology;

CCS Concepts
•**Human-centered computing** → User studies;

INTRODUCTION
Eleven years ago, Thaler and Sunstein [48] introduced the idea of *nudging*, defining nudges as *“any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any option or significantly changing their economic incentives”*. Leveraging knowledge from the field of Behavioral Economics about how people make decisions, and in particular, how decision-making may deviate from rationality, nudges attempt to re-arrange choices in a way that guides individuals to desired ones [48]. For instance, replacing cake with healthier items at the cash register has been shown to increase the likelihood of healthy item selection [48].

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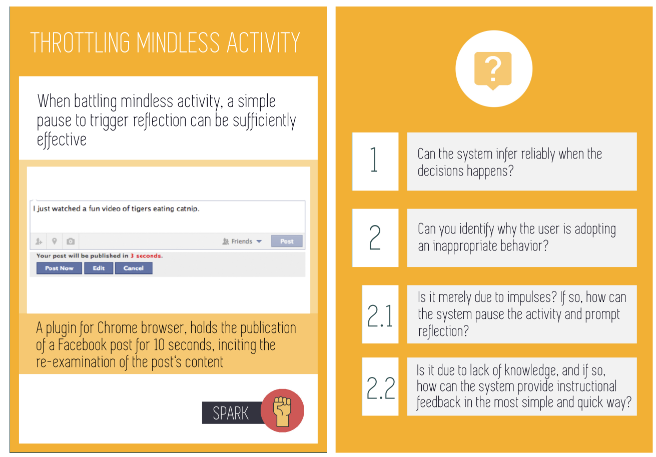

Figure 1. One of the 23 mechanisms present in the Nudge Deck, called “Throttling mindless activity”. The front side of the card (left) provides a definition of the mechanism and an illustrated example. The back side (right) lists design considerations that can trigger discussion and reflection among team members.

The idea of nudging was eagerly adopted in Human-Computer Interaction (HCI) across different domains, including health, sustainability, and privacy (see [12] for a review). Nudging offers an alternative to the *information-centric* approach dominating the design of behavior change technologies (c.f. [34, 1]). This approach assumes that people lack the knowledge in order to successfully implement changes in their behaviors, and the role of the tool is to support them in logging, reviewing and reflecting upon their behaviors. With recent research raising skepticism on the idea that knowledge alone can drive behavior change [3, 22], nudging has become an important additional technique in the repertoire of interaction designers.

However, designing effective nudging interventions is far from trivial. First, with over a hundred cognitive biases found online, identifying which of them, and how they relate to a particular decision context, can be challenging [20, 50]. Secondly, even when one has identified a cognitive bias that is prevalent in a certain decision context, translating this to concrete nudging interventions is not straightforward [12]. As a result, recent frameworks have attempted to structure theoretical knowledge around the *why* of nudging (i.e., which cognitive biases can nudges combat) [20, 50, 39], as well as the *how* of nudging (i.e., what exact mechanisms can nudges employ to incur behavior change) [12]. Third, even when theoretical frameworks are available, these are often found to be inaccessible by practitioners, and in particular, during design meetings, due to being lengthy, dense, complex, and presented in a way that does not support the design process [15, 11]. As a result, designers often fail to understand and take advantage of behavioral theory, as evidenced by recent reviews that have shown the majority of behavior change mhealth apps to lack theoretical content [17, 4, 16].

One way to make theory accessible during the design process is through *design cards*. Acknowledged as effective *"knowledge transfer vehicles"* [19], design cards are able to provide step-by-step guidance and allow designers to quickly review content and take decisions that secure a solid design flow [33, 52]. Building on prior work on design cards, we designed the *Nudge Deck*, a card-based design support tool for the implementation of nudging interventions. The *Nudge Deck* is grounded on our *23 Ways to Nudge* framework [12], which lays out the design space of technology-mediated nudging, in the form 23 mechanisms of nudging, grouped in 6 categories, and tapping to 15 different cognitive biases.

In this paper we first present how we translated the *23 Ways to Nudge* framework into the *Nudge Deck*. Then we present two case studies that explored the efficacy of the Nudge Deck as a design support tool in two contexts: physical activity promotion and misinformation mitigation.

BACKGROUND

Dual process Theories of Decision Making

For years, researchers in the field of economics have worked on the assumption that humans are rational actors - willing to examine every choice alternative, to assess its value and select the alternative that provides the best outcome. And, when they occasionally fail to choose the optimal outcome, they learn from their mistakes and adjust their behaviors accordingly [10]. Simon [45] introduced the notion of *bounded rationality*, suggesting that our ability to make rational decisions is limited by the cognitive resources and time to make the decision that are available to us at a given time.

A number of, so-called, dual process theories of decision making (see [30, 46]) were later developed, with the goal of providing an account of decision making that takes into consideration the notion of bounded rationality. While differing in their details, these theories broadly suggest that decision-making happens through the interaction of two modes of thinking: the *automatic* and the *reflective* [30]. The *automatic* is the principal mode of thinking. It is instinctive, emotional and operates unconsciously making decisions quickly and effortlessly by evaluating options through associative inferences (i.e. using heuristics). The reflective, in turn, makes decisions through a knowledge-based process. It is rational and conscious and as a result, it is slower and effortful.

It is estimated that 95% of our daily decisions are driven by the automatic mode of thinking [43]. One example is our use of *heuristics* - mental shortcuts that allow us to substitute information that is hard to access by an available cue in the environment that is likely to produce an accurate judgment. While heuristics help us in simplifying decision making under conditions of information overload, they also make as susceptible to *cognitive biases* - systematic deviations from rational thinking. Take as an example the *status-quo bias*, which denotes our tendency to avoid effort and resist to change. This bias lead us to adopt the path of least resistance (e.g., to select the default option, rather than considering the alternatives). For instance, countries that implement an opt-in organ donation policy have a donation rate of about 15%, while for countries with an opt-out policy (where the default option is to donate, from which citizens may opt-out), the rate is 80%.

