Guess what? Implicit motivation boosts the influence of subliminal information on choice

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Guess what? Implicit motivation boosts the influence of subliminal information on choice

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ABSTRACT

When is choice affected by subliminal messages? This question has fascinated scientists and lay people alike, but it is only recently that reliable empirical data began to emerge. In the current paper we bridge the literature on implicit motivation and that on subliminal persuasion. We suggest that motivation in general, and implicit motivation more specifically, plays an important role in subliminal persuasion: It sensitizes us to subliminal cues. To examine this hypothesis we developed a new paradigm that allows powerful tests of subliminal influences as well as stringent assessments of subliminality. The results of two experiments suggest that implicit motivation can enhance the effects of subliminal priming on choice.

1. Introduction

Can our decisions be affected by subliminal messages? This question has fascinated scientists and the general public alike, but it is only recently that reliable empirical data began to emerge, suggesting that it is indeed possible. The new data also suggest that conscious needs may modulate this effect: subliminal messages become more effective when they are related to or can potentially satisfy a physical need (e.g. thirst; Strahan, Spencer, & Zanna, 2002). Yet, given the limited capacity of consciousness (Kahneman, 1973), and the multiplicity and complexity of human behaviors, the scope of influence of conscious needs and motivations is likely to be very limited, and much control must be relegated to implicit motivations (Custers & Aarts, 2010; Hassin, Aarts, Eitam, Custers, & Kleiman, 2009). In the current study we bridge the implicit motivation literature with that on the subliminal modification of choice. In two experiments we examine whether implicit motivation boosts the influence of subliminal stimuli on choice, and how.

2. Subliminal priming and choice

While debated for many years (e.g., Eriksen, 1960; Holender, 1986), there is a growing body of research indicating that the cognitive system can process subliminal information, and that meaningful single units (e.g., words, numbers) can even be processed semantically (for recent reviews see Kouider & Dehaene, 2007; Van den Bussche, den Noortgate, & Reynvoet, 2009; but see Pratte & Rouder, 2009). The evidence comes mainly from priming paradigms, in which subliminal primes affect the way in which participants categorize supraliminal targets (Abrams, 2008; Dehaene et al., 1998; Forster, 2004; Greenwald, Klinger, & Schuh, 1995; Kiesel, Kunde, Pohl, & Hoffmann, 2006; Kinoshita & Hunt, 2008; Klauer, Eder, Greenwald, & Abrams, 2007; Naccache & Dehaene, 2001).

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Evidence for *direct* influence of subliminal stimuli on *choice*, however, is scarcer. Two main paradigms have been used to investigate this question. In one, scientists insert *free choice trials* into priming experiments of the type described above. Thus, for example, Schlaghecken and Eimer (2004) showed that subliminally presented arrows biased participants' responses in trials in which they could freely choose which among two buttons to press (e.g., left vs. right key-press). Importantly, this effect was found *only when free choice trials were intermixed with instructed trials*, in which participants were instructed to press a button that corresponded to supraliminal arrows. The authors concluded, then, that the effect of subliminal primes on free choice can be obtained only when the appropriate stimulus–response mapping is consciously active and rehearsed (see also Kiesel, Wagener, Kunde, Hoffmann, & Fallgatter, 2006; Klapp & Haas, 2005).

Another source for evidence on subliminal influence on choice is the literature on subliminal persuasion. Since Vicary's infamous report in 1957, in which he claimed that the subliminal message *Drink Coke* affected drink consumption, scientists have been trying to document similar effects in laboratories (Pratkanis, 1992). It is only recently, however, that replicable findings of this sort were obtained (Bermeitinger et al., 2009; Karremans, Stroebe, & Clauss, 2006; Strahan et al., 2002; Winkielman, Berridge, & Wilbarger, 2005). Strahan et al. (2002) showed that subliminal primes affected consumption, but only if there was a relevant physical need.[1] Thus, for example, when exposed to thirst-related subliminal words, thirsty participants (but not non-thirsty ones), were more likely to choose a thirst-quenching beverage (compared to a control beverage). Extending these findings, Karremans et al. (2006) demonstrated that priming thirsty (but not non-thirsty) people with a subliminal *brand* of beverage increased the likelihood that they choose to drink this brand. Similarly, Bermeitinger et al. (2009) showed that subliminally presented brands of dextrose pills biased choices of tired (but not non-tired) participants. To summarize, then, subliminal persuasion research suggests that subliminal stimuli affect action when that action seems relevant to a conscious physical need.[2]

While two literatures reviewed above converge in suggesting that subliminal stimuli can directly influence choice, they highlight different preconditions of that influence. In the free-choice paradigm, subliminal stimuli were found to bias choices *only if* the appropriate stimulus–responses mapping has been rendered active (Klapp & Haas, 2005). In the subliminal persuasion paradigms, however, influence of subliminal primes occurred *only if* an appropriate physical need was active (Strahan et al., 2002).

