Exploring the Feasibility of Subliminal Priming on Web platforms.

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ABSTRACT

Despite the initial premise of behavior change tools, recent work has questioned their efficacy over the long term. Many of these technologies rely on a "one-size fits all" strategy – *self-monitoring* – to foster behavior change. However, individual's capacity to change their behaviors depends on their ability and motivation for self-regulation. We explore a different approach to persuasive technology design and investigate how subtle influences falling outside conscious awareness can instinctively motivate behaviors. Subliminal priming has the potential to influence people's attitudes and behaviors, without relying on people's will to engage with the process. Yet, little research has studied it effectiveness encouraging behavior change outside a laboratory setting. In this paper we explore the feasibility of subliminal priming on web-platforms. We present an *in the wild* study where 12 participants were exposed to *subliminal cues* to motivate water intake while they browsed on the web. This paper contributes with a practical application of subliminal priming in the field of behavior change as well as design implications for future research.

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KEYWORDS

Persuasive technology, behavior change, nudging, subliminal priming, affective computing.

1 INTRODUCTION

There is a growing interest in the design and development of technologies to support well being and promote healthy behaviors. Take as example personal informatics tools, such as physical activity trackers, which have been gaining a widespread adoption in recent years [42]. These devices track and collect personal relevant information relevant to users' goals (e.g. steps count) and generate timelines of past events for later inspection, for instance, providing an overview of users' performance and their general wellness [43]. They are seen as a promising change intervention towards a healthier lifestyle by increasing awareness of user's behaviors and promoting physical activity [33]. They can support education, motivation and empowerment with change, decreasing health care costs by targeting disease prevention [33].

However despite their initial premises, the reality of these technologies is rather discouraging with recent research underlining high levels of disengagement among their users. Ledger found that over a third of owners of activity trackers discarded their wearables within the first six month [23], Shih, et al. found that 50% of users quit using the tracker after only two weeks and Gouveia et at. observed that only 14% of users adopted their tracker longer than two weeks [15]. One might notice that the majority of current technologies seek to support change through *reflection*, relying on the principle of *self-monitoring* to engage individuals with behavior change [1]. Long-term engagement is important as the principle of *self-monitoring* assumes continuous engagement with data. It has been observed that when people stop reflecting on data, the effect of self-monitoring disappears and users relapse into old behaviors [8].

The reality is, that the vast majority of these tools disregard the fact that reflection strongly relies on people's *motivation* and *ability* to constantly track, integrate data and identify opportunities for action [1]. Motivation and ability are highly variable, and while these tools currently provide the initial encouragement for the change process, people find self-monitoring time-consuming and remain frustrated with their lack of success [22]. People cease tracking their activity and abandon the devices [22].

In this work we investigate how technologies can be designed to inspire behaviors without putting too much burden on the user, or relying on people's will to drive action. Drawing on research on subliminal priming, we explore how cues presented below the threshold of perception can instinctively encourage behaviors in daily life. Making the representation of a behavior accessible subliminally has the potential to increase the chances that the behavior will be performed, while mitigating some of the negative consequences of self-regulation strategies lessening the risk of reactance without interrupting ongoing activities. Subliminal priming has been explored in different settings and has been proved effective in influencing preferences in an image selection task [6], supporting users during complex tasks [7], instigating creativity [14, 25] and even motivating desired behaviors [9, 19, 24, 34]. Yet, little research have investigated it effectiveness in prompting behavior change in a non-controlled setting.

In the current paper, we describe the design and evaluation of an *in the wild* study were 12 participants were motivated to drink water while they were browsing on the web. We took advantage of *Subly* [6] a research tool that subliminally primes behavioral concepts that are present in the content of web pages visited (i.e. to drink). We evaluate the effectiveness of two types of stimuli, positive and neutral, and explored their influence over different levels of hydration. Our results suggest that behavior-related cues can increase water intake levels when participants exhibit low levels of deprivation (i.e. when participants were semi hydrated), while losing its effectiveness when fluid levels are replenished. While those effects were not statistically significant, the tendencies observed support the work of Veltkamp M. et al [34] and indicate that when semi deprived, people infer the goal more readily than participants with low deprivation of fluids. Thus, subliminally priming behavioral concepts is more likely to result in behavior change when people are relatively more deprived of it.

