Towards Establishing Design Principles for Balancing Usability and Maintaining Cognitive Abilities

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Abstract. While technology has improved the speed, accuracy, and efficiency of work, its prolonged use also weakens users' cognitive abilities over time. By creating usable, efficient, emotive, and engaging experiences, HCI researchers and practitioners have inadvertently led users to offload their innate capabilities onto their devices. How should technology be (re)designed so as to reduce the negative effects of on users' cognitive abilities when used over time? In this paper, we discuss a set of design principles intended to help designers consider how long-term use of their artefacts could maintain and even improve users' unassisted abilities and reduce negative impacts of over-reliance on technology. We illustrate the design principles by redesigning commonly-used applications, and report the findings from a workshop conducted with digital natives to obtain feedback on these redesigned applications.

Keywords: Design practice · Technology use over time · Persuasive System Design · User interface · Gamification

1 Motivation

While technology has improved the speed, accuracy, and efficiency of work, its prolonged use also weakens users' cognitive skills over time. By automating our cognitive tasks such as problem-solving and decision-making, we reduce our ability to "translate information into knowledge and knowledge into know-how" [1].

Many research efforts conducted among different domains corroborate this. Through a series of experiments van Nimwegen and colleagues observed that computer-game players who received minimal guidance in the game had better conceptual understanding of the game, strategised better and finished the game faster than players who received assistance from the system [2]. Similar observations were made with experiments involving the use of everyday applications

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like planning software [3,4]. The theory of technology dominance [5] (studied and tested in accounting and taxation, e.g. [6–8]) discusses how both experienced and novice decision makers may become reliant on decision aids. In the case of novice users, they end up not acquiring domain expertise at all and as a result, they come to rely on the decision aid, whereas, in experienced users, there is a de-skilling effect due to over-reliance on the decision aid when the task complexity, decision aid familiarity, and cognitive fit are all high. A study on cab drivers' reliance on GPS units concludes that it causes atrophy of drivers' hippocampus [9]. Our ability to read long articles has decreased, owing to bite-sized information readily presented over the Internet [10]. A series of recent experiments indicates that the ready availability of information online weakens our memory [11]. Architects seem to have lost their sense of scale due to employing computer-aided designing over paper-drawing [12]. The shortcomings of spell-checker software discussed in [13] exemplify *automation complacency*, i.e., the user becomes less vigilant about system's output due to a false sense of confidence in the system's accuracy [1]. Simply knowing that an experience has been photographed with a digital camera weakens a person's memory of the experience [14].

2 Need for Redesign

We see a need to propose a new set of design principles in the wake of growing evidence on the negative impact of prolonged use of technology. This is because traditionally human-computer interaction (HCI) has emphasized on usability, optimization, and efficiency, in order to reduce cognitive overload on the user with a task at hand. This approach increases the overall productivity of users, but it also makes them offload their innate capabilities onto the plethora of 'smart' devices surrounding them. Borgmann introduces the concept of 'devices' in his 'device paradigm' and describes them as highly commoditised and disengaging us from our surroundings [15]. He argues that as result of using devices, skilled engagement with one's environment is no longer required. Hence the satisfaction of adeptly completing a task is now replaced by passive consumption of technology. One may argue that engagement with digital technologies could increase certain capabilities of the user that are directly related to the interaction with technology. For example, because of working more on a PC, one's typing skills in terms of speed, would improve. However, spell-check and autocorrect software functionality may actually reduce the user's inherent spelling abilities.

Unlike the more observable and immediate physical effects of over-reliance on technology, the cognitive effects are likely long-term, thus may be more difficult to discern and reverse when they have become observable. How should technology be (re)designed so as to reduce the negative effects of on users' cognitive abilities when used over time? Many of the design guidelines/heuristics such as Nielsen's heuristics [16] and Shneiderman's Golden Rules [17] focus on designing for efficiency and usability, as these have been the main aims and goals of many consumer hardware/software products in the past. As we spend increasingly longer hours interacting with IT devices, this trend is expected to increase, thus a shift of design approach is a timely and necessary endeavor.

In the next section, we summarise some alternative points of view on designing for usability and how they address the limitations of the efficiency/productivity- and user satisfaction-focused interactions which we have been aiming for today. Then in Sect. 4, we summarise our design exercises that consider some of the commonly-used applications today and come up with artefacts that may support minimising the negative cognitive effects of use over time. Section 4 also reports the findings from a half-day workshop with 21 young participants who discussed and gave feedback on the designed artefacts. Section 5 then extracts from the design exercises and the findings from the workshop, the common and essential factors and concepts that may serve as principles for any future designs to ensure minimal negative long-term consequences in the use of any interactive application.

