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LikeWant: A new methodology to measure implicit wanting for flavors and fragrances

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ABSTRACT

According to the incentive salience hypothesis framework (Berridge, 2007, 2012; Berridge & Robinson, 1998, 2003; Berridge, Robinson, & Aldridge, 2009), wanting and liking can be dissociated, suggesting that two products having similar liking levels could trigger different wanting behaviors in consumers. Defined as a motivational state that promotes approach toward and consumption of rewarding stimuli, wanting can be measured through the Pavlovian instrumental transfer (PIT) procedure. Having emerged from animal models, the PIT procedure aims to measure the effort exerted by an organism (consumer) to obtain a particular reward (product). By adapting and optimizing existing human PIT procedures, we developed *LikeWant*, an innovative behavioral method that measures consumers' motivation to pursue flavors and fragrances as rewards. Two studies were conducted to test the sensitivity of the *LikeWant* procedure. In the first experiment, we investigated the sensitivity of the *LikeWant* procedure to measure wanting for a pleasant odor with odorless air as a neutral control. In the second experiment, we assessed the ability of the *LikeWant* procedure to simultaneously measure wanting for two competing fine fragrances. The results showed that the *LikeWant* procedure is able to (1) measure wanting for a pleasant odor with odorless air as a neutral control condition and (2) discriminate between two fine fragrances on the basis of their rewarding properties, potentially enabling the use of the procedure in consumer studies.

1. Introduction

During the last century, competitive theories emerged to allow a better understanding of the cognitive mechanisms underlying reward processing. Of these theories, the incentive salience hypothesis (Berridge, 2007, 2012; Berridge & Robinson, 1998, 2003; Berridge, Robinson, & Aldridge, 2009) is the most prominent. This hypothesis argues that reward processing can be dissociated both psychologically and neurobiologically into two distinct components: liking and wanting. Wanting, or incentive salience, refers to a cognitive process that induces approach toward and consumption of rewarding stimuli, whereas liking refers to the hedonic experience that is immediately gained from its consumption. In general, wanting and liking are positively correlated, meaning that the effort exerted by an organism to obtain a particular reward is proportional to the pleasure experienced from its consumption. Moreover, under particular circumstances, wanting and liking can be dissociated, meaning that an organism (consumer) could irrationally work to obtain a reward (product) that is not liked once consumed. Thus, two products having similar liking levels could potentially trigger different wanting behaviors in consumers. According to Berridge's theory, incentive salience has both perceptual and motivational features. On the one hand, the salience attribution converts the perceived reward into an object that captures the attention of the organism. On the other hand, the incentive attribution transforms the perceived reward into an object of attraction, making the organism work to obtain it. When perceived with incentive salience, a product has thus the ability to grab consumer's attention and elicit an appetitive and consummatory behavior. Incentive salience can be triggered not only by the perception of a rewarding unconditioned stimulus (UCS; the product itself), but also by its conditioned stimulus (CS; its brand and packaging), i.e. a formerly neutral stimulus that, after being repetitively associated with the UCS, predicts the presence of the UCS. While a CS

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encounter generally triggers wanting for its related UCS, the CS often becomes highly desirable and attractive per se (a “motivational magnet”; Berridge, 2007), even to an irrational degree (Berridge, 2012). That is, the CS could trigger the response produced by the UCS itself, with the organism working to obtain the CS even in the absence of the UCS. Notably, incentive salience is an unconscious mechanism that results from the interaction between the Pavlovian system and the physiological state of the organism (e.g. satiety, hunger; Zhang, Berridge, Tindell, Smith, & Aldridge, 2009) and is distinguishable from explicit desires, which involve explicit goals or expectations (see explicit wanting; Berridge & Robinson, 2003).

The incentive salience hypothesis became increasingly popular among behavioral scientists who were interested in human motivation. Although dissociation between liking and wanting components in humans has been suggested for food (Berridge, 2009; Epstein, Truesdale, Wojcik, Paluch, & Raynor, 2003; Finlayson, King, & Blundell, 2007a, 2007b, 2008; Lemmens et al., 2009), alcohol (Arulkadacham et al., 2017; Hobbs, Remington, & Glautier, 2005), nicotine (Brauer, Cramblett, Paxton, & Rose, 2001; Tibboel et al., 2011), and sex (Dewitte, 2015; Krishnamurti & Loewenstein, 2012), there is ongoing debate regarding *how* to best dissociate these components in human studies (Havermans, 2011, 2012). In an interesting review, Pool, Sennwald, Delplanque, Brosch, and Sander (2016) concluded that an important number of human studies include measures that do not reflect wanting and liking as defined in the animal literature, i.e. within the incentive salience hypothesis framework. Indeed, wanting is often measured through subjective ratings (45% of the studies), by way of single quantitative questions (e.g. “How much do you want to eat this item right now?”, Born et al., 2011; “How much do you want to smell this again?”, Triscoli, Croy, Olausson, & Sailer, 2014), or with questionnaires (e.g. the Partner-Specific Sexual Wanting Scale, Krishnamurti & Loewenstein, 2012; the Desires for Alcohol Questionnaire, Love, James, & Willner, 1998). Although explicit measures have shown high validity for assessing affective experiences, subjective ratings could have limitations, since wanting and liking reactions can occur at an implicit level, without conscious awareness (Berridge & Robinson, 2003; Tibboel, De Houwer, & Van Bockstaele, 2015). Two promising approaches were proposed to measure human wanting without using introspective methods: (1) by adapting existing implicit methods such as the Implicit Association Task (Dewitte, 2015; Koranyi, Grigutsch, Algermissen, & Rothermund, 2016; Tibboel, De Houwer, et al., 2015; Tibboel et al., 2011; Wiers, van Woerden, Smulders, & de Jong, 2002) and (2) by adapting effort measures used in animal models (for a review, see Cartoni, Balleine, & Baldassarre, 2016). The latter has the advantage of measuring wanting in a similar way to that defined in the incentive salience hypothesis framework.