3. The present research

In the current research we turn our spotlight from physical needs to implicit motivation (Bargh, 1990; Kruglanski, 1996). We do so because motivation is very broad in its scope, and it influences many of the decisions we make, the thoughts we think, and the emotions we experience (Higgins, 2011; Higgins & Kruglanski, 2000). We focus on *implicit motivation* because given the limited resources available for conscious processes (Kahneman, 1973), it is likely to play a significant role in human behavior (Hassin, Aarts et al., 2009).

The research on implicit motivation has significantly expanded in recent years (for recent overviews see Custers & Aarts, 2010; Dijksterhuis & Aarts, 2010). It shows that implicit motivation can affect various processes, from behaviors in public good games (Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trotschel, 2001), through executive functions, allocation of resources, and self control (Aarts, Custers, & Marien, 2008; Bijleveld, Custers, & Aarts, 2010; Fishbach, Friedman, & Kruglanski, 2003; Hassin, Bargh, & Zimerman, 2009), to emotional phenomenology (Shidlovski & Hassin, 2011). Interestingly, recent research shows that, under certain circumstances, implicit motivation may even have stronger influence than explicit motivation (Bijleveld, Custers, & Aarts, 2011).

The current research, then, examines whether and how implicit motivation modulates the effects of subliminal stimuli on choice. To do so we developed a novel paradigm that draws on the strengths of both paradigms described above. In the category-based choice task (CBC) paradigm participants are asked to choose one out of four category-labeled cards (see Fig. 1). The winning category is randomly determined in each trial, and if participants choose the right category they are rewarded. Prior to choosing, participants are exposed to a subliminal prime – an exemplar from the winning category. The CBC task, then, allows for measuring the effect of subliminal primes in *repeated decisions*, and the decisions can be rendered more or less *consequential* by manipulating reward.

The CBC allowed us to use two measures for distinguishing conscious from unconscious perception: subjective and objective (Merikle & Daneman, 2000). The first measure is an elaborate and motivated trial-by-trial *subjective measure*: Participants were asked to report the prime by typing it in a response window. This trial-by-trial probe method allows minimizing memory distortions (Kunimoto, Miller, & Pashler, 2001). A second indication of awareness was a trial-by-trial *objective* measure. After participants had made their choice, they were asked to make a lexical decision, namely, to determine whether the prime had been a word or a non-word (Reingold & Merikle, 1988).

[1] In Experiment 3, the authors examined how subliminal priming alters conscious phenomenology and thereby choice, in a way that is very similar to goal priming techniques used by various laboratories (see Custers & Aarts, 2010, for a review).

[2] In an interesting extension of this literature Veltkamp, Custers, and Aarts (2011) subliminally associated drinking-related words with positive affect, and showed that this manipulation also leads to increased drinking. Thus, the increase in physical need (and respective behavior) can result not only from deprivation, but also from a change in the need's hedonic value.

