doi:10.1080/17461391.2017.1339735

Induced Beliefs About a Fictive Energy Drink Influences 200 m Sprint Performance

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The authors have no conflict of interest to declare. No funding was obtained for this research.
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Abstract

Placebo and nocebo effects occur in response to subjective expectations and their subsequent neural actions. Research shows that information shapes expectations that, consequently, influence people's behaviour. In this study, we examined the effects of a fictive and inert green-colour energy drink provided for three groups (n=20/group) with different information. The first group was led to expect that the drink *augments running performance* (positive information), the second group was led to expect that the drink *may or may not improve performance* (partial-positive information), while the third group was told that earlier research could not demonstrate that the drink improves performance (neutral/control). At baseline, the three groups did not differ in their 200 m sprint performance ($p > .05$). One-week later, 20-min immediately after ingesting the drink, all participants ran again 200 m. The positive information group increased its performance by 2.41 s, that was statistically significant ($p < .001$) and also perceived its sprint-time shorter ($p < .05$) than the other two groups. A better performance (0.97 s) that approached, but did not reach statistical significance, was also noted in the partial-positive information group-, and a lesser change (0.72 s), that was statistically not significant, was noted in the neutral information control group. These results reveal that drinking an inert liquid, primed with positive information, changes both the actual and the self-perceived time on 200 m sprint. The current findings also suggest that the level of certainty of the information might be linked to the magnitude of change in performance. ***Key words:*** Athlete; Conditioning; Exercise; Expectation; Placebo

Induced beliefs about a fictive energy drink influences 200 m sprint performance

The "Expectancy Theory", proposed in the context of social learning (Bandura, 1977), is a hybrid of learning and subjective mental-neural processes (White, Bates, & Johnson, 1990). The theory explains behaviour through individuals' expectancies of the rewarding effects of their action toward a desired outcome. Whether the expectancies are valid/rational is unimportant; to have an effect on a behaviour, they simply need to exist (Jones, Corbin, & Fromme, 2001). Research shows that expectancies raise brain glucose metabolism by up to 50%, mainly in the thalamus region (Volkow et al., 2003). Further, the strength of the expectancies may mediate the outcome, since different brain regions appear to be activated by the certain and less certain, or uncertain, expectancies (Ploghaus, Becerra, Borras, & Borsook, 2003).

Given that the beliefs-linked expectancies modify the neural processes in the brain, they also play part in the placebo response (Atlas, & Wager, 2012; Stewart-Williams & Podd, 2004), which is a pleasant and desired outcome induced by subjective beliefs that one has received a beneficial treatment (Clark, Hopkins, Hawley, & Burke, 2000). Placebo effects may surface in sports (Szabo, 2013) by enhancing physical and/or mental performance. Beedie and Foad (2009) reported -7.8% to 50.7% placebo-effects in 12 intervention studies, while a meta-analysis of 14 studies yielded a mean effect size of .31 (Bérdi, Köteles, Szabó, & Bárdos, 2011).

Qualitative research, based on interviews with cyclists, suggests the placebo-effects occur in four categories: (a) beliefs, (b) pain sensation, (c) expectancy, and (d) arousal, and stem from beliefs based on information given to the athletes prior to, or during performance (Beedie, Stuart, Damian, & Foad, 2006). Therefore, information shapes the beliefs and, thereby, the actions of individuals. Beliefs trigger neurological activities (Meissner et al., 2011) similar to psychoactive agents (Price, Finniss, & Benedetti, 2008). Positive beliefs induce facilitating *placebo* effects, negative beliefs yield debilitating *nocebo* effects (Benedetti, Lanotte, Lopiano, & Colloca, 2007).