3 Discussion of Related Work

There is increasing discussion in the HCI community about design approaches that run counter to accepted design practices. In this section, we highlight four related design approaches that may inform how we can come up with principles for helping designers consider how long-term use of their artefacts could maintain and even improve users' unassisted abilities and reduce negative impacts of over-reliance.

3.1 The Philosophy of "slow" Technology

Hallnas and Redstrom [18] explore creating 'slow technology' for supporting reflection over efficiency in performance. They describe slow technology as one where the user "takes time to: learn how it works, understand why it works the way it works, apply it, see what it is, find out the consequences of using it." While such slowness is considered to be bad design as it could cause user frustration, it could be intentionally leveraged to provide opportunities for the user to reflect on/while using the technology.

This philosophy has been applied in a variety of applications. Hessenwahl and Klapperich [19] compare the experiences of brewing coffee in automated and manual ways and recommends an "experience-centred design" of everyday automation. If response time of search systems were to be compromised, while the perceived quality of results may be low, in certain scenarios the actual search results may be of greater value to the user, as discussed in [20]. A reflective approach for motivating people to increase their physical activity has been discussed in [21].

3.2 "Hard-to-use" Interfaces

There is growing evidence that sometimes what is traditionally viewed as "usability issues" may actually benefit the user sometimes [22]. The work of

Cockburn et al. [23] discusses how user interfaces that require more user effort improve users' spatial memory and benefit the learning of spatial tasks. However, this extra effort has to be *meaningful* and *discretionary* i.e. the user is not mandated to go through additional effort, but willingly chooses to do so [24]. Pierce and Paulos' work [25] is aimed at studying what affordances can be provided through counter functional things and intentionally designed limitations. This approach of introducing "counter functionality" takes "hard-to-use" systems to an extreme by suggesting the opposition or even omission of functionality to actually provide the feature.

3.3 (In)appropriateness of Technology and "Undesigning"

Baumer and Silberman [26] discuss a series of questions aimed to help design practitioners to gauge the appropriateness of using technology to solve problems in specific contexts. They ask designers to consider if a problem can be solved using a "low-tech" or even non-technological solution. When designers choose to provide a technological solution, they have to consider if the solution does more harm than the good it provides. Finally, designers have to ascertain if the technology they choose solves the actual problem, or just a representation of the problem that can be solved by that technology.

Pierce [27] proposes "undesigning of technology" i.e. elimination of design, to negate the harmful effects of technology, on social and environmental issues, through design. One of the design elimination approaches discussed in this paper is the use of persuasive design. While the approach is generally thought of as persuading users to behave in an intended manner, Pierce proposes the use of self-inhibition, that is, designing technology that inherently inhibits its own usage. The author also explains how the principles of persuasive design (discussed in the next sub-section) can in fact be applied to dissuade undesirable user behaviour or attitudes.

3.4 Persuasive System Design and Gamification

Persuasive system design and persuasive technologies have been extensively used for promoting behaviour change for health and safety [28], supporting self-management of health [29], promoting sustainable behaviours [30], help overcome substance addiction [31], in web-based learning environments [32], and even for contributing to crowd-funding campaigns [33].

The persuasive system design (PSD) framework proposed by [34] discusses design principles for *primary task support* (including guiding users in moving closer to attaining desired behaviour/attitude, providing tailored and personalised content and services, and tracking users' performance over time), *dialogue support* (such as praising and rewarding target user behaviour, and providing suggestions that aid users in performing target behaviour), *system credibility support* (through third-party endorsements and verification), and *social support* (by creating opportunities for competition, cooperation, social comparison, and recognition among users).

The use of game elements to persuade user behaviour/attitude in intended direction has been studied by [41]. Gamification can be defined as "the application of lessons from the gaming domain to change behaviors in non-game situations" [35]. Gamification concepts (such as those discussed in [36]) have been employed to promote healthy behaviour [37], in education [38], to increase performance of elderly and disabled workers in production environments [39], and even in enterprise software use [40].

There is considerable overlap between gamification concepts and persuasive design principles, specifically those corresponding to dialogue and social support. Also, understanding the inevitable trade-offs incurred when serious situations are gamified (e.g. time efficiency and short-term productivity vs. sustained engagement and fun) and the strategies to strike the right balance, seem to share similar considerations for trade-offs in designing technologies that promote users' cognitive efforts while at the same time ensure a reasonable level of usability.