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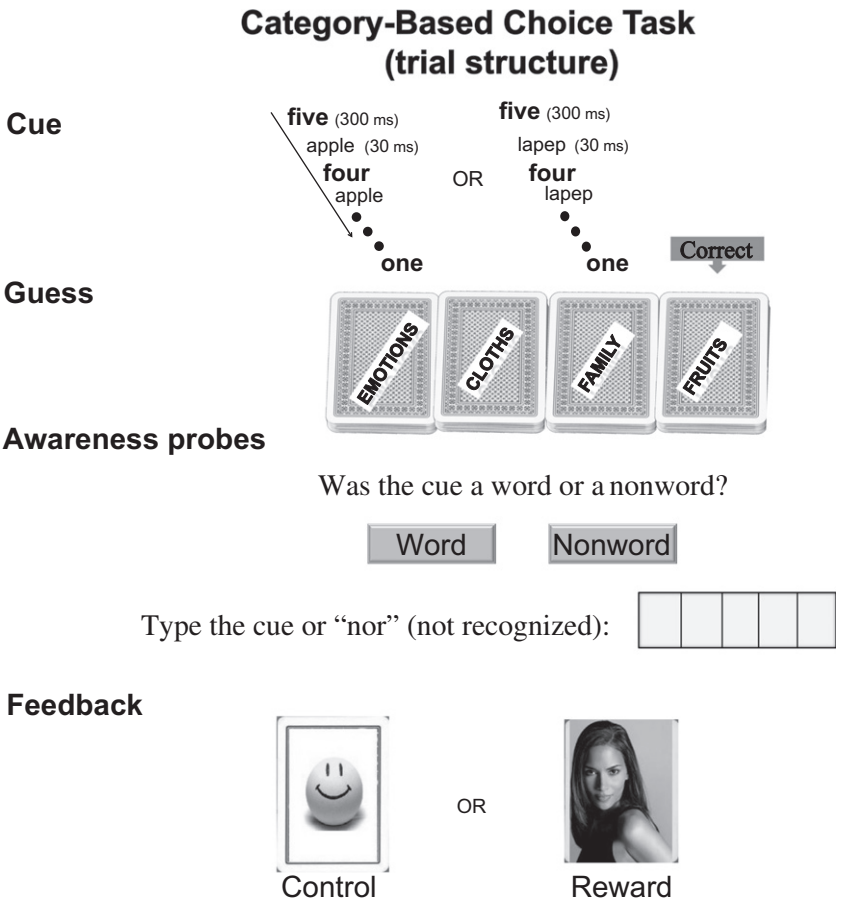

Fig. 1. The category-based choice task. On each trial, a cue is presented four times, embedded between the 5 number masks. Then, participants guess the winning category. Next, two awareness tests are conducted: (1) A lexical decision regarding the cue; (2) reporting the cue's letters. Feedback on the decision is given on each trial. In Experiment 1, two kinds of feedback images were used – control and reward.

Motivation was manipulated in two ways: We either subtly primed achievement motivation, or designed the feedback for correct answers so that it became more pleasant, thereby raising the incentive value of correct responses. Awareness measures at the end of the experiment suggest that these manipulations did not affect conscious commitment to the goals, and the use of statistical control suggests that their effects on behavior were independent of experienced motivation.

The two experiments reported below tested two hypotheses – that subliminal cues would improve participants' card-choices above chance level, and that implicit motivation will increase this effect.

4. Experiment 1

4.1. Method

4.1.1. Participants

Seventy Hebrew-University male undergraduates participated in the experiment in exchange for course credit (21 participants) or payment (49 participants, no difference between the two subsamples). They were run individually and were assigned randomly to one of three conditions: Primed motivation, Feedback motivation or Control.

4.1.2. Category-based choice (CBC) task

Each trial of the CBC task consisted of the following phases: priming, choice, and awareness testing (see Fig. 1 for a full depiction of a trial).

4.1.2.1. Subliminal priming. Each trial began with a visual, verbal countdown (i.e., *Five, Four, Three, Two, One*) that appeared in the center of the screen. Each number word appeared for 300 ms (font: Arial 60). These numbers served as forward and backward masks for the primes that were presented in the center of the screen for 30 ms (Arial 48), between consecutive numbers.

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4.1.2.2. Choice. Immediately after the countdown, four category-labeled cards (i.e., Emotions, Family, Fruits and Cloths; see Fig. 1) appeared on the screen, and participants indicated their choice using the mouse. The spatial location of the categories was randomly determined on each trial. The winning category was also randomly determined on each trial. Feedback on the choice was given after the awareness test (see more below).

4.1.2.3. Awareness testing. After having made their choice, a lexical decision (LD) probe appeared, and participants were asked to indicate whether the prime had been a word or a non-word. No feedback was given on the LD. Immediately after their response, a subjective report window appeared, and participants were instructed to type in the prime. They were told that each letter they correctly type in will be rewarded by 5 game points (no punishment for mistakes), thereby ensuring that it is in their best interest to report as many letters as they can. Participants were asked to type the letters "n.o.r" if they did not see the prime at all. This was done to minimize participants' tendency to refrain from reporting letters because this was easier than reporting letters.