2 BACKGROUND

Several theorists have postulated that the conscious mind is not the only source of our behaviors and that in fact, the majority of our everyday actions are initiated in the absence of intentional guidance [13, 26, 36]. Dual-process and dual-system theories in both cognitive and social psychology, suggest that the decision-making process happens through the interaction of two modes of thinking: one intuitive and one deliberative, also know as the automatic and the reflective minds [18]. 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. The reflective in turn, makes decisions through a rational process. It is conscious, slow, effortful and goal-oriented. Both systems cooperate. We make use of rational strategies to properly respond to situations that the automatic mind cannot handle (i.e. complex computations) and during this process the automatic mind is not totally inhibited as it continuously provides suggestions to the reflective (i.e. hunches) [18]. Yet, as we tend to reduce mental effort, it is estimated that 95% of our everyday decisions are performed by the automatic mind activated by a situational stimulus [4].

2.1 Automatic Behaviors

Researchers have developed and studied technology to encourage certain actions without demanding thoughtful processing [1]. For instance, Nakajima, T., et al. simulated user's tooth brushing practices, through aquarium elements dwelling in the bathroom mirror, to offer real-time guidance while the behavior is carried out [28]. Consolvo's *UbiFit Garden* delivered abstract behavioral feedback to facilitate how users convey information of their physical activity levels [8]. The system mapped user's daily step count to the growth of a garden displayed on the background of a mobile phone, increasing user's awareness about their activity level. Hassenzahl, M. et al. instead create friction during the decision-making moment to help people to consider the alternative when undesired practices were selected. Take as an example *Keymoment*, a key holder that nudges individuals towards a sustainable transportation mode. Upon departure, if the car key is chosen over the bike key, the system drops the bike key in the floor, nudging the user to reconsider his decision [21]. Other approaches explored perception biases to influence behaviors. For instance, the *mindless plate* leverages the *Delboeuf illusion* to influence individual's perception of the amount of food on the plate, inducing people to reduce the amount served [1]. The modification of the color of the inner circle of the plate causes the portion of food to appear bigger due to the amount of area covered and the proximity to the edge of the plate. Other example explore stripes designed on the road, which are spaced closer together as the vehicle approaches the curve biasing driver's speed perception, which believe that he is speeding [32], or 3D floating zebra cross that tricks drivers to slow down [29].

Lastly, other strategies explored the re-arrangement of elements to make the desired alternative more accessible. For instance, the replacement of a cake basket with a fruit basket in a cash register [31] or stopping the elevator one floor before user's destination to encourage people to take the stairs [17]. One might notice that these strategies provide a subtle stimulus at the right time and place, with the goal of guiding action while avoiding cognitive overload. However, since the stimulus is still consciously detectable these strategies still involve the risk of reactance - users rejecting interventions when they perceived a loss of freedom to preserve their behavioral autonomy [5, 11].

2.2 Subliminal Priming

Numerous findings from cognitive and social psychology suggest that a way to instigate merely an automatic process is by making a representation of the behavior accessible unconsciously. This method, known as *subliminal priming* refers to the presentation of information in a way is not consciously perceived but is still processed by the automatic mind [19]. For instance, briefly flashing the cue, reducing it opacity or masking the stimulus [6, 34, 35]. One requirement is that the stimulus must be acquainted and have a preexisting association with the goal, including the means to attain it (i.e. drink) [30, 34]. Secondly, individuals should be repeatedly exposed to the stimulus to increase the likelihood that the individual perform the behavior in like with the related goal [37]. Lastly, it is recommended to pair the stimulus with positive affect to increase preferences towards the behavior. Pairing with affect helps focusing attention on elements relevant to the problem and is able to alter people's perception of expectancy and the idea that the action is worth striving for, facilitating decision-making and supporting goal commitment [12].

There is quite evidence for the effectiveness of subliminal priming affecting behavior. For instance, Karremans J. and Strahan et al. [19, 30] found that subliminally disguising a beverage brand logo increased people's motivation to drink and to select a drink from that brand. Veltkamp M. et al. [34] found that combining a positive word with the word 'drinking' instigated drinking behaviors even when participants were not deprived. Bargh, J. et al. [3] found that priming the words "old age" made people walk slower down a corridor. Wallace FL. et al. [35] observed that subliminally masking cues to support users during demanding tasks (i.e. displaying instructions) reduced the frequency with which they asked for help. Chalfoun P. and Frasson C. [7] found that flashing a hint in the square corresponding to the correct answer, boosted participant's performance and enhanced intuition during the learning process. Caraban A. et al. [6] found that reducing the text opacity of certain words influenced participant's choice selection and Lewis, S. et al. [25] in turn, observed that priming positive affect (i.e. image of a baby laughing) positively influenced the quality of ideas generated and boosted creativity.