Nudging

Thaler and Sunstein [48] introduced the concept of nudging to suggest that we can leverage our knowledge about cognitive biases to influence behavior in a positive direction. Within HCI, researchers have eagerly adopted the idea of nudging to promote healthy behaviors [34, 24], to protect users from unintended disclosures on social media [49], to encourage users to reflect on their privacy settings when installing mobile apps [27], and to encourage safer password selection [31], among others (see [12] for a review).

Given the wide abundance of cognitive biases, researchers have attempted to devise frameworks that structure biases in different categories and provide examples of how cognitive biases can be mitigated through nudging. For instance, Hansen & Jespersen [26] classified nudges in four categories based on the mode of thinking they attempt to engage (i.e. automatic vs. reflective) and whether their intention and means they employ to incur behavior change are transparent to the user. Dolan et al. [20] proposed the *Mindspace* framework which summarizes nine effective behavioral influences in the Mindspace mnemonic (Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitment and Ego), while Schneider et al. [44] attempted to link cognitive biases to the type of choice, being binary, discrete or continuous, and the different user interface elements that can be employed, such as radio buttons, check boxes and drop-down menus.

In prior work [12], we observed that while there is ample discussion on the *why* of nudging (*i.e.*, which cognitive biases can nudges combat), knowledge on the *how* of nudging (i.e., what exact mechanisms can nudges employ to incur behavior change) is limited. Through a review of the use of nudging in HCI literature, we identified 23 distinct mechanisms of nudging, such as making one choice among a set the default, rearranging the positioning of choices, hiding undesirable choices, or suggesting alternatives, among others. Our work translates the *"23 ways to nudge"* framework, which is elaborated in the next section, to a set of design cards.

Supporting Design Practices through Design Cards

An approach to making conceptual knowledge accessible during design practice is the use of design cards [19, 7]. In the context of behavior change, Colusso et al. [15] developed the *Behavior Change Design Sprint*, a design process that supports the design of effective behavior change technologies through a set of sprint deployments. The researchers translated behavior change theories to cards and found that the tool was able to facilitate the application of behavior change theories into design, facilitated focused ideation and supported argumentation around design decisions. Konstanti et al. [32] developed the Behavior Change Design (BCD) cards, that combine two widely adopted theoretical models: the Transtheoretical Model of Behavior Change (TTM) [42] and the Behavior Change Techniques (BCT) taxonomy [38]. The *Behavior Change Strategy Cards* [41] summarize insights from behavioral economics and cognitive psychology to assist designers in creating effective behavior change interventions. Finally, Lockton et al. [36] developed the *Design with Intent* tool, a set of 101 design cards that illustrates diverse examples of artifacts and environments that influence people's behaviors.

Beyond the immediate context of behavior change technologies, design cards have have been widely adopted in interaction design research and practice. For instance, Lucero and Arrasvuori [37] created the *PLEX* cards that communicate the 22 categories of the Playful Experiences framework, while Deng et al. [19] created the *Tango Cards* to assist the design of tangible learning games by providing examples and design considerations on three different dimensions: tangibility, games and learning. Bekker and Antle [8] developed cards to inform designers about children's cognitive, physical, emotional and social behavior at different ages and support the design of developmentally appropriate technologies. Halskov and Dalsgard [25] created the *Inspiration Cards* to support designers by bringing multiple sources of inspiration into the design process.

All in all, design cards have been found to bring a number benefits to the design process. They support designers in situating their design efforts, in understanding users and the context of use, they facilitate ideation and knowledge acquisition, they support collaborative work, and they support the evaluation and refinement of ideas as they emerge. We elaborate on these points in more detail below:

Design cards can help in *understanding users and the context of use*. Lucero et al. [37] and Bekker and Antle [8], found that providing designers with information about children's abilities at different ages, or the different forms of playfullness in users' experience with interactive products, supported user-centered design practice by enabling a finer characterization of the user and the context of use.

Cards *facilitate knowledge acquisition and ideation*. By serving as a source of inspiration, design cards support divergence during ideation [8, 19, 28, 37]. The constraints induced by the physical form of the cards, enforces card designers to *summarize information in a digestible manner*. Cards can also act as *tangible references* - designers can shuffle them, combine them, or point at them as they jointly think of new ideas [19]. They can also be used as an *anchor of discussion* [19], or to "bookmark ideas", and to guide their line of thinking [19, 28].

Design cards are also helpful in *supporting collaboration*. Deng and Hornecker [19, 28] observed that presenting succinct information in the cards (e.g., brief titles), *allowed designers to acquire a common language* and *structure design discussions*. By enabling designers to share an understanding of the content, cards facilitate discussion, turn-taking and the exchange of ideas between team members [19, 28].

Cards can also help designers *in evaluating and refining ideas* as they emerge. The provision of questions and design guidelines helps designers to identify constraints, enables them to validate if they are on the right track, to reveal details missing in their ideas, or to consider trade-offs of different ideas [8].

THE DEVELOPMENT OF THE NUDGE DECK

In the following section we describe the creation of the Nudge Deck. We first present the "23 ways to nudge" framework which formed the basis of the Nudge Deck, and then describe how we translated the framework into a set of design cards.

The '23 ways to nudge' framework

The *"23 ways to nudge"* framework, that we presented earlier in Caraban et al. [12], was derived out of a systematic review of the use of nudging in HCI research over the past 10 years. Our objectives was to layout the design space of technology-mediated nudging, by linking the *why* (i.e., which cognitive biases do nudges combat) with the *how* (i.e., what exact mechanisms do nudges employ to incur behavior change). We identified 71 papers that present technology-mediated nudges and identified, through our analysis, *23 distinct mechanisms of nudging*, grouped in 6 categories (see fig.2), and leveraging 15 different cognitive biases or heuristics.