4 Redesign Exercise and Feedback Session

Drawing from some of the techniques and theoretical concepts discussed in the previous section, we conducted a series of design exercises to re-design commonly-used applications today, specifically calculator, spell-checker, scheduling/to-do list, GPS navigation app, and app marketplace. They illustrate how the interaction could be designed in such a way that may reduce the negative effects of over-reliance on them and possibly even to increase the users' cognitive ability while using them, while at the same time supporting the task that the users want to achieve.

To validate our proposed design approach and to elicit feedback on various aspects of the redesigned applications, we undertook a design studio approach (similar to the methodology described in [42,43]) and conducted a half-day feedback workshop with 21 participants. Demographics of the participants were: ages between 18 and 23; 11 females and 10 males; nationalities included Cambodian, Chinese, Filipino, Indonesian, Japanese, Malaysian, Mongolian, Myanmarese, Singaporean and Sri Lankan.

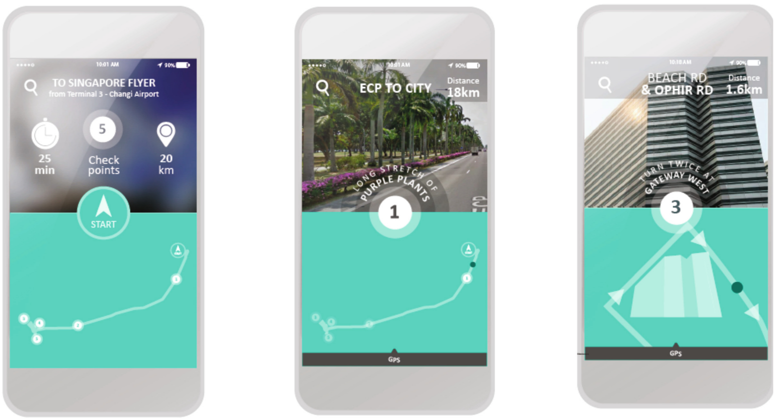
The workshop was conducted with users of this specific age-group as they are considered to be "digital natives" who have been using IT applications and devices throughout their lives and hence are at high risk of over-reliance on technology and yet may not be aware of how it could adversely affect their cognitive abilities/skillset over time. By engaging users from a breadth of countries with varying levels of technological adoption and attitude towards tech-use, we obtained a more balanced feedback on the acceptability of our design approach.

The participants were divided into five groups of four/five users and moved around each design artefact. Each artefact had a dedicated facilitator walking the participant group through the redesign and rationale. Participants were encouraged to ask questions and discuss the design implications among other members of their group. In addition, they provided individual and anonymous feedback on each artefact through post-it notes. At the end of the workshop we collated the feedback received and identified common themes for each and across all artefacts.

4.1 GPS Navigation App

Instead of providing turn-by-turn directions, the GPS navigator makes the user look out for landmarks and cues that help to retain and even improve the driver's situational awareness (Fig. 1).

In this redesign, instead of providing very specific, detailed, step-by-step instructions, we provide leeway for users to figure out intermediary steps on their own. When the usage situation repeats over time, instead of providing the entire set of instructions, we encourage users to recollect from their memory, as much as possible, before intervening and revealing the instructions. The GPS app has been redesigned such that it exhibits *self-inhibition* through the use of gamification elements such that the lesser the users require the app's assistance for navigation, the more they progress through levels. (See Fig. 6 in Sect. 5 for explanation in the context of extracted design principles.)



a b c

Fig. 1. Redesigned GPS app: Provide spatial cues instead of detailed directions. (a) Upon indicating the destination, an overall route with major enroute landmarks is visualised. (b) As the user drives by the landmarks, photos of the landmark scenes are displayed. (c) Instead of providing turn-by-turn instructions using length measurements, spatial cues are used so that users may recollect from memory during subsequent trips.

Feedback: The redesigned GPS navigation app met with unanimous positive feedback from the participants. They felt it is good to have the role of the GPS navigation app relegated to that of *sous*-navigator who only helps when the driver explicitly asks, rather than actively directing the driver. In fact, one participant commented "I like how it brings technology to its assistive role, to be there when I really need it, while letting me use my own memory otherwise."