The effects of information-induced beliefs were sparsely studied in sports and exercise. In a longitudinal study by Desharnais, Jobin, Cote, Levesque, and Godin (1993) it was found that an exercise program delivered with positively biased information for one group, resulted in psychological benefits in contrast to a non biased control group. In a later work, in a 10-min exercise study, the mood of the participants has improved in function of the biased recall of pre-exercise mood (Anderson & Brice, 2011). Recently, Szabo and Kocsis (2016) demonstrated the net effect of information bias on the subjectively perceived well-being after 3-min deep-breathing where the information biased group reported more positive changes than the non biased group. Earlier, Crum and Langer (2007) showed that mere information bias, without any intervention, could favourably alter the blood pressure, body fat, body mass index, waist-to-hip ratio, and body mass in women, however, apart from blood pressure, the replication of the results has failed in another work (Stanforth, Steinhardt, Mackert, Stanforth, & Gloria, 2011).

Wullimann (2010) examined the effects of the type of information and manipulated the expectancy linked to physical activity in positive-, neutral-, and negative information biased groups. The author found that the positive information resulted in increased levels of physical activity and psychological well-being. Similarly, Horcajo and De La Vega (2014) revealed that attitudes toward doping legislation changed in parallel with the type of information. In an acute intervention study (Duncan, Lyons, & Hankey, 2009), subjects who were led to believe that they drunk caffeine exhibited better performance in contrast to the controls. Based on the handful of studies in the area, it is evident that information-manipulated beliefs have an effect on behaviour.

In the present work we tested the hypothesis that the manipulation of information and its level of certainty has a measurable effect on 200 m sprint-run performance. Specifically, we hypothesized that the positive information associated with the fictive energy drink will result in shorter 200 m sprint time and similar, but less prominent, results may surface in the partial positive information group too, but not in the neutral information group.

Method

Participants

Sixty participants were recruited for this study from two local sports facilities and were included only if they were active runners over the age of 18 capable of performing two 200 m sprints a week apart. The required sample size (n=57), calculated by using the G*Power (v. 3) software (Faul, Erdfelder, Lang, & Buchner, 2007), was based on power (1-β) = .95, a medium effects size (Cohen's d = 0.5; Cohen, 1988), α = .05, with two dependent measures and three groups. Participants mean age was 26.93 (±SD = 7.51) years, that ranged from 19 to 56 years. There was a relatively balanced ratio between men (47%) and women (53%). All participants provided written informed consent to taking part in the study. The research was approved by the institution's ethics board and it was carried out in accord with the Declaration of Helsinki (Harriss & Atkinson, 2009) as well as human participant research guidelines of the British Psychological Society and World Medical Association (The British Psychological Society, 2010; World Medical Association, 2008).

Design

A two-way mixed experimental design was used in which participants were randomly assigned to one of three drink-information groups (between-subjects factor: positive-, partial positive-, and neutral information) and repeated a 200 m sprint one week apart (trial, within-subjects factor: baseline and intervention).

Procedure

All testing took place at the same time of the day, during the normal working hours. Upon reporting for the testing, participants first signed the consent form and when ready, after a warm up, they sprinted 200 meters on the indoor running track while the time of the run was recorded with an Ultrak 360 digital stopwatch by one of the experimenters. Subsequently, the person was given an appointment one week later at the same time of the day. The first test (at baseline) was the identical for all participants.

Before the second test, participants were randomly allocated to three groups. The only difference between these groups was the information provided to them before drinking 200 ml of a fictive green energy drink, which took place 20 minutes preceding their second 200 m sprint test. The information given to the three groups were a) positive: the drink improves performance, b) partial positive: the drink may or may not improve performance, and c) neutral: the drink does not affect performance. The drink consisted of plain drinking water tainted green with a commercially available food colorant, obtained through the mixing of the blue and yellow colorants (Colorantes Alimentarios; Vahiné, 2012). The manufacturer's indicative composition is water, dyes (yellow: E102, blue: E133), citric acid, and a preservative (E202). Four to five drops were sufficient to colour 1-liter preparation, that yielded five doses of the fictive energy drink.

After ingesting the fictive energy drink, participants gently warmed-up for 15 minutes and then sprinted 200 meters again. Their time was recorded by the same experimenter who was blind to the group assignments. After the second run, participants were provided with their run-time at baseline (the first run one week earlier), following which they were asked to estimate their current run time (perceived time). Ensuing, they were debriefed, but to avoid spread of information and bias in the data, the deception associated with the intervention, and the aim of the work, was only disclosed after all the 60 participants completed the study.