We used two methods to examine awareness of the motivation. First, in the debriefing section, we asked participants to report wanting (i.e., "how much did you want to guess the winning card (1 – not at all; 9 – very much)". If explicit motivation is affected by priming then participants' ratings should reflect it (for similar logic see Aarts et al., 2005; Bargh et al., 2001; Eitam, Hassin, & Schul, 2008; Ferguson, 2008; Fitzsimons & Bargh, 2003; Hassin, Bargh et al., 2009). If, however, explicit motivation is not affected by priming, then we should find no differences between conditions. Another way of examining the role of phenomenal motivation, one that does not involve testing the null hypothesis, is to use participants' explicit ratings as a covariate in the analyses (for a similar logic see Kleiman & Hassin, 2011). If explicit motivation is correlated with the effects, then they should disappear upon entering the covariate. If it does not play a role in determining the effects of interest, then the covariate should not affect the main results.

4.1.2.4. Stimuli. The list of primes contained 32 items: 16 word-cues (see Appendix A) and 16 non-words. The cues were all tokens of the winning categories (e.g., the cue *joy* for the card *emotion*). Every non-word was arbitrarily assigned to one of the categories (e.g., *ireg* was assigned to the category *family*); the assignment was fixed for all participants in all blocks. Thus, every prime always predicted only one winning card.

4.1.3. Motivation manipulations

Motivation was manipulated in two different ways – through priming and through feedback incentives. In the *Primed-motivation condition* we employed a commonly used manipulation of implicit achievement motivation – a word-search puzzle (see for example, Bargh et al., 2001; Chartrand & Bargh, 1996; Eitam et al., 2008; Ferguson & Bargh, 2004; Hassin, Bargh et al., 2009). The word search consisted of a 10×10 array of letters, in which participants were to find words from a list that appeared on the page. In the Achievement condition, 6 out of 13 words were semantically related to achievement. Participants in the *Feedback-motivation condition* (see below) and in the *Control condition* received a word search puzzle with motivationally neutral words.

In the *Feedback Motivation condition* participants were shown a desirable picture of an attractive female as feedback for correct choices. As was shown in past research, men are motivated to exert effort to see faces of attractive women (Levy et al., 2008). The pictures were chosen randomly without replacement from a large pool of such photographs.[3] Participants in the Primed-Motivation condition and in the Control condition were shown a smiley instead. No feedback was given for incorrect choices.

4.1.4. Procedure and design

Upon arriving at the lab participants were told that the experiment would consist of several tasks. They first practiced the CBC task, then did the word-search task, and then went back to do the CBC. Before starting the CBC task, participants were given a thorough explanation of the task. They were encouraged to "use your intuition and gut feeling" in choosing the winning card and to report every single letter of the prime they recognized. Participants were told that a correct choice would win them 30 game points. Then they were familiarized with the list of the word cues. To prevent any benefit from counting the winning cards, participants were given no information about the expected frequency of primes, or about the size of the 'deck'. The experimental session consisted of one practice and three main blocks (32 trials each). Finally, participants were debriefed, thanked and dismissed.

4.2. Results

4.2.1. Preparing data

Four participants were excluded from the analyses. Three chose one card systematically, and the objective test performance of the fourth exceeded the mean performance by more than 3 SDs. All trials in which the RTs exceeded the mean of each condition by more than 3 SDs were also discarded (4% of all trials).

[3] To create this pool of pictures we submitted 180 pictures of women to a pilot test with 11 male participants, who were asked to rate attractiveness. The 70 highest-ranking pictures were used in the experiment.

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Table 1
Means (standard deviations in parentheses) of the major dependent measures (Experiment 1).

	Experimental condition		
	Primed (n = 22)	Feedback (n = 23)	Control (n = 21)
Unrecognized cues (%)[a]	70.5	80.8	80.5
Correct card-choices when cues were unrecognized (%)	29.8 (9.6)	30.1 (10.7)	23.3 (7.8)
Fully recognized cues (%)	18.9	12.8	12.1
Correct card choices when cues were fully recognized (%)[b]	99.1	99.8	100
RT of correct card-choices when cues were unrecognized (ms)	1969 (842)	2105 (1156)	2077 (1014)
RT of wrong card-choices when cues were unrecognized (ms)	1982 (638)	2198 (1137)	2067 (750)

[a] Cues were either unrecognized (0 letters reported), partially recognized (1–3 letters reported) or fully recognized (4 or more letters correctly reported).
[b] Due to the asymptotic performance, standard deviation of correct-choice performance following fully recognized cues is practically zero.