While these results are promising, the reality is that the effectiveness of subliminal priming has been only tested in controlled studies and it is not clear whether it can be effective as a behavior change intervention in the real world. In this paper we investigate the effectiveness of subliminal priming in a different setting – web browsing. With 50% of people spending over 6h per day surfing the web, we explore web platforms for the delivery of subliminal priming interventions. This work presents an *in the wild* study where 12 participants were exposed to *subliminal cues* to motivate water intake while they browsed on the web. To explore it effectiveness, we exposed participants to behavior-related cues (e.g. sip) and cues boosted with positive affect and observed their influence on different hydration levels. In the following sections, we describe our experiment in detail, discuss our results and conclude with the challenges and the need for future work.

3 EXPERIMENT

3.1 Participants

We selected 12 participants through a university mailing list (6 males, mean age 26, min=22, max=33). Participants were recruited based on their working schedule (~ 9am to 5pm) and the working space they usually attend (i.e. fixed), they were office workers and researchers. Participants were asked to participate during five consecutive working days and were not compensated for their participation.

3.2 Apparatus

We make used of *Subly*, a Chrome extension to subliminally prime cues during user's browsing activity (see Appendix 1) [5]. The tool is composed by a back-end and front-end interface developed using HTML, CSS, JavaScript, PHP and JSON. The plugin operates by analyzing the content of every page visited, searching for words that match a list of cues predefined. When the words are found, the extension updates the words' opacity to make the cues consciously imperceptible (i.e. subliminal). We replicated Caraban et al. [6] subliminal setting for web priming and adopted the opacity values suggested on their study 1, 0.76% opacity for font color black and 0.73% for blue (i.e. in case the word is found in a hyperlink). We connected the extension to a MySQL database and logged the cues presented: behavior-related and positive and the frequency of their occurrence on a web page, user's interaction with the cues (i.e. click, select, mouse over), the time to which participants were exposed to the primes (i.e. the time elapsed since they opened the page until it was closed) and the time active on a page (i.e. inferred through the mouse activity). Based on recent findings suggesting

that users often leave the web page in 10 seconds, we did not logged interactions whose duration was shorter than 10 seconds assuming that while peeking through web pages participants have no time to read the content of the pages and reach the cues [27].
Cues: We selected 46 goal-related words related with drinking behavior, water and hydration and words to instigate thirst (see Table 1). With literature postulating that anchoring a stimulus to a positive affect word (i.e. good) can enhance individual's attitude towards a behavior [34], we elected 31 positive words from the *AFINN affective lexicon* [2]. Positive affect primes were activated (i.e. subliminally primed) once a goal-related word (i.e. drink) was presented in the page within the surrounding area (i.e. previous or next paragraph) e.g. *"**Drink**ing is **good**"* (where the letters in bold were subliminally primed). All cues were presented in the participant native language (i.e. Portuguese) or in English, based on the language of the page (see Table 1).

Table 1 - The full list of cues primed can be found in Appendix 1.

Behavior-related cues			Positive affect
Water	Gulp	Drink	Good
Hydrate	Sip	Potable	Great
Thirst	Dryness	Cup	Beneficial

Water sensing infrastructure: A water scale was specially built to measure and log user's water intake behaviors. The water scale consisted of a load scale sensor whose signal was amplified and processed by an Arduino compatible circuit and whose structure was built using a *3D* printer (see Figure 1). The system tracks water intake behaviors by detecting changes in weight every time a bottle is placed on device after having a sip. We recorded the amount of water consumed, day and time. This enabled us to compare user's water intake levels across different times of the day, the time elapsed between sips and variations in participant's hydration levels over the course of a day.

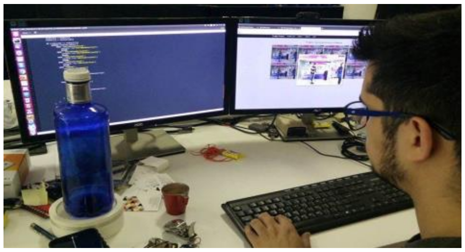

Figure 1 - Sensing device built to measure and log water intake.