To provide an example, the *availability heuristic* reflects our tendency to judge the probability of occurrence of an event based on the ease at which it can be recalled. As a result, we might overestimate the probability of events when they are readily available to our cognitive processing (*e.g.*, judging higher than the actual probability of cancer when detecting a lump in our body) while we might be overly optimistic when these events are distant. One approach to battle the availability heuristic is to *prompt users to reflect on the consequences* of their action (nudge mechanism). For instance, Harbach et al. [27] redesigned the permissions dialogue of the Google Play Store to incorporate personalized scenarios that disclosed potential risks from excessive app permissions. If the app required access to one's storage, the system would randomly select images stored on the phone along with the message *"this app can see and delete your photos"*. Similarly, Wang et al. [49] designed a web-plugin that aims at mitigating impulsive disclosures on social media through reminding users of the audience. The system selects five random contacts from the user's friend list, according to the post's privacy settings, and presents the contacts' profile picture along the message *"These people and [X] more can see this"*.

All in all, the 23 mechanisms of nudging are clustered in the following six overall categories (see fig. 2): *facilitate* - nudges that reduce the (physical or mental) effort required for an activity, in order to motivate people to pursue it; *confront* – nudges that attempt to pause an unwanted action by instilling doubt, with the goal of breaking mindless behavior and prompting a reflective choice; *deceive* – nudges that use deception mechanisms in order to affect how alternatives are perceived, or how activities are experienced, with the goal of promoting particular outcomes; *social influence* – nudges that take advantage of people's desire to conform and comply with what is believed to be expected from them; *reinforce* – nudges that attempt to reinforce behaviors through increasing their presence in individuals' thinking; and, *fear* – nudges that evoke feelings of fear, loss and uncertainty to make the user pursue an activity.

Figure 2. The 23 mechanisms of nudging are clustered into 6 categories. Category cards list the mechanisms that belong within each category, and are color-coded to facilitate mapping the mechanisms to categories.

Transforming the framework into design cards

For the development of the Nudge Deck, we adopted the following process suggested by Mueller et al. [40]:

Establish target boundaries

Following Sutcliffe's [47] requirements for making theoretical knowledge applicable in design, we *concealed the complexity of theory from designers* by omitting information on *heuristics* and *cognitive biases* relevant to each nudge mechanism. We did so because we found examples along with mechanisms' definitions to describe sufficiently nudges' rationale. Furthermore, we *generalized the content* to be usable in a wider range of contexts; we kept merely one example per mechanism and selected the example that provided the most intuitive and descriptive image while not implying a specific use. All in all, we aimed at creating cards able to provide inspiration, support requirements elicitation and help designers to identify the constraints and tradeoffs of each nudge mechanism.

Reduce Items

We limited the number of cards so that designers would not feel overwhelmed. A max of four design considerations were presented on the back side of each mechanism card (fig. 2).

Visualize

We gave each mechanism a descriptive title, definition and illustrated example and followed the same rationale for triggers.

Incorporate feedback

We organized a formative evaluation of the first version of the cards with three experts, senior PhD students in Digital Media, all with a post-graduate degree in Human-Computer Interaction. Experts first joined a design workshop where we observed how they used the cards, followed by a focus group where they elaborated on their experience using the cards and offered their feedback regarding their redesign. We elicited feedback on the visual appearance of the cards, the content and its presentation (e.g., highlighted areas of interest, minimizing content, condensing and clarifying descriptions, changing wording). We refined the cards based on experts' input, which helped making the information easier to understand and the cards better designed to support knowledge transfer.

The Nudge Deck

The current version of the Nudge Deck consists of twenty-three mechanism cards, six category cards and three trigger cards, making a total of 32 double-sided cards, described below. A digital copy of the Nudge Deck can be accessed at http://persuasive.cut.ac.cy/nudgedeck and a printed version will become available for order through the same website.

Mechanism cards

Mechanism cards (see figure 1), describe the 23 nudge mechanisms proposed by the framework. The front-side of each card presents the name of the mechanism along with a description, and one example presented through a picture and text. The back-side of the card lists design considerations: questions, hints and suggestions that can trigger discussion within the design team and promote creative design thinking.

Category cards

Category cards represent the six nudge categories – *Facilitate, Confront, Deceive, Social Influence, Fear and Reinforce* – color-coded to simplify their recognition (see fig. 2). Each of the 23 nudge mechanisms is clustered into one of these six categories (see [12] for more information on this classification). To facilitate mapping mechanisms to categories, mechanism cards use the same background color with the nudge category they belong to.

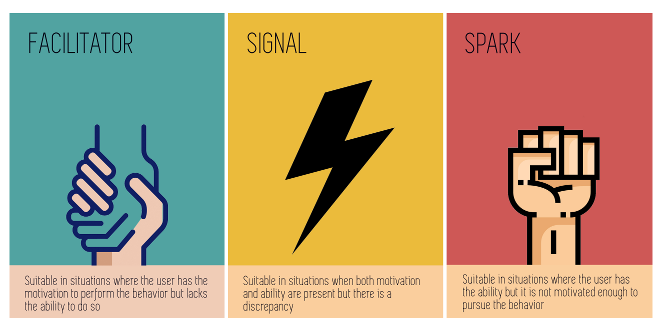

Figure 3. Trigger cards provide a brief definition along with an icon that aims to support their identification in the mechanism cards.

Trigger cards

Leveraging Fogg's Behavior Model [21], trigger cards identify three types of triggers: *Facilitators* (*i.e.*, strategies that aim to increase people's ability to perform a behavior), *Sparks* (*i.e.*, strategies that aim to increase people's motivation to perform the behavior) and *Signals* (*i.e.*, strategies that aim to remind of the behavior that should be pursued). These cards aim to help designers distinguish which types of nudge mechanisms are more appropriate in a given situation (see Figure 3). Each of the 23 mechanisms is mapped to one of the three triggers (see [12] for more information on this mapping), and highlighted on the front-side of the mechanism cards (see fig. 1).

CASE STUDIES

With the goal of assessing the efficacy of the Nudge Deck in supporting design teams when designing nudging interventions, we conducted two case studies, one in the context of *physical activity promotion* and one in the context of *misinformation mitigation*. Our studies aimed at addressing the following research questions:

A. How does the Nudge Deck influence the design activity? Through observation and post-session interviews with participants, we will attempt to inquire into the roles that the cards serve, and the benefits that they bring to the design process.