Data Analyses

All calculations were performed with the SPSS (v. 22) software. To test the effects of the information-induced beliefs on sprint performance, the data were analysed with a 3 (groups: positive information, partial positive information, and neutral information) by 2 (time: baseline and intervention) mixed model repeated measures analysis of variance (RM-ANOVA) using gender as covariate. The differences between baseline sprint times in the three groups and the difference between the actual and perceived sprint times after ingesting the drink were analysed with univariate analysis of variance (ANOVA).

Results

At baseline, the three groups did not differ in their 200 m sprint performance ($p > .05$). The RM-ANOVA yielded a statistically significant group by time interaction (Wilk's Lambda = .968, $F_{2,\,56} = 6.48$, $p = .003$, effect size: partial ETA squared (η_p^{2}) = .187, power (1-β) = .889). The covariate (gender) had no effect on the results. The interaction was followed up with three paired t-tests, comparing the baseline with the intervention sprint times within each group. We used the conservative Bonferroni correction (α/number of tests) for these multiple t-tests, which has reduced the acceptable level of error probability to $\alpha = 0.017$. Based on this adjustment, as shown in Table 1, the positive information group improved its sprint performance, but an evident and statistically considerable trend has also emerged in the partial positive information group, while statistically no significant change was seen in the neutral information group.

Insert Table 1 about here

Finally, the ANOVA testing the difference (Δ) scores between the actual- and perceived sprint times during the second run (after the drink intervention) yielded a statistically significant group main effect ($F_{2,\,57} = 5.43$, $p = .007$, $\eta_p^{2} = .160$). The post-hoc Bonferroni comparisons showed that the positive information group (Δ = -1.66, 4.07%) differed statistically significantly ($p = .006$) from the neutral information group (Δ = -0.32, 0.79%), but only showed a non-significant trend ($p = .087$) in contrast to the partial positive information group (Δ = -0.73, 1.88%). The latter and the neutral information group did not differ from each other ($p > .05$).

Discussion

The current findings show that the nature of the information affects outcome behaviour as demonstrated in the 200 m sprint run. Strengthening Duncan et al.'s (2009) and Wullimann's (2010) works, these findings may be important and merit consideration from both research and applied perspectives, because they shed new light on the relationship between the form, or the level, of information and exercise behaviour. The key mediating factor between the two is most likely the information-based beliefs, that in past research was shown to alter brain functions (Benedetti, Mayberg, Wager, Stohler, & Zubieta, 2005), to yield a modified response. These are placebo responses manifested primarily by "responders" who fully trust the information to alter their expectation through which the behavioural modification occurs (Benedetti & Frisaldi, 2014). However, there are "non-responders" too, who handle the information with scepticism and, therefore, the neural connection to an outcome behaviour remains inactivated due to lack, or weak expectation (Benedetti & Frisaldi, 2014). Therefore, in addition to information, the trust or strength of belief in the provided information should be also assessed. Earlier research has demonstrated that the level of subjective certainty, yielding the belief-linked expectancy, may be a principal mediator in the outcome (Ploghaus et al., 2003). Subjective certainty can be manipulated with the level of information (positive, or partial positive) as also demonstrated in the current work. Future studies should replicate the current study with both placebo responders and non-responders, or at least gauge the strength of belief, in the presented information, to obtain a more specific picture about the impact of information-priming on one's behaviour.

The results of the current work agree with the limited past research that disclosed a link between information and psychological or physiological behavioural responses (Crum & Langer, 2007; Desharnais et al., 1993; Duncan et al., 2009; Horcajo & De La Vega, 2014; Szabo & Kocsis, 2016; Wullimann, 2010). The current results also expend the knowledge from past research. For example, by using a short exercise intervention, this study expands the findings of Wullimann (2010), showing that not only the perceived (subjective) performance, but also the actual (objective) performance increases significantly when the information is aimed at inducing a positive expectancy. The current results also show that when only partial positive information is delivered to the participants, the behaviour appears to change in accord with subjectively-generated beliefs based on the partial information that may not be independent of past experience with, or possible learned information about the intervention. The role of the latter two should be untangled in future studies.