3.3 Study design and procedure

With the goal of assessing the impact of subliminal priming on water consumption, our experiment was designed for a within-subjects analysis, employing two experimental conditions during five days: control (C) and subliminal condition (S). We employed a multiple baseline study design with two days of subliminal condition and three days of control. To balance the design, the conditions were randomly assigned across the days, except for the first day that was always assigned the control condition (i.e. CCSSC or CSSCC). The sequences were arbitrarily assigned to the participants and each sequence was used the exact same amount of times (i.e. by two users - full counterbalance).
Before the experiment, participants were asked to install the Chrome plugin and attach the sensing device (i.e. water scale) to their computer (USB cable). Participants were told that the purpose of the experiment was to understand people's behaviors in the workplace environment and were not told about the primes. They were supplied with a bottle of water (1,5L) and we priory assured there was the water provision option was available in the workspace (e.g. water refill station). At the end of the study, participants were informed about the real purpose of the experiment and we conducted an interview to understand their interactions with the sensing device and the primes.

3.4 Measures

During the subliminal condition, we monitored water drinking behavior (i.e. total daily water intake, number of sips per day, quantity of every sip), the number of webpages visited, the interaction with the cues with respect to the webpages visited (i.e. how many cues, both behavior primes as well as positive affect primes present in every webpage) and the overall duration of the page visits. During the control condition, we logged user's water drinking behavior and we did not present any cue. We placed a temperature sensor in the room and asked participants to wear a smartwatch during the study with the goal of observing the influence of physical activity and ambient temperature on the engagement with the primes, and the perceive effect of the primes on people's water drinking behavior. We installed Google Fit in every smartwatch and measured temperature hourly.

4 RESULTS

Cues perception
At the end of the experiment participants were inquired if they detected any anomaly in the text. During the interview one of our participants reported noticing subliminal messages while changing the Gmail theme background to a darker color, which happened in the first day of subliminal conditioning and was excluded from the analysis. When asked about the influence of consciously perceived cueing (i.e. supraliminal priming) motivating behavior, the participant reported that he felt that the cues did not influence his water intake behavior. We observed however that the amount of water consumed increased sharply the day when the messages were consciously perceived. This

change was not sustained and highlights the need for the design of mindless interventions (see Figure 2).

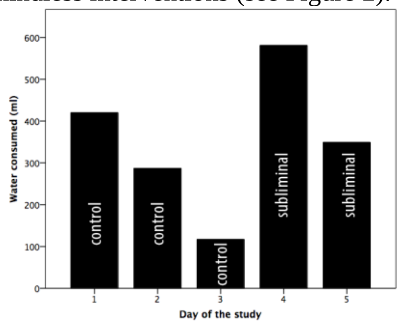

Figure 2 - Differences on water drinking behavior after the participant noticed the primes.

Understanding participants' web surfing behavior and exposure to stimuli

All in all, participants visited on average of 359 pages per day, with an average duration of page visit of 1.17 minutes, STD = 3.10 minutes, MIN = 5 seconds, MAX = 27 minutes. On average a webpage would have 11 behavior-related primes (STD = 29, MIN = 0, MAX = 913) and 1 affective prime (STD = 7, MIN=0, MAX = 686). Out of the 8 hours of daily exposure, an average of 5 hours and 33 minutes were spent web surfing. The total number of pages visited during the study, depicted by hour and participant, can be observed in Figure 3.

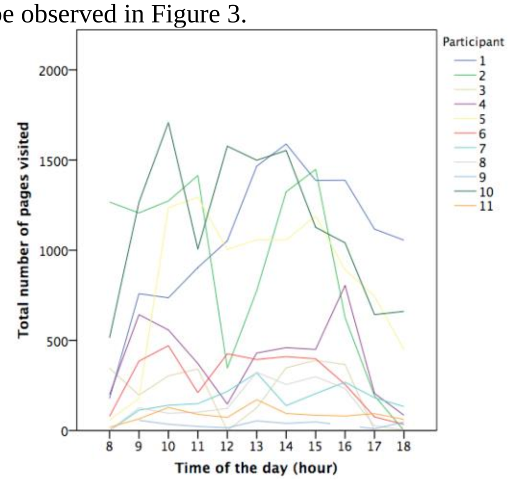

Figure 3 - Web surfing activity over time of day.