4.2.2. Subliminality of primes

4.2.2.1. Subjective test. To minimize the possibility that participants used partial awareness of cues to guess the card, we excluded all trials that met at least one of the following conservative criteria. When two or more letters were reported we excluded trials either if one of the letters was typed in its correct position or if two letters or more were recognized correctly regardless of their positions. If only one letter was typed in, the trial was excluded if the letter appeared somewhere in the prime. Overall, 22.6 % of all trials in which word cues appeared were discarded from the analyses (see Table 1).

4.2.2.2. Objective test. The accuracy of lexical-decisions in trials that were not excluded according to the criteria described above did not deviate from chance (M = 49.63, SD = 5.97), $t < 1$, d = 0.06.

4.2.3. Effects of subliminal cues on choice

4.2.3.1. Accuracy. First, we compared the accuracy of choices to that expected by chance (i.e., 25%). Planned t-tests show that the cues improved choices of participants both in the primed-motivation (M = 29.76, SD = 9.55), $t(21) = 2.34$, p = .03, d = 0.50 and in the feedback-motivation condition (M = 30.14, SD = 10.67), $t(22) = 2.31$, p = .03, d = 0.48.[4]

Performance in the control condition (M = 23.25, SD = 7.81) was not statistically different from chance, $t(20) = 1.03$, p = .31, d = 0.22.[5] Secondly, a between-participants ANOVA (Motivation: Control vs. Priming vs. Feedback) showed that motivation significantly affected performance, $F(2, 63) = 3.61,\ p = .03,\ \eta_p^2 = .10$ (see Table 1). The main effect was partitioned into two orthogonal components. The planned contrast comparing accuracy in the two motivation conditions to that in the control condition was highly significant, p = .009, d = 0.75. Yet, there were no difference between the two motivation conditions themselves, $t < 1$, d = 0.04. Thus, in the motivation conditions subliminal priming improved choices, while in the control condition there was no indication of its influence.[6]

4.2.3.2. Choice RT. A Mixed-Model ANOVA with Accuracy (Correct vs. Incorrect choice) as a within-participant factor and Motivation (Control vs. Priming vs. Feedback) as a between-participants factor was performed on choice RT. No significant effect was found, suggesting that the effects on accuracy were not caused by changes in speed-accuracy tradeoffs.

4.2.4. Awareness of motivation

To examine whether our manipulations altered phenomenology, we asked participants during the debriefing phase how much they wanted to make correct choices (see Section 4.1). There were no differences between conditions ($M_{control}$ = 6.57, SD = 2.34 vs. $M_{priming}$ = 6.96, SD = 2.26 vs. $M_{feedback}$ = 6.91, SD = 1.86), $F < 1,\ \eta_p^2 = .01$. Another way to dissociate the effects on behavior from explicit motivation is to add participants' explicit motivation ratings as a covariate to the analyses (see Kleiman & Hassin, 2011). ANCOVA conducted on card-choice accuracy, with Motivation as a between-participants factor, and Explicit motivation as a covariate, revealed that the effect of Motivation remained statistically significant, $F(2,62) = 3.47$, p = .04. Finally, it should be noted that although the accuracy of the motivated participants' was higher than of the controls, they were not investing more time in deliberating on their choices, which is in line with the recent findings on implicit motivation (Bijleveld et al., 2010). Altogether these results support our contention that the manipulation of motivation did not reach phenomenology.

[4] To further examine this issue we applied the regression method suggested by Greenwald et al. (1995). Regressing participants' priming scores (percent correct – chance level) on their objective test scores (percent correct – chance level) yielded significant positive intercepts in both motivation conditions, b = .05, p = .02, but not in the control one, b = –.02, p = .26. These results strongly indicate that the primes influenced choices even when they were invisible (Greenwald et al., 1995). The slopes were not significant, b = .37, p = .20, b = .60, p = .22 and b = .54, p = .07 for the primed-motivation, feedback motivation and the control conditions respectively.

[5] Since we had no a priori prediction regarding the non-word cues, we only conduct analyses for the word cues. Analysis of trials involving non-word cues reveal that the accuracy of card-guessing was not different from that expected by chance $M_{control}$ = 24.43, SD = 6.42, $t < 1$, $M_{priming}$ = 26.95, SD = 6.87, $t(21) = 1.33$, p = .20. In the Feedback condition the accuracy was higher than that expected by chance, yet since this effect was not hypothesized it awaits replication.

[6] If participants in the motivation conditions under-reported awareness to the cues, their superiority could be ascribed to trials in which they were aware of the cues but did not report awareness. Did they under-report then? The simple answer is no: there were *more* trials in which cues were recognized in the motivation than in the control conditions ($M_{motivation}$ = 24.23 vs. $M_{control}$ = 19.53), $t < 1$, d = 0.22.