B. How does the Nudge Deck influence participants' experience of the design activity? We expect the *Nudge Deck* to enhance participants' *self-efficacy* beliefs for the design of nudging interventions. By presenting nudging techniques along with their constraints, cards should support designers in formulating a set of refined solutions, which should increase their perceived ability in designing informed nudging interventions. We also expect the Nudge Deck to increase participants' *experienced creativity* through supporting ideation, minimizing the likelihood of design fixation and supporting discussion between team members, which should translate to participants feeling more creative during the design session. Finally, we expect participants to judge the Nudge Deck as a *useful* and *easy to use* tool as it provides actionable knowledge in a digestible form, and provides a structure to the design activity.

C. How does the Nudge Deck influence the quality of ideas? We expect that the Nudge Deck will make participants better able to devise ideas that are *theoretically grounded*, as it provides access to intervention mechanisms and associated theoretical constructs. In turn, we expect those ideas to display stronger *fitness to the context of use*, due to the increased access to alternative approaches to changing individuals' behaviors. Finally, we expect those ideas to be more *creative*, as prior work has demonstrated that design cards are able to foster divergent thinking, which has been linked to the creativity of the outcome [37, 28].

Participants

A total of 29 students (14 male; 15 female; median age = 29) joined each case study. Participants were first exposed to case study 1 (physical activity) and following two weeks were recruited for case study 2 (misinformation). All participants had background in Human-Computer Interaction and were graduate students, either at PhD or Masters level, in Digital Media, Graphic Design, or Computer Science. The same 15 participants were assigned to the experimental condition in both studies, while the remaining 14 were assigned to the control condition. Most participants reported having prior exposure to behavior change theories. When asked to assess their self-efficacy beliefs around the design of technologies for behavior change, prior to engaging with the design task, participants self-reported an average of 57 on 100-point scale.

Study design and procedure

We employed a simple between-subjects design with two conditions: *experimental* (using the nudge deck) and *control* (without the nudge deck). Participants were grouped in teams of three to four members. In both conditions, participants were first introduced to the definition of nudging along with three examples of technology-mediated nudges, retrieved from the "23 Ways to Nudge" framework [12]. Participants were then provided with a design brief (see Appendix A), asked to sketch out their idea in a provided template (see Appendix A) and instructed to include descriptions on their sketches. Participants in the experimental condition were told to explore the cards until finding a card or a combination they might want to use during the design task. All participants worked on the design task for 40 to 60 minutes, until they could no longer come up with new ideas or the 60 min interval elapsed. After the design session was over, participants were asked to individually document their concept and its design rationale. Finally, the completed a set of questionnaires and joined in an interview with all their team members.

Measures & data elicitation

To address our research questions, we triangulated data from questionnaires, observation, interviews and the documentation of the concepts and their design rationales.

Semi-structured Interview

In order to gain an understanding on how the cards assisted the design activity, we complemented the observation of design activities with a semi-structured exit interview. Prior work has shown different ways in which design cards are used, such as creating personas, for brainstorming, as part of requirements elicitation, to identify constraints and to identify design decisions [19, 37, 8]. Interviews aimed to inquire into the overall experience with the cards, how the cards fitted into the design activity, and in which ways the cards helped, or hindered the design activity.

Self-Efficacy

We measured participants' self-efficacy beliefs through a custom-made 4-item questionnaire grounded on Bandura's guide for creating self-efficacy scales [6], measuring the following four facets of self-efficacy, using 11-point Likert scales (0: Can not do at all to, 10: Highly certain can do): a) design technologies for Behavior Change, b) implement different behavior change techniques, c) objectively select the best design solutions, d) justify design decisions. Participants responded to the questionnaire before and after the design session, in both conditions (control and experimental). Internal reliability of the instrument was good (Cronbach's alpha = 0.85).

Experienced Creativity

We employed the Creativity Support Index [13] to measure participants' experienced creativity during the design session. Participants responded to the questionnaire after the design session, in both conditions (control and experimental) using six 10-point Likert scales. Internal reliability of the instrument was good (Cronbach's alpha = 0.82).

Perceived Usefulness & Ease of Use
In the experimental condition, after the end of the design session, participants were asked to respond to an adapted version of TAM's *perceived usefulness* and *perceived ease of use* scales [18]. Internal reliability was excellent for both constructs (Cronbach's alpha = 0.98 & 0.91 respectively).

Quality of design concepts
The first and second author rated independently, using a 10-point scale, participants' documented concepts and design rationales, in terms of how theoretical grounded they were, how well they fit the context of use, and how creative they were. Both raters were blind to the condition. We adopted the *Consensual Assessment Technique* [5] to assess the creativity of the concepts, and appropriated it for theoretical grounding, assessing whether any of the design features leveraged behavioral theory, and to what extent was the use of theory appropriate, as well as fitness to the context of use, assessing how well participants responded to the problem at hand. To assess creativity, we decided to take into account two aspects: *originality* - the uniqueness and novelty of the concept, as compared to other concepts in the pool, and *flexibility* - the use of elements and insights from the Nudge Deck in atypical configurations [2]. To reach consensus on the evaluation criteria, the two experts jointly rated a small subset of existing design solutions (i.e., ones found in literature) and discussed the rating strategy, prior to analyzing the workshops' output. Interrater agreement was high for theoretical grounding (spearman's rank-order correlation $r_s = 0.82$) and creativity ($r_s = 0.71$), and moderate for fitness to context ($r_s = 0.55$).

FINDINGS
We present below our findings, organized in three sections, each responding to the respective research question.