4.2 Calculator

We have designed a calculator app (see Fig. 2) which, when invoked for simple calculations, elicits a 'guesstimate' from the user. The app then reveals the actual answer and indicates how accurate the user's guess was. We have used the concept of *counter-functionality* whereby, the user, who wants an accurate answer immediately with minimal effort, is asked to first try to 'guesstimate' the value. We believe the extra effort is *meaningful* and *discretionary* as the user is provided the option to skip this step and directly obtain the calculated value. Finally, the system provides tips on how to guess better, corresponding to PSD framework's design principle on providing *suggestions* for system-human dialogue.

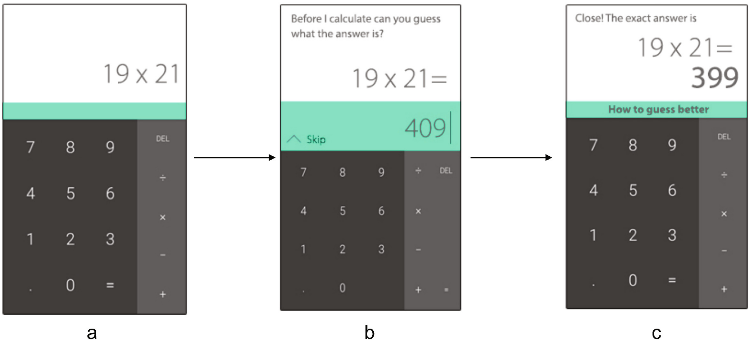


Fig. 2. Redesigned calculator: Encourage the user to 'guesstimate' arithmetic calculations before revealing the actual answer. (a) User types in query. (b) Instead of displaying the answer immediately, the system asks the user to estimate the answer, while also providing the option to "skip". (c) The system then responds how close the estimate is, and reveals the correct answer.

Feedback: Participants welcomed the approach of asking them to attempt to calculate values on their own first. However, they acknowledged that they may sometimes be in situations where accuracy and timeliness are of the essence. Hence they liked the feature to quickly switch between 'ability' and 'accuracy' modes. Some participants suggested identifying and designing for specific usage scenarios where the 'ability' mode is strictly enforced and tips and hints are displayed everyday, for example, in education. Participants also wanted to see some kind of analytics to understand how their "guessing accuracy" has improved over time.

4.3 Scheduling App/to-do List

In this redesigned calendar/scheduling app (see Fig. 3) the user is made to recollect the agenda and timing of the day's meetings, instead of being informed by the app. The user is presented with the timings for the events/appointments of the day and a list of possible events. (The number of events is more than the number of time slots.) The user is required to match the timing with the event that is scheduled for that time, in order to see the actual appointments for the day.

By making the user match the day's meetings with their corresponding times, we hope to encourage users to *reflect* on those events when they go through the extra step. By *praising* the user for correctly matching the tasks and timings, the redesign supports system-human dialogue principle of the PSD framework.

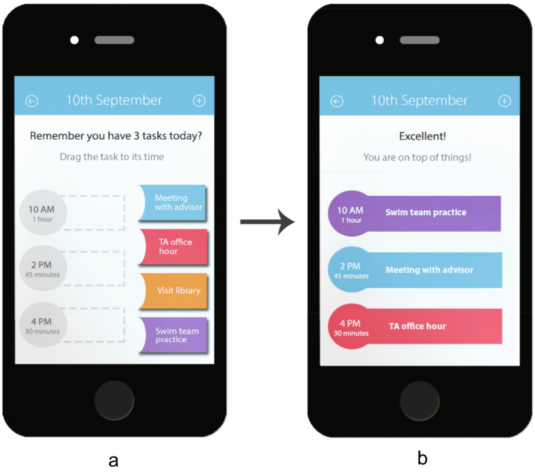


Fig. 3. Redesigned scheduling app: Help users in recollecting meetings and agendas, instead of reminding them. (a) When the app is opened, the user is asked to drag and drop the main events to the correct time slots. (b)The correct schedule is then shown, thereby confirming the user's answers.

Feedback: Participants saw the redesigned interaction as opportunities for reflecting on the events/meetings. Some even suggested adding more dimensions, like testing the user on facts relating to the meetings or using photographs to "involve more senses." The interaction could be gamified through incentives, points, or unlocked features. However, a few participants felt that planning/scheduling should not be complicated and should remain in the form of passive notifications or popups.