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Table 2
Means (standard deviations in parentheses) of the major dependent measures (Experiment 2).

	Motivation (n = 49)		Control (n = 46)	
	Blocks (1–3)	Blocks (4–6)	Blocks (1–3)	Blocks (4–6)
Unrecognized cues (%)[a]	75.2	74.6	77.6	78.1
Correct card-choices when cues were unrecognized (%)	29.5 (10.8)	29.3 (9.6)	26.0 (10.1)	30.8 (9.6)
Fully recognized cues (%)	17.8	19.2	15.6	16.3
Correct card choices when cues were fully recognized (%)[b]	100	99.5	98.9	99.9
RT of correct card-choices when cues were unrecognized (ms)	2004 (786)	1637 (580)	2233 (1227)	1946 (887)
RT of wrong card-choices when cues were unrecognized (ms)	2045 (831)	1758 (727)	2285 (1159)	2003 (955)

[a] Cues were either unrecognized (0 letters reported), partially recognized (1–3 letters reported) or fully recognized (4 or more letters correctly reported).
[b] Due to the asymptotic performance, standard deviation of correct-choice performance following fully recognized cues is practically zero.

4.3. Discussion

Accuracy data showed that subliminal primes improved participants' choices. The effects on actual choices were only obtained in the motivational conditions, thus supporting our hypothesis that implicit motivation boosts the effect of subliminal primes.

The fact that there was no effect on choice in the control condition may suggest that enhanced implicit motivation is a necessary prerequisite for affecting decisions in the current paradigm. Based on our past research, however, we believed that this is not the case, and that the motivation manipulation simply allowed participants to more quickly learn how to use the primes (see Eitam et al., 2008). Accordingly, we hypothesized that non-primed participants should be able to develop this ability later. To test this hypothesis, we conducted Experiment 2, in which we doubled the number of trials.

5. Experiment 2

5.1. Method

5.1.1. Participants

Ninety-nine (61 females) Hebrew University undergraduates participated in the experiment in exchange for course credit or payment. They were randomly assigned to one of two conditions: motivation or control.

5.1.2. Procedure and design

The procedure was identical to that of Experiment 1, except two changes. First, there were only two conditions: Priming motivation and Control. Second, the number of experimental blocks was doubled to six.

5.2. Results

5.2.1. Preparing data

Four participants were excluded from the analyses. Two chose systematically one card; two others were excluded because their objective-test performance exceeded the mean participants' performance by more than 3 SDs. All trials with extreme card-choice RTs were discarded (4% of all trials).

5.2.2. Subliminality of primes

5.2.2.1. Subjective test. Participants' subjective awareness of the cues was analyzed (see Table 2 for means). We used the same exclusion criteria as in Experiment 1, and discarded 23.6% of all trials in which word cues appeared.

5.2.2.2. Objective test. The accuracy of the lexical decisions in the trials where no letter was recognized (M = 50.21, SD = 4.23) did not deviate from chance, $t < 1$, $d = 0.05$.

5.2.3. Effects of subliminal cues on choices

5.2.3.1. Accuracy. First, we compared the accuracy of card-choices following subliminal cues[7] to that expected by chance (25%). As predicted, across both conditions, participants benefited from the subliminal cues, $t(94) = 4.91$, $p < .001$, $d = 0.50$ (see Table 2). Simple-effect analysis revealed that the cues improved card-choices of the participants both in the motivation condition, $t(48) = 3.55$, $p = .001$, $d = 0.51$ and in the control condition, $t(45) = 3.4$, $p = .001$, $d = 0.50$.[8]

[7] Analyses of accuracy following non-word cues showed no deviation from chance, $M_{control}$ = 25.4, SD = 5.62, $t < 1$, and $M_{priming}$ = 24.75, SD = 5.2, $t < 1$. No difference in accuracy between the conditions was found, $F < 1$.

[8] Regressing participants' priming effect scores on their objective test scores yielded significant positive intercepts in both conditions, $b = .05$, $p = .001$ and $b = .04$, $p = .007$ for the control and the motivation conditions respectively (see Greenwald et al., 1995). These results indicate that the primes affected decisions even when their visibility was zero. The slopes were not significant, $b = .56$, $p = .06$ and $b = .21$, $p = .47$ for the control and the motivation conditions respectively.