How did the Nudge Deck influence the design activity?
Observation logs and interview transcripts were submitted to a content analysis [29] in order to lay out how participants used the Nudge Deck during the design activity, and what benefits they derived from it. We highlight below the dominant themes that emerged from this analysis:

It supported design teams in laying out directions for design
We observed that the Nudge Deck assisted design teams in defining the problem and laying out directions for design. This happened through the use of the trigger cards. Our goal when including the trigger cards in the Nudge Deck was to help designers identify the nudge mechanisms that are more relevant to their specific setting. The trigger cards would help them clarify which is their primary means of behavior change - increasing motivation, ability or both? We observed that when designing for the context of physical activity, participants used the trigger cards to define personas:

> *[P11] "I see these cards as personas, one does not have the motivation... think of someone like Jennifer.. and another does not have the ability, like John... John cannot exercise"*

Defining personas brought a number of benefits to the design task: it helped creating realistic scenarios, keeping the user in the forefront of design decisions, and supported designers in laying out the problem and in analyzing competing needs:

> P[12] *"If this happened, Jennifer would walk... but I do not think this would work for John. Let's focus on an app just for people like Jennifer(..) So... which activities are less tedious and have a social component?"*.

We further observed that trigger cards helped in narrowing down the options available when designers attempted to choose which nudge mechanism to work with, and to structure the design process through assisting designers in defining their objectives and maintaining their focus on these objectives throughout the different steps of the design activity.

It informed and inspired during the initial steps of ideation
In line with the work of Wetzel et al. [51], we observed that the Nudge Deck supported the initial steps of ideation by providing a framework as a source of reference to build ideas off. The mechanism cards helped in creating, but also in collecting and organizing ideas, as they emerged. They served to inform or remind of nudging techniques (e.g., P[7] *"Some of the approaches are familiar but I do not remember them when I try to design"*) [15, 14]; to provide knowledge on alternative uses of a technique (e.g., P[1] *"I never thought that reminders could be designed in this way.."*); or to provide an overview of existing work (e.g., P[10] *"It is a good tool when you don't have any knowledge on what has been done, it gives you a summary, what is out there and what strategies are available"*). Participants often commented on the capacity of mechanism cards to inspire ideation (e.g., P[9] "... a valuable tool that sparks inspiration when designing").

It supported jumped off ideation
In line with Hornecker [28] and Halskov et al. [25], we observed that the Nudge Deck helped participants in shifting their focus when the discussion was becoming unproductive. Participants went back to the cards to introduce new ideas to the discussion, or to approach the task in a different way:

> P[3] *"the price should be something that she likes, based on her preferences"* (extended pause) *Let's see this one"* (reading the placebo card aloud)*"another example could be a paddle app because it is something she likes to play... or you select the exercise you like first"*.

It provided a common vocabulary
We found the Nudge Deck to provide a common vocabulary, thus making ideas and directions more memorable and enabling more efficient collaboration among team members. We found participants to quickly understand and adopt the vocabulary employed by the *Nudge Deck*:

> P[27] *"So...* (Placing the spark card in the middle of the table) *we would explore these cards to see how we can manipulate the spark... the motivation... Can you see which of those cards fits?"*.

It facilitated collaborative work
More than providing a common vocabulary, we found the cards to facilitate collaborative work by acting as physical references to ideas, and as anchors for arguments [37, 8]. We

observed that when having access to the Nudge Deck, participants spent more time working collaboratively, bringing them up for discussion within the group, rather than working on their own solutions as it was observed in the control condition. Participants in the experimental group, jointly deliberated during early steps of the design session - from problem definition, to ideation, and idea refinement. Discussing over their use of the cards allowed participants to clarify misunderstandings, coordinate their actions and plan joint activities:

> P[21] *"We select two categories and two mechanisms to devise a solution? You take one [card], and you another one, could it be? As long as it is a spark"*

We observed that when teams thought of more than one design directions, they would split in sub-groups to look at the problem from different perspectives, and reunite to discuss their findings. This allowed sub-groups to approach problems from different points of view and encouraged them to adopt different roles, and to build on each on other's work sharing. In most groups, one team member implicitly took the role of the leader. Leaders redirected tasks and synthesized the outcomes of the different sub-groups, or the ideas introduced by team members, and ensuring cohesion among the different contributions.

The hierarchical structure of the cards provided a line of work

We observed that the hierarchical structure of the cards in three levels (i.e., triggers, categories and mechanisms) helped participants in breaking down the design activity in smaller and less complex tasks. Participants often commented on the value of this systematic approach:

> P[23] *"The task was educative... The cards provide a systematic approach for the design. This tool is useful"*.

Participants tended to use the trigger cards to define the objective, the categories cards to identify the most adequate strategies to the problem, and the mechanism cards to create or refine their ideas. For instance, while grabbing the spark card one participant mentioned: *"So we are designing a system to motivate John... And we want to…* (Grabbing the Confront car)] *Confront him"* P[16].

Design considerations sparked idea evaluation & refinement

We observed that the design considerations, placed on the back side of the mechanism cards, were used to evaluate and refine the ideas being produced. They helped participants in revisiting their assumptions about mechanisms, in refining and making their ideas more concrete, and in identifying approaches they had overlooked. While the information provided on the front side of mechanism cards served to introduce ideas, information on the back side helped them spot gaps and push the boundaries in their thinking. Often, participants encountered information that challenged their current line of work.

> P[1]*"Really? This is true? I thought that this would only have a positive impact…"*.

However, we observed that evaluating ideas during the brainstorming phase sometimes had negative side effects, as it led participants to quickly discard ideas and cards based on the constraints observed, rather than fostering divergent thinking to overcome their limitations: P[1] *"... but wait, there is a warning in the back, perhaps it is better to follow another strategy"*, P[3] *"It helps discard some problematic approaches"*..

How did the Nudge Deck influence participants' experience of the design activity?

Did the Nudge Deck enhance participants' self-efficacy in designing nudging interventions?

Given our findings in relation to the first research question, we expected the Nudge Deck to boost participants' self-efficacy beliefs, as it was found to facilitate the acquisition of knowledge, with all design teams in the experimental condition having at least one reference to a nudge mechanism in their submitted design rationales. Indeed, a dependent samples t-test revealed a significant increase (pre-post) in participants' self-reported efficacy beliefs for the experimental condition both in the physical activity case ($M_{pre} = 50.58$, $SD_{pre} = 18.38$; $M_{post} = 63.46$, $SD_{pre} = 9.87$; t(12) = -3.82, p<0.05) as well as in the misinformation case ($M_{pre} = 63.67$, $SD_{pre} = 14.39$; $M_{post} = 70.83$, $SD_{pre} = 12.98$; t(14) = -5.05, p<0.05).