4.4 Spell-Checker

Figure 4 shows how a text-writing application (e.g. email or word-processor) could be redesigned such that the user is informed of the presence of error in the text, without being shown the exact error and the correct solution. The user

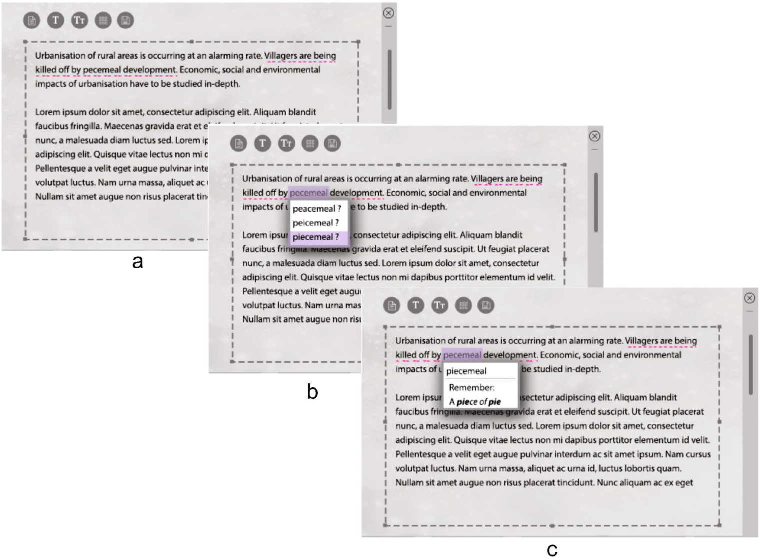


Fig. 4. Redesigned spell-checker: (a) The sentence with incorrect spelling is highlighted, as a whole. (b) When the user identifies the misspelt word, spelling variations are presented for the user to choose the correct spelling. (c) Upon choosing a word, the system reveals the answer.

would thus have to first identify the error, then decide on the correction and finally, learn ways to remember the correct form.

The proposed redesign can be considered *slow* and *hard-to-use* as the user is required to spend some effort in pinpointing the exact error and then choosing the correct version. However, the additional effort followed by hints and suggestions should improve error prevention and users' recall.

Feedback: While participants liked how the redesigned spell-checker makes them identify and correct the mistake on their own rather than auto-correcting, they felt the redesign could be extended to cater to different learning abilities of individuals, some through examples, some through mnemonics, and others through explicit repetition of words that are always misspelt by the user. One participant suggested displaying a summary of mistakes the user had made, as recap, when the user saves and closes the document.

4.5 App Marketplace

Given the innumerable number of apps, how can we ensure that users actually choose those that are beneficial to them despite the perceived extra effort in using those apps?

We propose that, in addition to the existing information like app ratings, customer ratings and reviews, app marketplaces should also display information about how prolonged use of the app could affect the user's different cognitive abilities. We have named this set of information "UX2.0 index" as we hope our proposed design approaches encourage designers to think about user experience design as being more than just usable, compelling, and emotive, but also consider the long-term consequences to the users. Similar in approach to those for enforcing ethical behaviour-design [44], the proposed elements support *system credibility* design principles of the PSD framework.

In Fig. 5, the app download page pertains to a section that shows possible effects on the user's cognitive skills over time, in ratings by different cognitive abilities/skills. Such quantitative ratings may be difficult, if not impossible, to measure for a newly developed app, but in this exercise we are illustrating how the consideration of long-term use and its cognitive consequences might eventually manifest so that it becomes one of the features from which the potential users could decide whether to purchase it or not.

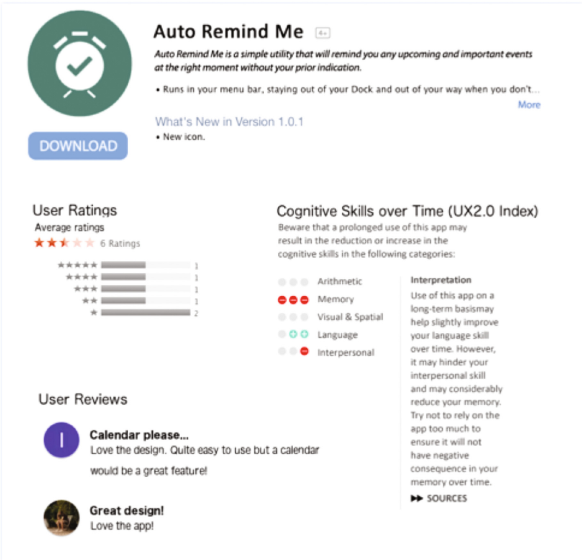


Fig. 5. Redesigned app marketplace: On the lower-right side of the screen, the page provides the ratings in 5 cognitive abilities/skills (arithmetic, memory, visual and spatial, language and interpersonal) and explanations on how prolonged use of the app may affect users' cognitive abilities

Feedback: Participants felt that rather than discouraging them from choosing apps that are harmful for them, the information in app marketplace could actually encourage app designers and developers to create apps that rate highly on the UX2.0 index, thereby indirectly designing better for cognitive abilities. Some participants suggested including limiting access to apps by age, based on effect on cognitive abilities. Others advocated allowing users to make their choice and potentially only displaying warning messages, like similar labels on cigarette packs. A couple of participants raised the issue of reliability of UX2.0 index rating and suggested having a credible organisation or institution to review and rate apps based on the index parameters.