The marginal improvement in the partial positive information group may be due to self-generated associations between the thought to be a green energy drink and expected performance. Without knowing the actual ingredients, hypothetical green drinks are believed to be the most potent in enhancing strength and endurance as compared to other hypothetical performance enhancers, ranging from white powder to red pill (Szabo, Bérdi, Köteles, & Bárdos, 2013). In spite of this plausible explanation, the change in performance in the partial positive information group only bears tentative interpretations, because the actual beliefs associated with the drink were not assessed. Although in contrast to the baseline the subjectively perceived sprint time showed a decrease, the difference was statistically not significant in contrast to the neutral information group. However, given the perceptual characteristics of the unlabelled green drinks (Szabo et al., 2013), it is possible that even the neutral information group has generated some sort of positive beliefs in context of the drink, since their performance, both objective and subjective, has also increased slightly (1.76% and 0.79%, respectively). However, these changes were not statistically significant and cannot be compared to the more robust changes induced by the positive or partially positive information; they also may simply reflect a non-significant practice effect.

Limitations of the study

The obvious limitation of the current work is the lack of a random sample, the recruitment of which is difficult, if not impossible, when researchers are aiming for a skill-dependent sample. The other two limitations are linked to the understanding of the observed placebo effects. The first is that the subjective belief about the drink was not determined, instead only the perception of performance change, in contrast to the previous run, was the sole subjective measure. Second, not independent from the first, is that the past experience with energy drinks was not assessed in the current work, which could be another potential mediator of the observed placebo responses. Further, one may critique the use of a handheld stopwatch for measurement accuracy, but past research has shown that the average error in recording 200 m sprint times is about 0.05 s, while the handheld measurements also correlate strongly with electronic measurement ($r > .96$; Hetzler, Stickley, Lundquist, & Kimura, 2008). Finally, even though the participants were experienced runners, their sprint time data could have been contaminated by practice effects. In spite of the logical assumption that such effects would surface equally in the three groups, and that they would be no more than that observed in the neutral information group (i.e., 0.72 s), their actual impact is unknown. Future studies, employing a similar design, should conduct familiarization trials before the actual intervention.

Conclusions

The current research reveals that a 200 m sprint-run performance can be altered via mere information supplied to the participants. The level of certainty of the information, linked to the intervention, affected the level of change in performance. Clear positive information had a greater effect than only partial positive information, while neutral information did not have an effect on performance. The observed changes may be closely related to information-generated subjective beliefs of varying strength, that could trigger various levels of expectancies, affecting the neurophysiological system in performance behaviour. In this context, the current study also raises questions for future studies concerning the role of personal beliefs, their strength, and their link to expectancy-mediated action(s) for the better understanding of the mechanism(s) through which external information influences one's objective performance.

Acknowledgments

The author wish to thank the meticulous work of two anonymous reviewers, as well as their constructive feedback and valuable suggestions, that were extremely helpful in improving the current report.

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Table 1

Means and standard deviations (in brackets) of the 200 m sprint-times in three groups. The statistical (paired t-test) analysis of the within-group differences between baseline and intervention run times are presented along with the differences in seconds (s), t values, confidence intervals of the difference (95% CI of Δ), alpha (α) error probability levels (p), and Cohen's d (1988) effect sizes.

Group	**Baseline (Time 1)**	**Intervention (Time 2)**	***Difference (seconds)***	***t* (19)**	**95% CI of Δ**	***p***	**Effect size (*d*)****
Positive information	40.72 (9.09)	38.31 (8.48)	2.41 s	9.27	1.87-2.95	<.001	1.939
Partial positive information	43.75 (11.23)	42.78 (11.14)	0.97 s	2.58	0.18-1.77	=.018*	0.613
Neutral information	37.59 (6.69)	36.87 (6.70)	0.72 s	1.72	-0.16-1.59	=.103	0.378

NOTE:*Since the Bonferroni corrected alpha (α) was 0.017, the p = .018 can only be considered a strong trend; **Corrected for the dependence between the means, using Morris and DeShon's (2002) equation No. 8.