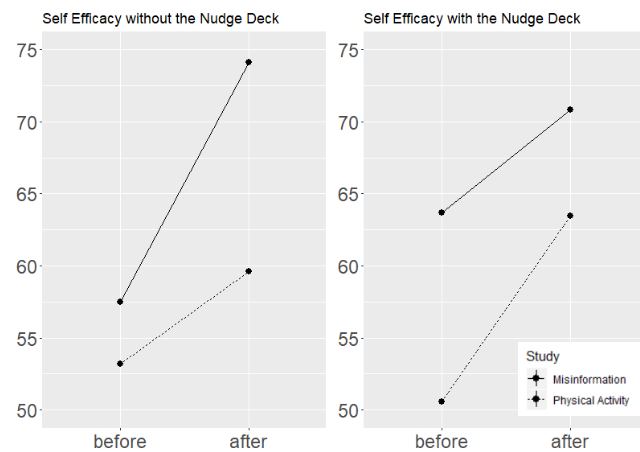

Figure 4. Participants' self-reported Self-Efficacy increased after the design session across both conditions (control vs experimental) and cases (physical activity vs misinformation).

However, the same was true for the control condition in the physical activity case (t(13) = -2.33, p<0.05) as well as in the misinformation case (t(13) = -6.29, p<0.05). Moreover, no significant difference was observed in participants' post-session self-efficacy scores, between the experimental and the control group, in the physical activity (t(25) = -0.69, p>0.05) and the misinformation cases (t(27) = 0.68, p>0.05).

Did the Nudge Deck increase participants' experienced creativity?

Given our findings in relation to the first research question, we expected the Nudge Deck to increase participants' experienced creativity during the design session, as it provided participants with a repertoire of techniques they could use in their task, it promoted collaborative work, spurred ideation, and structured the activity flow. However, a two-way ANOVA with *experienced creativity* as the dependent variable and *condition* (control vs Nudge Deck) and *case* (physical activity vs misinformation) as independent variables revealed no significant main effects for condition ($F(1,55) = 0.30$, $p > .05$, $h_p^2 = .3005$, control: M = 7.54, SD = 1.51, Nudge Deck: M = 7.29, SD = 1.17) and for the case ($F(1,55) = 2.48$, $p > .05$, $h_p^2 = .04$, physical activity: M = 7.14, SD = 1.37, misinformation: M = 7.66, SD = 1.26), and no interaction effect.

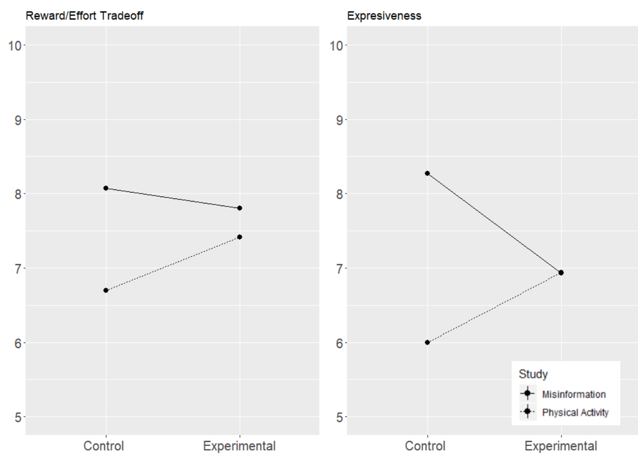

Figure 5. Participants reported significantly higher reward/effort tradeoff and perceived expressiveness in the misinformation case. An interaction effect between case and condition was observed in related to perceived expressiveness.

A closer look at the individual items of the CSI questionnaire revealed a significant effect of the *case* (misinformation vs physical activity) on *expressiveness* ("I was able to be very expressive and creative during the activity"; $F(1,50) = 5.4$, $p < .05$, $h_p^2 = .098$) and a significant interaction effect between *case* and *condition* ($F(1,50) = 5.5$, $p < .05$, $h_p^2 = .099$)). Similarly, we found a significant effect of *case* on *effort/reward trade off* ("What I was able to produce was worth the effort I had to exert to produce it"; $F(1,55) = 4.4$, $p < .05$, $h_p^2 = .074$). Participants felt more expressive and thought that what they achieved was worth their effort when designing nudging interventions to combat misinformation, rather than physical activity, and while the Nudge Deck increased their perceived expressiveness in the first case (physical activity), the direction of the effect was reverse in the second case (misinformation).

How did participants perceive the Nudge Deck?

All in all, participants rated the Nudge Deck as a *useful* (M = 5.8, SD = 1.1 on a 7-point Likert scale) and *easy to use* (M = 5.53, STD = 1.07) tool. We observed, however, lower ratings in relation to how easy it is to *learn using* (M = 4.5, STD=1.4) and to *become skillful* at using the cards (M = 4.9, STD =1.2). Some participants reported feeling overwhelmed at the start of the session, struggling to understand the relation between the different levels of the cards (i.e., triggers, categories and mechanisms). This feeling of confusion, however, dissipated as participants started to explore the cards P[7]: *"At the beginning it was hard to understand all the cards and to connect the different types of cards but after a while you understand and it helps",* P[3] *"The part that was hard was to understand the connection of the different levels"*.

How did the Nudge Deck influence the quality of design output?

Theoretical Grounding

Given that participants in the experimental condition were provided with the Nudge Deck, it was natural to expect that their ideas would have a stronger grounding on theory, as compared to the control condition, where participants had no interaction with theoretical content, apart from the definition of nudging and the provision of one example. As expected, ideas produced in the experimental condition were rated as more theoretically grounded than ones produced in the control condition. A two-way ANOVA with *theoretical grounding* as the dependent variable and *condition* (control vs Nudge Deck) and *case* (physical activity vs misinformation) as independent variables revealed a significant main effect for condition ($F(1,19) = 6.3$, $p < .05$, $h_p^2 = .25$, control: M = 4.42, SD = 2.38, experimental: M = 6.91, SD = 2.96) as well as for the case ($F(1,19) = 5.6$, $p < .05$, $h_p^2 = .23$, physical activity: M = 4.50, SD = 3.32, misinformation: M = 6.91, SD = 2.96), and no interaction effect (see figure 6).