Understanding water intake behaviors

Over the 8 hours, participants consumed an average of 803.15ml per day, disclosing inadequate hydration levels compared to the amount of water suggested by medical practitioners (70% STD=21.55) [15]. On average, participants took 8 sips per day, with a mean of 109 ml per sip (SD=83ml), with approximately 65% of the daily water consumed being in the second half of the day (2.706 ± 1256 ml) than in the first half (1.457 ± 677 ml), t(20), p= 0.009 (i.e. water consumed by participants during the five days of the study). We observed the role of novelty instigated by the sensing device (see Figure 4). Participants were more likely to drink higher amounts of water in the first days of the study.

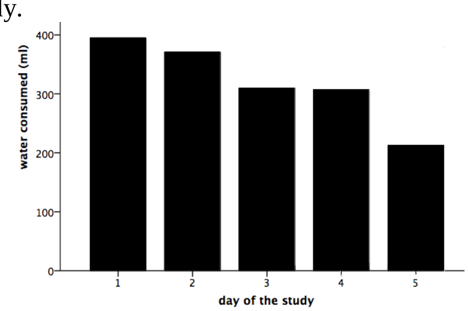

Figure 4 - Water consumption levels by day of study

Influence of subliminal primes

To test whether the subliminal manipulation had an effect on participant's water intake levels, we compared the daily amount of water consumed when participants were presented with subliminal messages and when they were not. A Kruskal-Wallis H test showed that presenting subliminal primes did not increase the *overall amount of water consumed*.

We observed, however, a statistical significance on the *amount of water drink per sip* when the behavior-related cues were paired with positive affect. The more behavior-related cues presented, the more the water consumed given the 30 minutes period. This effect was found when the number of positive cues were provided within a range lower than 20 words, r = .28, p < .005 (see Fig. 5) (i.e. when the user was exposed to at least one positive affect word and less than 20 over the 30 minutes period).

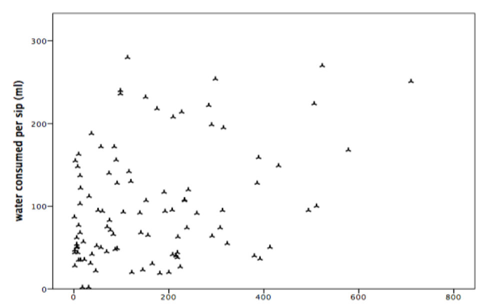

Figure 5 - Water consumed per sip as a function of behavioral-related stimulus paired with positive affect. We observed a linear association between the number of cues presented and the water consumed.

Predisposition towards the behavior

We looked into how different levels of hydration could have influenced the participants' motivation to drink water over the two conditions and how it affected the effectiveness of the cues. To this end, we calculated the participants' level of hydration thorough the day by comparing the amount of water consumed along the day until a given moment to the amount of water that should have been consumed [16]. We took into account ambient temperature, participants' weight, the amount of physical activity performed and assumed that they started the workday with a 20% fluid deficit and slept on average 8 hours [20]. We calculated the requirement of water intake based on previous research that estimates daily water requirement is 64 ounces (1890 milliliters) in a normally cool environment for an individual weighing 150 pounds (68 kilograms) and exercising about 20 minutes a day. We then labeled hydration levels in a scale of 1 to 3, where 1 denoted *"thirst stimulated"* and 3 denoted *"none fluid deficit and optimal performance"* [16].

As expected, we observed a significant difference in the *amount of water consumed* between different hydration levels, $\chi^2(2) = 17.67$, $p < 0.01$. Our first examination showed that subliminal primes (i.e. behavior-related and positive) did not increase the overall water consumed compared to the control condition, regardless of the hydration level (see Figure 6). We observed however that participants experience low hydration levels (i.e. level 1 – thirst stimulated) during the control condition, which were not experience in the subliminal condition. While participants' dehydration levels were not associated with the incidence of hotter days during the control condition ($p>0.05$), we observed that participants consumed more water when semi-hydrated during the subliminal condition than during the control condition. We hypothesize that the higher consumption level prevented participants from reaching a lower hydration level in the subliminal conditioning.