Pavlovian instrumental transfer (PIT) is a key procedure assessing wanting for reward-associated cues. Having emerged from animal models (e.g. Wyvell & Berridge, 2000), the PIT procedure is composed of three main phases: the Pavlovian conditioning, the instrumental conditioning, and the transfer test. During the Pavlovian conditioning, animals are trained to associate neutral stimuli (e.g. auditory cues) with the delivery of the rewarding UCS (e.g. sucrose pellets): after repeated associations with the UCS, the previously neutral stimuli (e.g. auditory cues) become conditioned stimuli (CSs). That is, the rewarding properties of the UCS are transferred to the CSs, making the latter able to trigger the wanting response produced by the UCS itself. During the instrumental conditioning, animals are trained to perform an instrumental action (e.g. press on a lever) to receive the rewarding UCS (e.g. sucrose pellets). Finally, during the critical transfer test, the instrumental task is performed again, but this time, the CSs are presented during the session. The effect of presenting the Pavlovian cues over the instrumentally learned behavior is thus evaluated, which is known as the “Pavlovian-To-Instrumental” transfer (PIT) effect. Notably, the transfer test is normally conducted under extinction, meaning that expected rewards (UCS) are not delivered after the instrumental action. Since the hedonic experience is avoided under extinction, the investigator obtains a pure measure of wanting dissociated from liking.

An example of a successful human PIT study comes from Talmi, Seymour, Dayan, and Dolan (2008). In this study, participants first learned to associate two combined auditory and visual stimuli (CSs) with the presence and the absence of a monetary reward of 20 pence (UCS). The bimodal stimuli presented in the presence of the UCS denoted the positive CS (CS+), whereas the bimodal stimuli presented in the absence of the UCS denoted the negative CS (CS-). During the instrumental conditioning, participants learned to squeeze a handgrip to obtain the same monetary reward (UCS). Finally, during the transfer test, the authors examined the frequency with which participants squeezed the handgrip in the presence of either CS+ or CS- under extinction. Results suggested that the frequency of handgrip squeezes increases in the presence of the CS+ stimuli (i.e. the PIT effect). Pool, Brosch, Delplanque, and Sander (2015) adapted this procedure to measure wanting for a chocolate odor under different stress conditions. Similar to Talmi’s procedure, during the instrumental conditioning, participants were asked to squeeze a handgrip to trigger the release of the reward, i.e. chocolate odor (24 trials). During the Pavlovian conditioning (36 trials), participants learned to associate the presence and absence of the chocolate odor with two neutral images, i.e. CS+ and CS-, respectively. Finally, during the critical transfer test (45 trials); the squeeze frequency was measured in the presence of CSs (CS+ and CS-) and under extinction. The results of the transfer test showed that squeeze frequency increased during CS+ trials, suggesting that the PIT procedure can be successfully used to measure wanting for sweet olfactory rewards in humans.

Although existing human PIT procedures were successfully validated to measure wanting for chemosensory stimuli (Chillà et al., 2019; Pool et al., 2015), such methods cannot be applied as is in consumer research for several reasons. First, existing olfactive PIT procedures are too time-consuming (about 40 min) to be used to evaluate wanting for flavors and fragrances on a regular basis. Second, the Pavlovian learning indicators proposed in existing olfactive PIT (reaction time on the key-pressing task and likability of the CSs) cannot be used at an individual level to identify – and potentially exclude – participants who did not learn UCS-CS contingencies. Third, since PIT existing procedures end with a long series of trials performed under extinction, participants should not have previous experience with the experimental procedure. For this reason, existing PIT procedures cannot handle a within-subjects design. Enabling repeated measures is nevertheless crucial in consumer research, where participants could be asked to provide wanting data for a series of products or for a particular product over time. By adapting and optimizing existing human PIT procedures, we developed *LikeWant*, a new procedure that is likely to suit the following consumer research requirements: reduced experimentation costs, performance assessment at an individual level, and the ability to enable repeated measures design. One of the biggest challenges was to reduce as far as possible the execution time of the whole *LikeWant* procedure (from 40 to 15 min) while ensuring its sensitivity and validity. This was made possible by (1) drastically reducing the number of trials in the whole procedure, (2) integrating the instrumental learning phase (ILP) in the wanting task, (3) providing shorter instructions to participants, (4) removing the baseline, and (5) optimizing ergonomic aspects, thus facilitating the administration of the task. To assess UCS-CS learning performance at an individual level, we introduced a new task into the procedure: the Pavlovian check phase. Finally, repeated measures design has been made feasible by (1) minimizing as much as possible the number of trials performed in the extinction phase (EP), measuring thus wanting for each CS in a critical trial under extinction; and (2) by introducing a reconditioning phase (RP) immediately after the EP, providing participants with the expected reward.