5 Moving Towards Design Principles

From our review of literature, design exercise, and the user feedback for our designs we extract a set of general considerations as the step towards establishing design principles intended to help designers consider how long-term use of their artefacts could maintain and even improve users' unassisted abilities and reduce negative impacts of over-reliance.

One of the designed artefacts, the GPS navigation app, has gone through more rigorous discussions and thus covers wide principles and categories we considered. We ended up redesigning the GPS app more fully. We present our design principles, along with illustrations of how apply them, through the redesigned GPS navigation app, which we call "GPS2.0".

1. Consider whether the domain you are designing for and the technology and interactions you are designing, have long-term effects on users' cognitive abilities. Determine which abilities will be affected and how.
2. Allow users to switch easily between a mode in which the principles are implemented (*ability* mode), and a mode in which speed, efficiency and accuracy are the main goals (*accuracy* mode). Leave the choice of using the *ability* or *accuracy* mode to users, as some may not be concerned with effects of prolonged technology use, but warn them of the potential consequences.
   In Fig. 6d and e, the user is able to easily switch between *GPS2.0* mode where there is more wholesome interaction offering some room for exerting more mental effort, and *normal* GPS mode in which the system provides turn-by-turn instructions. When the system operates in *normal* mode it displays a warning message about potential harm to user's spatial abilities.
3. *Show, don't tell*: Don't show full solution but find a way to help users find the solution themselves by:

   – Suggesting a more wholesome/physical/natural way of solving
   – Giving minimal amount of information, in the form of appropriate hint or quiz to guess or reflect first
   – Highlighting user's error, rather than auto-correcting

   In Fig. 6a the system displays a general overview of the entire journey, akin to physical map, and minimal information in terms of expected duration, number of main decision points/landmarks and total distance of the journey. In Fig. 6b–d landmarks and visual cues (i.e. expected scenery or view during the drive) are used to inform and confirm users about driving directions, rather than the traditional way of turn-by-turn instructions and distance measurements.

Fig. 6. GPS2.0: Proposed design principles applied for redesigning GPS navigation app

4. Hints should not be repeating the same pattern but changing.
   When the user requires directions for the same route repeatedly, do not provide the entire set of hints. Encourage users to recollect from their previous experience(s) of driving through the same route. Only if they explicitly request assistance or appear to be lost, provide the hints/suggestions. Even then, change the nature or pattern of hints.
5. Introduce gamification elements like (a) rewards (b) progression through levels and (c) competition, to ensure sustained use of the app.
   As seen in Fig. 6f, the system uses gamification concept of levels and progression, to encourage users to drive unassisted by GPS as much as possible. In this particular example, the user has used the app in *GPS2.0* mode for a great part of the journey, thereby attaining the level of "London cab driver" (whose spatial navigation skills are well-known [45]).

6. Encourage users to exercise their abilities through data analytics to show how the abilities progress over time.
   The GPS2.0 app tracks how well the user is able to navigate (a) without assistance of the app and (b) using *GPS2.0* mode instead of *normal GPS* mode. This information is used in conjunction with gamification elements to encourage users to continue using their inherent abilities, as shown in Fig. 6f.

6 Conclusion

In this paper, we have established the necessity for approaching user experience design from the perspective of reducing and preventing over-reliance on technology, and maintaining and possibly even improving users' cognitive abilities when used over time. Through investigation of literature on recent design discussions in the HCI community, persuasive systems, and gamification, we have derived a set of design principles to help designers consider how long-term use of their artefacts could maintain and even improve users' unassisted abilities and reduce negative impacts of over-reliance.

The principles encourage users to keep using their own unassisted cognitive abilities in completing a task while also allowing them to get an immediate task solution. This is an important facet that manifests in the changed tone from the existing design guidelines. To address the dichotomy between the two modes (i.e. *ability* versus *accuracy*, as described in Sects. 4 and 5), we continue to explore by expanding the concepts and principles introduced in this paper into a spectrum for determining the appropriate tradeoff/balance point(s). We hope that our proposed design approach generates discussions to start the awareness in the HCI community.