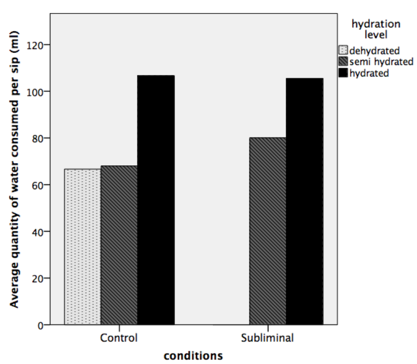

Figure 6 - Hydration levels experienced by participants under the different conditions.

Difference between types of messages and levels of hydration

We observed differences between the type of message and the level of hydration. Participants exhibiting moderate hydration levels (i.e. semi hydrated) consumed more water per sip after being exposed to subliminal messages (80.68, SD=7.85) than when not (68.03, SD=7.85). This difference however was not significant ($p>0.05$) see Figure 7.

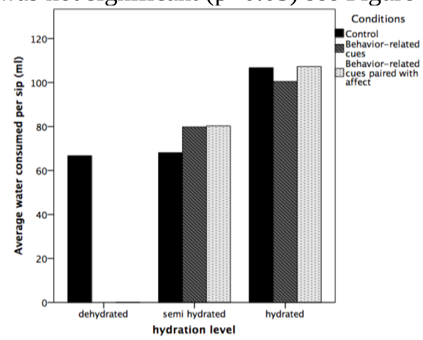

Figure 7 – Average quantity of water consumed per sip (ml) as a function of hydration levels and conditioning. Hydrations levels were computed every 30 minutes taking into account what users' water consumption during that timeframe.

While we expected that cues paired with positive affect would increase the amount of water consumed, this was not observed. An explanation for this finding may be that the behavior was desirable as participants were not fully hydrated and thus, combining the stimulus with affect did not lead to a higher motivation to carry out the action [34]. We observed however that subliminal cues were more effective motivating drinking behaviors when water intake levels were fully replenished (i.e. when participants were hydrated) than when participants were semi hydrated. This was observed when the messages provided were behavior-related (hydrated - 103.14, SD=14.80, semi hydrated – 95.52, SD=12.38) and when behavior-related cues were paired with positive affect (hydrated - 105.21, SD=14.80, semi hydrated - 80.92, SD=11.04), this different was not significant.

Difference between types of messages and time elapsed between sips

We observed a significant difference in time elapsed between sips when participants were semi hydrated, depending on which type of message was presented ($\chi2$ (2) = 137.418, $p < 0.01$). Cues paired with positive affect significantly reduced the time between sips, when compared to the neutral condition (Z =-2.983, p = 0.003). In turn when hydrated, pairing behavior-related cues with affect significantly reduced the time between sips when compared to neutral cues ($p < 0.01$) (see Table 2).

To conclude, we found a negative correlation between the time active on a page (i.e. time exposed to cues) and the overall amount of water consumed (r= -.152, n=394, p=0.002). We did not find however a correlation between the times exposed to the cues and the time elapsed between sips. This could have been caused by the use of an external monitor as the time active inferred by the mouse activity.

Table 2 – Mean time between sips per condition and hydration level

	Hydrated (SD)	Semi hydrated (SD)	
Control	0:43 (0:03)	1:31 (0:17)	min
Neutral	0:52 (0:08)	1:17 (0:09)	min
Positive	0:40 (0:05)	1:05 (0:09)	min

Persuasion check

At the end of the study, we asked participants if they detected any anomaly in the text, if something disturbed their reading and we provided the list of cues predefined in the plugin. None of our participants reported difficulties reading or being distracted while glancing across the text. However, in the post experiment interview we found that behavior-related words did not have the same capacity to trigger behavior. Participants reported lack of knowledge of the meaning of certain words (i.e. in the foreign language) and did not associate some cues to the action of drinking water (i.e. aridity). For instance, the participant that noticed the subliminal conditioning reported *P[11] "I do not know some words, is it related with drinking? [...] When I tried to understand if the words were associated with drinking, I Google the common ones to see if they would be highlighted... like water or drink."* when glancing over some words as 'drought' or 'gulp'. Altogether, fourteen behavior-related cues were unfamiliar or not associated to drinking behavior. In turn, affective words were all acquainted in both languages. We believe that the lack of familiarity with the cues could have affected the effectiveness of the subliminal condition. However, as the cues elected had the same denotation and behavioral goal, we did not distinguish the cues found by the plugin and thus, this analysis could not be performed.