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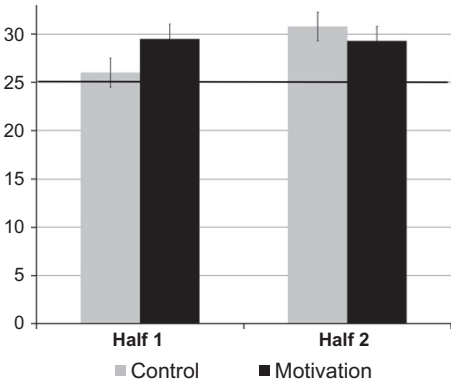

Fig. 2. Mean accuracy of choices following subliminal word-cues in the control and the motivation conditions in the two halves of Experiment 2.

In order to compare the accuracy of card-choices between the conditions, we conducted a mixed-model ANOVA with Half (1st vs. 2nd half of the experiment) as a within-participant factor, and Motivation condition (Motivation vs. Control) and Gender (Male vs. Female) as between-participants factors. In line with the hypothesis, the Motivation × Half interaction was significant, $F(1,91) = 4.27,\ p = .04,\ \eta_p^2 = .05$ (see Fig. 2). None of the main effects or other interactions reached significance, all $Fs < 2.1,\ \eta_p^2 < .023$.

To clarify the nature of the Motivation × Half interaction, we conducted additional paired *t*-tests comparing the performance in the 1st half to that in the 2nd half in each condition separately. This comparison revealed comparable accuracy in the two halves for participants in the Motivation condition (M_{1st} = 29.51, SD = 10.78 vs. M_{2nd} = 29.27, SD = 9.60), $t < 1$, d = 0.02. However, in the control condition a significant difference between the 1st and the 2nd half emerged, $t(45)$ = 2.32, p = .03, d = 0.48, indicating an improvement in performance in the 2nd half (M_{1st} = 26.0, SD = 10.13 vs. M_{2nd} = 30.78, SD = 9.62). Motivated participants performed above chance both in the 1st half, p = .005, d = 0.42 and in the 2nd half, p = .003, d = 0.45, while control participants performed at chance level in the 1st half, $t < 1$, d = 0.1 and above chance in the 2nd half, $t(45)$ = 4.08, p = .001, d = 0.60 (see Table 2).[9]

5.2.3.2. Choice RT. A mixed-model ANOVA with Accuracy of Choice (Correct vs. Incorrect) and Half (1st vs. 2nd) as a within-participant factors and Motivation condition (Motivation vs. Control) and Gender (Male vs. Female) as between-participants factors was conducted on the latencies of choices. This analysis revealed that correct card-choices were faster than the incorrect ones ($M_{correct}$ = 1940, SD = 771 vs. $M_{incorrect}$ = 2013, SD = 894), $F(1,91) = 5.01,\ p = .03,\ \eta_p^2 = .05$. This finding suggests that participants had to overcome their (prime based) intuition when making the wrong choices though since it was not found in Experiment 1, this conclusion should be taken with a grain of salt. There was no other main effects nor interactions, $Fs < 1.7,\ \eta_p^2 < .02$, indicating that motivated participants did not invest more time in their choices.

5.2.4. Awareness of motivation

As in Experiment 1, we asked participants during the debriefing phase how important it was for them to make correct choices. The differences between conditions were not significant ($M_{control}$ = 6.70, SD = 1.67 vs. $M_{motivation}$ = 7.04, SD = 1.72), $t < 1$, d = 0.20. To further test whether the accuracy of choice was influenced by the explicit motivation, we added explicit motivation as a covariate to the ANOVA described above. This measure did not change the nature of the results, and the Motivation × Half interaction was marginally significant, $F(1,90) = 3.67$, p = .06. Replicating Experiment 1, then, these analyses along with the lack of speed-accuracy tradeoff suggest that our motivation manipulation did not reach subjects' awareness.

5.3. Discussion

Replicating Experiment 1, both choice accuracy and choice RT show that participants' choices benefited from subliminal cues. Moreover, the first half replicated the pattern of Experiment 1 in which only implicitly motivated participants benefited from subliminal cues. In the second half, however, control participants gained from the subliminal cues too. Thus, our findings indicate that the time course of performance was different: When motivation was enhanced by the experimental manipulation the performance was above chance from early on, while in the control group it grew above chance only in the second half of the experiment.