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References

1. Carr, N.: The Glass Cage: How our Computers are Changing Us. W. W. Norton & Company, New York (2015)
2. van Nimwegen, C.: The Paradox of the Guided User: Assistance Can be Counter-Effective. Utrecht University (2008)
3. Burgos, D., van Nimwegen, C.: Games-based learning, destination feedback and adaptation: a case study of an educational planning simulation. In: Games-Based Learning Advancements for Multi-Sensory Human Computer Interfaces: Techniques and Effective Practices, Information Science References, Hershey, PA, pp. 119–130 (2009)

4. van Nimwegen, C., van Oostendorp, H.: The questionable impact of an assisting interface on performance in transfer situations. Int. J. Ind. Ergon. **39**(3), 501–508 (2009)
5. Arnold, V., Sutton, S.G.: The theory of technology dominance: understanding the impact of intelligent decision aids on decision makers' judgments. Adv. Acc. Behav. Res. **1**, 175–194 (1998)
6. Hampton, C.: Determinants of reliance: an empirical test of the theory of technology dominance. Int. J. Acc. Inf. Syst. **6**, 217–240 (2005)
7. Masselli, J.J., Rickets, R.C., Arnold, V., Sutton, S.G.: The impact of embedded intelligent agents on tax-reporting decisions. J. Am. Taxation Assoc. **24**(2), 60–78 (2002)
8. Dowling, C., Leech, S.A., Maroney, R.: The deskilling of auditors' abilities: an empirical test of the theory of technology dominance. In: The 2nd Asia-Pacific Research Symposium on Accounting Information Systems (2006)
9. Maguire, E.A., Gadian, D.G., Johnsrude, I.S., Good, C.D., Ashburner, J., Frackowiak, R.S., Frith, C.D.: Navigation-related structural change in the hippocampi of taxi drivers. Proc. Nat. Acad. Sci. **97**(8), 4398–4403 (2000)
10. Carr, N.: Is Google Making Us Stupid? (2008). http://www.theatlantic.com/magazine/archive/2008/07/is-google-making-us-stupid/306868/
11. Sparrow, B., Liu, J., Wegner, D.M.: Google effects on memory: cognitive consequences of having information at our fingertips. Science **333**(6043), 776–778 (2011)
12. Caicco, G.: Architecture, Ethics, and the Personhood of Place. University Press of New England, Hanover and London (2007)
13. Galletta, D.F., Durcikova, A., Everard, A., Jones, B.M.: Does spell-checking software need a warning label? Commun. ACM **48**(7), 82–86 (2005)
14. Henkel, L.A.: Point-and-shoot memories: the influence of taking photos on memory for a museum tour. Psychol. Sci. **25**(2), 396–402 (2014)
15. Borgmann, A.: Technology and the Character of Contemporary Life. University of Chicago Press, Chicago (1984)
16. Nielsen, J.: Usability Engineering. Morgan Kaufmann Publishers, San Francisco (1994)
17. Shneiderman, B., Plaisant, C., Cohen, M., Jacobs, S., Elmqvist, N., Diakopoulos, N.: Designing the User Interface: Strategies for Effective Human-computer Interaction, 6th edn. Pearson Addison Wesley, Boston (2016)
18. Hallnäs, L., Redström, J.: Slow technology-designing for reflection. Pers. Ubiquit. Comput. **5**(3), 201–212 (2001)
19. Hassenzahl, M., Klapperich, H.: Convenient, clean, and efficient?: the experiential costs of everyday automation. In: Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational, pp. 21–30 (2014)
20. Teevan, J., Collins-Thompson, K., White, R.W., Dumais, S.T., Kim, Y.: Slow search: information retrieval without time constraints. In: Proceedings of the Symposium on Human-Computer Interaction and Information Retrieval (2013)
21. Lee, M.K., Kim, J., Forlizzi, J., Kiesler, S.: Personalization revisited: a reflective approach helps people better personalize health services and motivates them to increase physical activity. In: Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing, pp. 743–754 (2015)
22. Riche, Y., Henry Riche, N., Isenberg, P., Bezerianos, A.: Hard-to-use interfaces considered beneficial (some of the time). In: CHI 2010 Extended Abstracts on Human Factors in Computing Systems, pp. 2705–2714 (2010)