5 DISCUSSION

With this research we aimed to explore whether subliminally priming behavior-related concepts as people browse on the Internet motivates water intake. Specifically, we examined the differences between priming behavior-related words and priming behavior-related cues paired with positive affect and observed it influence in different levels of hydration. Our results suggest that behavior-related cues can increase water intake levels when participants exhibit low levels of deprivation (i.e. when participants were semi hydrated), while losing its effectiveness when fluid levels are replenished. While those effects were not statistically significant, the tendencies observed support the work of Veltkamp M. et al [34] and indicate that when semi deprived, people infer the goal more readily than participants with low deprivation of fluids. Thus, subliminally priming behavioral concepts is more likely to result in behavior change when people are relatively more deprived of it.

Moreover, it was observed a predisposition towards the behavior when participants were exposed to subliminal cues, through the time elapsed between sips, which was significantly reduced, specially when the primes where paired with positive affect.

In this work, we also explored the feasibility of subliminal priming on web-platforms. As expected, integrating cues with a pervasive activity such as browsing, enabled a recurrent and long-exposure to the intervention, without disrupting from ongoing activities. Participants expended 5 hours and 30 minutes out of 8 web surfing and were exposed to a mean of 53 behavior-related cues per hour, despite the relative limited list of cues predefined, which matched only one behavior. Two main limitations of this research are the relatively small sample of our study and the novelty effect instigated by the sensing device (i.e. water scale). We encourage scholars to study the effectiveness of subliminal cues in the long-term and take advantage of the plugin to promote a wide range of behaviors, not only ones regulated by basic needs. Another constraint was that data retrieved from the mouse behavior revealed few to none interaction with the cues (e.g. mouse over) and we could not detect if participants glanced across all the cues. We believe that eye tracker data can bring interesting insights and contributions to the field. Monitoring participants' eye gaze can disclose if participants would gaze at the word, which cues were observed and the length of exposure. Moreover, we suggest prioritizing the location of the cues to increase the likelihood that they are read (i.e. priming cues in the header of the website or priming cues in the surrounding of the mouse pointer) and deduce participants' water drinking behaviors previously to the experiment to better understand the influence of the primes. Despite these limitations, we believe that this research has practical implications. We examined the effectiveness of subliminal priming in a real world scenario and identify some settings that should be considered in upcoming experiments, such as the need of tailored interventions to provide cues that are familiar to the user; the adjustment to different background colors and the location across the page. However, further work is needed to better understand how to develop and deliver web subliminal interventions. All in all, from an intervention standpoint, subliminal primes can potentially be leveraged to induce desirable behaviors in real-life scenarios without relying on people's motivation to engage with behavior change and evading effortful self-regulation strategies (e.g. avoiding high levels of deprivation or interrupt excessive use of social media). We believe that exerting conscious effort to mediate behavior, while limiting people's resources to other tasks, feels rather discouraging and downplays the importance of the automatic mode of thinking, which processes 95% of all incoming information. Given the wide reach and extensive capabilities of the Internet, the potential advantages of using the Internet to deliver subliminal interventions is vast. Yet, one should notice that using subliminal techniques to influence behavior is highly controversial and this strategy should entail a careful ethical analysis [10]. Researchers should be aware that these nudges should be employed to work best and match user's goals, influencing wellbeing and health, and not served as any way of manipulation plus ensuring that users are aware of how it functions.

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Appendix 1. Quick overview of Subly

How does it work? - Available at Google's Store, the Subly plugin acts as a web customizer through which researchers can easily manage cues displayed into web pages that are browsed by users. After installing the Subly Chrome extension, the tool is automatically added to the browser and its customization panel is instantly disposed for administration. The panel is located in the right sidebar (see Fig. 1) and can be used to configure standard input fields, associated with the cues retrieved while web browsing.

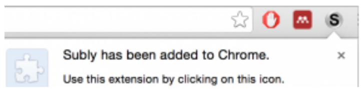

Fig. 1 - The customization panel is available in the toolbar for the researcher convenience.

The first step is to decide the target behavior(s) (e.g. to increase water intake) and generate a list of related words that will act as behavioral triggers (e.g. sip). The plugin will scan every page, searching for every pre-defined cue. The predisposition to display a cue relies on user's browsing activity (see Fig. 2).