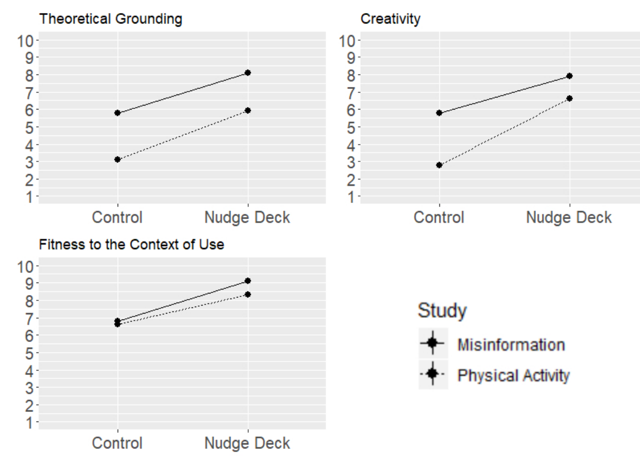

Figure 6. The Nudge Deck led to more theoretically grounded, fit to context of use, and creative ideas. Ideas in the misinformation case were more theoretically grounded and creative than ones in physical activity.

For instance, looking at the control condition, participants in the physical activity case often drew inspiration from their own personal experience using activity trackers and employed features such as prompting (N=6), social comparison and social support (N=6), self-monitoring (N=3), feedback on performance (N=3), goal-setting (N=2) and rewards (N=1). While these features are based on theoretically and empirically grounded behavior change techniques (see [38]), participants only superficially drew on these techniques without much elaboration on their functioning. For instance, when designing a goal-setting feature, participants did not elaborate on how they will engage users to self-set a concrete, and challenging yet attainable goal, which is considered to be a key predictor to the success of goal-setting [35, 23]. Similarly, when designing for social comparison, they did not reflect on ways to support appropriate comparisons (*e.g.*, against users with similar activity level), that have been found to lead to higher performance [24]. In contrast, ideas in the experimental condition often combined different mechanisms and detailed multiple steps in users' interaction with the system and how the system's actions would motivate desirable behaviors at each step. For instance, building on the "throttling mindless activity" mechanism, one team designed a browser plugin that infers the veracity of posts on one's Facebook feed and blurs the ones that are marked as misinformative. Users may press "see post" if they wish to unblur and engage with a post, or click for more information on the rationale for blurring this post.

Moreover, we observed significant differences between the two case studies (see fig. 6). For instance, ideas in the control condition were judged to be more theoretically grounded in the misinformation case (*M*=5.75, *SD*=1.81) than in physical activity (*M*=3.08, *SD*=2.22; $t(10) = 2.28$, $p < .05$). This is in contrast to what we expected, given that misinformation is a relatively recent topic and participants might have had limited experience both in terms of dealing with misinformation as well as interacting with systems that counter misinformation. We observed that ideas in the misinformation case were more detailed, elaborating on the different states in users' interaction with the system and the actions taken by the system, using mechanisms that were often supported by theory. We believe two factors have played a role in this result. First, the design brief in the misinformation case was more specific, asking participants to think about particular scenarios. This enabled participants to find specific solutions to each problem. Second, all participants worked on the misinformation case after having completed the physical activity, as counterbalancing the order was not feasible for practical reasons. While participants' allocation to conditions was kept the same across both studies, which meant that participants in the control condition of the second case (misinformation) were not exposed to Nudge Deck during the first case, their experience in thinking about changing users' behaviors might have factored in.

Fitness to the context of use

Drawing on, and combing different mechanisms during ideation made participants better able to design solutions that fit the context of use. A two-way ANOVA with *fitness to the context of use* as the dependent variable and *condition* (control vs Nudge Deck) and *case* (physical activity vs misinformation) as independent variables revealed a significant main effect for condition ($F(1,19) = 8.0$, $p < .05$, $h_p^2 = .30$, control: M = 4.42, SD = 2.38, experimental: M = 6.91, SD = 2.96) but not for the case ($F(1,19) = 0.4$, $p > .05$, $h_p^2 = .21$, physical activity: M = 4.50, SD = 3.32, misinformation: M = 6.91, SD = 2.96), and no interaction effect.

We observed that the cards supported participants in searching for strategies and mechanisms that better suit the context under concern. For instance, when designing interventions to promote physical activity, participants would narrow their inquiry based on the most relevant trigger category. Trigger cards, thus, served as a way to understand the problem they wanted to solve (*e.g.*, do users fail to perform sufficient levels of physical activity because they lack the motivation, the ability, or do they simply need a reminder?). Based on the answer to the above questions, participants would explore the mechanisms that were most relevant to the identified trigger.

Creativity

A two-way ANOVA with *creativity* as the dependent variable and *condition* (control vs Nudge Deck) and *case* (physical activity vs misinformation) as independent variables revealed a significant main effect for condition ($F(1,19) = 11.5$, $p < .05$, $h_p^2 = .38$, control: M = 4.42, SD = 2.38, experimental: M = 6.91, SD = 2.96) as well as for the case ($F(1,19) = 6.3$, $p < .05$, $h_p^2 = .25$, physical activity: M = 4.50, SD = 3.32, misinformation: M=6.91, SD=2.96), and no interaction effect.

We believe these results might be due to a number of factors. First, we observed that, in the control condition, participants took more time to warm up, and produced fewer ideas. This reduction in quantity might have led to a reduction in divergence, and in turn, to a reduction in the quality, or creativity of the ideas. The Nudge Deck enabled participants to jump-start their ideation process, as they often selected a card and readily applied it to produce an idea. For instance, inspired by the mechanism *Deceptive visualizations*, one group of participants thought of an interactive mirror that projects the future state of a user given his physical activity levels. Second, we observed that the cards enabled participants to engage in *"iterative loops of action and reflection"* [9], that allowed them to iterate and fine tune the ideas being produced.