23. Cockburn, A., Kristensson, P.O., Alexander, J., Zhai, S.: Hard lessons: effort-inducing interfaces benefit spatial learning. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 1571–1580 (2007)
24. Kelly, R., Gooch, D., Watts, L.: Technology appropriation as discretionary effort in mediated close personal relationships. In: Collaborative Appropriation: How Couples, Teams, Groups and Communities Adapt and Adopt Technologies, in Conjunction with CSCW 2016 (2016)
25. Pierce, J., Paulos, E.: Counterfunctional things: exploring possibilities in designing digital limitations. In: Proceedings of the 2014 Conference on Designing Interactive Systems, pp. 375–384 (2014)
26. Baumer, E.P., Silberman, M.: When the implication is not to design (technology). In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2271–2274 (2011)
27. Pierce, J.: Undesigning technology: considering the negation of design by design. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 957–966 (2012)
28. Purpura, S., Schwanda, V., Williams, K., Stubler, W., Sengers, P.: Fit4life: the design of a persuasive technology promoting healthy behavior and ideal weight. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 423–432 (2011)
29. Win, K.T., Mullan, J., Howard, S., Oinas-Kukkonen, H.: Persuasive systems design features in promoting medication management for consumers. In: Proceedings of the 50th Hawaii International Conference on System Sciences (2017)
30. Mustaquim, M.M., Nyström, T.: A system development life cycle for persuasive design for sustainability. In: MacTavish, T., Basapur, S. (eds.) PERSUASIVE 2015. LNCS, vol. 9072, pp. 217–228. Springer, Cham (2015). doi:10.1007/978-3-319-20306-5_20
31. Lehto, T., Oinas-Kukkonen, H.: Persuasive features in web-based alcohol and smoking interventions: a systematic review of the literature. J. Med. Internet Res. **13**(3), e46 (2011)
32. Daud, N.A., Sahari, N., Muda, Z.: An initial model of persuasive design in web-based learning environment. Procedia Technol. **11**, 895–902 (2013)
33. Wang, B., Lim, E.T., Van Toorn, C.: Gimme money! designing digital entrepreneurial crowdfunding platforms for persuasion and its social implications. In: Proceedings of the 20th Pacific Asia Conference on Information Systems (2016)
34. Oinas-Kukkonen, H., Harjumaa, M.: Persuasive systems design: key issues, process model, and system features. Commun. Assoc. Inf. Syst. **24**(1), 28 (2009)
35. Robson, K., Plangger, K., Kietzmann, J.H., McCarthy, I., Pitt, L.: Is it all a game? understanding the principles of gamification. Bus. Horiz. **58**(4), 411–420 (2015)
36. Cugelman, B.: Gamification: what it is and why it matters to digital health behavior change developers. JMIR Serious Games **1**(1), e3 (2013)
37. McCallum, S.: Gamification and serious games for personalized health. In: Proceedings of the 9th International Conference on Wearable Micro and Nano Technologies for Personalized Health (2012)
38. Muntean, C.I.: Raising engagement in e-learning through gamification. In: Proceedings of the 6th International Conference on Virtual Learning (ICVL), pp. 323–329 (2011)
39. Korn, O.: Industrial playgrounds: how gamification helps to enrich work for elderly or impaired persons in production. In: Proceedings of the 4th ACM SIGCHI Symposium on Engineering Interactive Computing Systems (2012)

40. Herzig, P., Strahringer, S., Ameling, M.: Gamification of ERP systems-exploring gamification effects on user acceptance constructs. In: Multikonferenz Wirtschaftsinformatik, pp. 793–804 (2012)
41. Fogg, B.J.: Persuasive Technology: Using Computers to Change What We Think and Do. Morgan Kaufmann Publishers, San Francisco (2003)
42. Reimer, Y.J., Douglas, S.A.: Teaching HCI design with the studio approach. Comput. Sci. Educ. **13**(3), 191–205 (2003)
43. Lindstrom, J.: Design Studios: The Good, the Bad, and the Science (2011). http://www.uxbooth.com/articles/design-studios-the-good-the-bad-and-the-science/
44. de Oliveira, R., Carrascal, J.P.: Towards effective ethical behavior design. In: CHI 2014 Extended Abstracts on Human Factors in Computing Systems, pp. 2149–2154 (2014)
45. Maguire, E.A., Woollett, K., Spiers, H.J.: London taxi drivers and bus drivers: a structural MRI and neuropsychological analysis. Hippocampus **16**(12), 1091–1101 (2006)