Adding nudges - To begin the process, researchers should click on the *Subly icon* placed in the Chrome toolbar and select the *Subliminal word* option. In this menu, researchers can add numerous cues and for each of them, assign a priority (optional). Priority helps define dynamic priming when two or more behavioral concepts (e.g., to walk, to drink) are at play. Priority values may be constant, when one goal is more important than another, or dynamic, depending on users' behavior. Imagine, for instance, that a user has been physically active on a given day but falls short of meeting the expected water intake levels. In this case, priority is assigned dynamically through connecting to external applications (Researchers can connect *Subly* to third party applications through http requests).

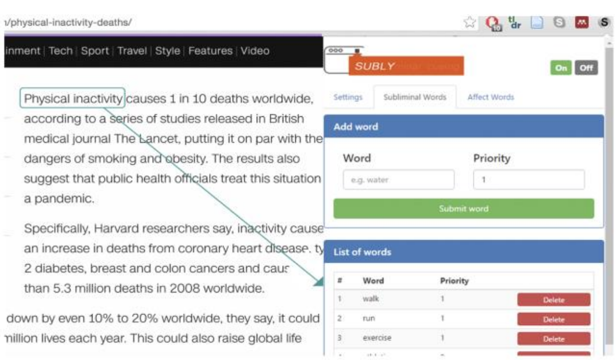

Fig. 2 - Menu where researchers can define the cues, which will be primed (e.g. run, walk and exercise)

Priming nudges - In the *Settings menu* researchers can define how they want to disguise the cues by selecting the *Subliminal Type* (see Fig. 3):

Blinking - Cues can be flashed so quickly that they become imperceptible. For this purpose, researchers must define the duration (ms) and frequency of the exposure.

Opacity – Word opacity for primes can be modified in to subliminal or supraliminal levels. Additionally, priming cues can vary in font-size, color or any other property, defined through a *CSS Style*.

Different configurations may be assigned to different behavioral concepts, specific primes, events, or user groups. For instance, blinking and opacity changes might be combined to primes related to one behavioral concept (e.g. to walk) when certain conditions are satisfied (e.g., low physical activity). Different priming configurations may be applied to different user groups, enabling AB tests.

Authentication – where the user authentication is set (e.g. id). After adding a user, the configuration panel is hidden.

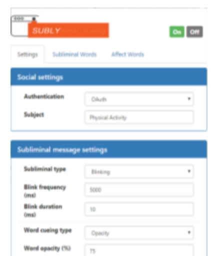

Fig. 3 - Subliminal type list of options

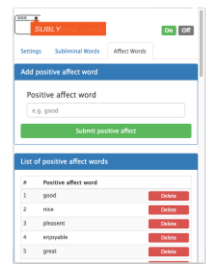

Fig. 4 - Affect words menu

Affect words menu - Researchers may opt to anchor behavioral concepts to a list of positively or negatively valenced words (e.g. good). In this situation, words are primed only when they co-occur with one of the affect words (e.g. good walk, walk is good) (see Fig. 4).

Data - *Subly* stores all data on a SQL Database. Data stored consists of a series of time-stamped events, identified and stored when the tool is confronted with one of the following scenarios: (a) user opened, refreshed or closed the page; (b) user became active; (c) user was presented with a subliminal cue and (d) user is inactive.

Behavior related cues

Water	Aqua	H2O	Drink
Hydro	Liquid	Fluid	Hydrate
Lake	River	Thirst	Dryness
Sip	Cup	Taste	Savor
Hydrant	Hydra	Dehydrate	Splash
Quaff	Swig	Guzzle	Imbibe
Inhale	Bottle	Ocean	Glass
Gulp	Hydration	Gargle	Drunk
Aridity	Swallow	Drought	Potable
Consume	Drank	Watery	Flood
Drinking	Sea	Irrigate	
Swill	Rain	Refreshment	

Affective Primes

Good	Nice	Fun
Friend	Pleasant	Peace
Favorable	Valuable	Pleasing
Precious	Pleasurable	Helpful
Constructive	Effective	Efficacious
Love	Happy	Super
Delightful	Great	Practical
Useful	Smile	Exceptional
Neat	Approved	Productive
Progressive	Excellent	Gratifying
Beneficial		