Similarly to theoretical grounding, ideas produced in the misinformation case were found to be more creative than ones produced in the physical activity case (see fig. 6). This might be due to a number of reasons. First, as participants in the physical activity case relied on their personal experience with physical activity trackers, their ideas did not deviate from the existing technological designs, while their design rationales were more superficial, as elaborated in the previous section (theoretical grounding). Second, while the Nudge Deck made a stronger impact on the physical activity case, participants were still more creative when ideating on misinformation with the use of the Nudge Deck. We believe this might have been influenced by the fact that physical activity was the first in order case, followed by misinformation. Not only were participants less familiar with the content of the Nudge Deck during the first case, they might have also been more constrained by their use of the Nudge Deck. We observed that during the first case, participants employed the trigger cards in an attempt to define their direction, and then chose appropriate mechanisms. In the second case (misinformation), participants ignored the trigger cards and chose mechanisms unconstrained. As Biskjaer et al. [9] argue, introducing sources of inspiration without constrains supports divergence, which might have contributed to the results observed here. That is, by narrowing the set of mechanisms and examples participants drew inspiration from, in the first case, they might have missed ideas worth pursuing.

DISCUSSION & CONCLUSION

Despite ample theory on behavior change, recent reviews have shown the majority of health behavior change apps to lack theoretical content [17, 4, 16]. In this paper we reported on the design and evaluation of the *Nudge Deck*, a card-based design support tool that makes nudging theory accessible to practitioners during design meetings.

All in all, our evaluation of the Nudge Deck revealed the the tool provided multiple benefits. In line with prior work [37, 8], we found that the tool supported participants in scoping down their problem and laying out directions for design. The trigger cards were often used to define *personas* and to narrow their perspective on what problem they are trying to solve, and what nudging mechanisms are relevant to this problem. The mechanism cards, along with the examples of existing nudging interventions acted as a source of inspiration, supporting *divergence* during ideation [19, 14] and minimizing design fixation, which was often observed in the control condition, where participants did not have access to the design cards.

The Nudge Deck also facilitated collaboration by providing a common vocabulary to the design team and by acting as a physical reference to ideas [19]. When using the Nudge Deck, participants jointly deliberated on the early steps of the design process - from problem definition, to ideation, and idea refinement. The Nudge Deck was also used as a way to evaluate ideas as they emerged. Participants often used the design considerations that were listed on the back side of the cards to revisit their assumptions about mechanisms, to refine and make their ideas more concrete, and to identify approaches they had overlooked.

The benefits that the Nudge Deck brought were also reflected in the quality of design output, as ideas produced by participants in the experimental condition (i.e., with Nudge Deck) had stronger theoretical grounding, displayed stronger fitness to the context of use, and were more creative, than ones produced in the control condition, where participants did not have access to the Nudge Deck. Given that participants had expertise in HCI and the majority of them self-reported to have some prior exposure to behavior change theory, these findings suggest that providing the Nudge Deck to design teams with moderate level of expertise while working in a design task under time constraints, should make the team better able to design stronger ideas in terms of theory, fitness to context and creativity. However, one should note that while participants in the control condition were not explicitly prohibited from accessing knowledge online, none of them did so, likely to due to time constraints. Thus, one might question whether these results can transfer to less time-constrained design meetings.

With respect to participants' experience of the design session, a more complicated picture was revealed. First, we found the Nudge Deck to make no impact on participants' *self-efficacy* beliefs. In particular, we found a significant increase in participants' self-efficacy ratings after engaging with the task in both control and experimental conditions, and no significant different between conditions in participants' post-session self-efficacy ratings. One potential explanation for this might be rooted in the study design, being between-subjects. As no participant engaged with both conditions, they might have judged their post-session self-efficacy against a different reference. While participants' objective efficacy was stronger in the experimental condition, as evidenced by the quality of design output, participants in the experimental condition might have become overwhelmed by the amount of information they engaged with during this limited amount of time, thus affecting their perceived self-efficacy.

Second, we found no significant difference between the two conditions in terms of participants' *experienced creativity* during the design task. Instead, we found a significant interaction between condition and the case study in terms of two sub-items of experienced creativity - expressiveness and effort/reward trade off. Participants felt more creative and thought that what they achieved was worth their effort when designing nudging interventions to combat misinformation, rather than physical activity, and while the Nudge Deck increased their perceived expressiveness in the first case (physical activity), the direction of the effect was reversed in the second case. We observed that participants' use of the cards across the two cases differed. Participants in the physical activity case explored trigger cards to define personas and spent more time defining the direction and less on creating ideas. At the same time, their ideas were less creative, making more references to existing solutions. In the misinformation case the lack of existing technological solutions, as well as the higher specificity of the design brief, as discussed in the findings, led participants to devise more creative and detailed ideas, which also translated to participants feeling more expressive and more rewarded for their effort. These findings highlight the critical role of the design brief and the multiplicity of factors that affect the quality of the outcome and participants' experience during a design task.

Finally, one should note a number of limitations in our studies that warrant further inquiry. First, the quality of produced ideas was assessed by the first two authors. While we took measures to minimize the likelihood of bias - specifically, being blind to the condition from which ideas came - our results may have been affected in ways we cannot anticipate or know. We suggest that future work should seek to engage external experts in performing the assessment of the quality of design output. Second, as all participants were graduate students and had prior experience in working together, we have no means to know whether these results will hold in professional settings, and how group dynamics may have influenced the results. Third, while the current studies assessed the capacity of the Nudge Deck to support the initial phases of design, and particularly in relation to ideation, one could further explore its potential to support later stages, during idea evaluation and refinement. Fourth, while our study asked whether the Nudge Deck supports designers during ideation as compared to having access to no design support tool, one could opt to compare the value and function of different tools (e.g., [15, 32, 41, 36]), or different representations of theoretical knowledge.

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