The effects of motivation and practice were not additive as revealed by the similarity of accuracy performance in the two conditions in the second half. Speculatively, this pattern could reflect a diminishing impact of the motivation manipulation in later trials. Alternatively, performance in the second half reached a ceiling. We have preliminary findings from yet unreported research which are consistent with the former.

[9] In the 1st half, the difference between the conditions was marginally significant, $t(93) = 1.63$, p = .054, one-tailed, and in the 2nd half, no significant difference was found, $t < 1$.

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6. General discussion

The purpose of our research was to study whether and how implicit motivation modulates the influence of subliminal information on choice. The results of two experiments which use a novel paradigm show that subliminal information can directly affect choice, and that this influence is enhanced by motivation. Direct comparisons of explicit motivation, as well as its statistical control, suggest that our manipulations did not alter phenomenology, and yet altered choice. Thus, we conclude that implicit motivation modulates how we process subliminal cues.

In Experiment 1, subliminal cues improved accuracy of choices for motivated, but not for control participants. The results of Experiment 2 indicated that when given more practice, participants in the control condition reached the same level of performance as those in the motivation conditions.

Our results significantly extend in multiple ways previous investigations of the relation between motivation and needs on the one hand, and choice on the other. One important step is to extend the findings from physical needs to motivation more generally. The second important step is that we documented an effect of *implicit* motivation on the processing of subliminal primes. Thus, these results open the door for an improved understanding of how non-conscious cognitions and motivations affect other, ongoing, non-conscious processes. They also suggest that the scope of subliminal effects on choice is wider than we had thought, as they do not depend solely on conscious motivations, and can be produced by messages semantically unrelated to the current motivation.

Interestingly, our results replicate those of Bijleveld et al. (2011) – in that the increase in accuracy in the motivation conditions did not require more time (or, in more technical terms, was not accompanied by speed-accuracy tradeoff). How does implicit motivation improve the efficiency of the cognitive system is an intriguing question we leave for future research.

Our results also allow us to reexamine the current views on the preconditions for subliminal effects on choice. As was mentioned in the introduction, some researchers concluded that subliminal stimuli can bias choices only when a related physical need (e.g. thirst) is elicited (Strahan et al., 2002). Other researchers (Klapp & Haas, 2005) identified the activation of stimulus–response mappings as a necessary precondition for subliminal stimuli to bias choices. Our results allow us to reconcile these conclusions. Specifically, it appears that the influence of subliminal information on choice depends both on motivation and practice. As showed Experiment 2, motivation indeed increased the effect of subliminal primes in the early blocks, yet given enough practice participants in the control condition reached the same level of performance. Our findings suggest that stimulus–response mapping is not necessary to obtain the effect of subliminal stimuli on choice (Klapp & Haas, 2005). In CBC, participants could not create stimulus–response mappings since they always used the same motor response (mouse button), while the choice alternatives (cards) appeared each time in different location on the screen. Also, unlike the priming paradigms reviewed in the introduction (e.g., Schlaghecken & Eimer, 2004) the prime stimuli were never presented supraliminally during the experiment proper. In short, neither conscious activation of stimulus–response mapping nor enhanced motivation should be considered as necessary preconditions for subliminal effects on choice. Thus, we suggest that both bottom-up and top-down activation are important for subliminal stimuli to become accessible to choice behavior (Dehaene, Changeux, Naccache, Sackur, & Sergent, 2006; Eitam & Higgins, 2010; Eitam et al., 2008).

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Appendix A

Prime words and non-words used in Exp.1 & 2 in English (Hebrew).

	Cards			
	Family (משפחה)	Emotion (רגש)	Cloth (בגד)	Fruit (פרי)
Words	aunt (דודה)	love (אהבה)	hat (כובע)	mango (מנגו)
	sister (אחות)	joy (שמחה)	pants (מכנס)	apple (תפוח)
	grandma (סבתא)	anxiety (חרדה)	vest (חזיה)	banana (בננה)
	sister-in-law(גיסה)	jealousy(גיסה)	shirt (גופיה)	pineapple (אננס)
Non-words	danhakh (דנהה)	nadsach (נדסח)	bauch (בעוכ)	szut (סזות)
	saremet (סרמת)	citam (ציתם)	kimsa (כימסה)	bagatam (בגתם)
	matskeach (מצכח)	dahma (דחמה)	rasmam (רסמם)	kamsu (כמסו)
	ireg (אירג)	ragham (רגהם)	nismenet (נסמנת)	tsihma (ציחמה)

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