In the experiments presented here, we aimed to evaluate the sensitivity of the *LikeWant* procedure by using food and nonfood odors (Experiment 1), extending its application to fine fragrances (Experiment

2). Existing human PIT studies showed that participants invest more effort during the presentation of a cue previously associated with the reward, CS+, than they do during the presentation of a cue associated with its absence, CS-. In particular, Pool and co-workers (2015) found that PIT procedures are able to measure wanting for chocolate by using a neutral condition – i.e. odorless air – as a control. Nevertheless, it is still uncertain as to what PIT procedures can be used to simultaneously measure wanting for two olfactory rewarding stimuli in the same experience. Recent studies showed that PIT procedures are able to discriminate between two odors characterized by a wide range of reported pleasantness – with participants exerting more effort to obtain pleasant odors than to obtain odors having a neutral hedonic value – but they lack sensitivity when discriminating between two pleasant odors (Chillà et al., 2019). In the first experiment, we investigated the sensitivity of the *LikeWant* procedure to measure wanting for a pleasant odor with odorless air as a neutral control. In the second experiment, we assessed the ability of the *LikeWant* procedure to simultaneously measure wanting for two competing fine fragrances. Finally, in these experiments we also aimed to assess and compare the sensitivity of different wanting indicators. Following the procedure usually applied in the literature (Chillà et al., 2019; Pool et al., 2015; Talmi et al., 2008), we extracted the number of squeezes surpassing 50% of each participant's maximal grip strength, i.e. the squeeze frequency. In addition, two additional indicators (expressed in volt-seconds, V·s) were extracted by computing the integral of the handgrip signal with trapezoidal numerical integration: the total force (reflecting participants' energy investment during a particular trial) and the force exceeding 50% of the participants' maximal grip strength (reflecting participants' superfluous energy investment during a particular trial). Force indicators have two advantages over squeeze frequency. First, since participants are explicitly instructed to squeeze the handgrip to obtain rewards, they may expect that squeeze frequency is tracked. Conversely, they are likely to be unaware that complex force measurements are being conducted by the investigator. Second, the force exerted on the handgrip is less easy to control than the squeeze frequency. The lack of awareness of what is being assessed and the lack of controllability of the response are often mentioned as requirements for implicit tests (Fazio & Olson, 2003; Greenwald & Banaji, 1995; Petty, Fazio, & Briñol, 2009). For these reasons, force measurements could be valuable implicit wanting indicators. In particular, since an effort of 50% of the maximal grip strength is sufficient to obtain the expected rewards, any effort exceeding this threshold should be considered superfluous, unnecessary, irrational, and contrary to the principle of least effort (Zipf, 1949). This indicator appears to be even more relevant in light of Berridge (2007) consideration: "Conditioned incentive salience (…) is manifested at the CS as a sudden and frenzied burst of effort to obtain the UCS reward" (p. 410). We consider the force exceeding 50% of the participants' maximal grip strength a privileged implicit wanting indicator.

2. Experiment 1

2.1. Method

All the experience data and analysis scripts used are available on the OpenScience Framework platform at: https://osf.io/6ywk2/.

2.1.1. Participants

Thirty-six undergraduate psychology students (mean age: 22.52 ± 4.81 years; 32 females and 4 males; 34 right-handed and 2 left-handed) participated in this experiment. All participants were native French speakers or declared themselves as being fluent in French. In addition, all participants declared themselves as being healthy and without a history of major neurological or psychiatric disease. Participants signed the consent form prior to the start of the experiment and received course credits in exchange for their participation. This study was approved by the ethical committee of the Department of Psychology of The University of Geneva.

2.2. Materials

2.2.1. Visual stimuli

In a preliminary study, 34 participants (mean age: 27.7 ± 2.97) were asked to rate the pleasantness of 33 geometric images by using a 10-points Likert scale from "not pleasant at all" to "extremely pleasant." The eight images evaluated as most neutral were included in our software (average score: 4.91 ± 0.23). Three of these images were randomly selected for each participant and used in the experimental procedure.

2.2.2. Olfactory stimuli

In a preliminary study, 30 participants (mean age: 28.6 ± 5.66) were asked to rate the intensity, pleasantness, edibility, and familiarity of an initial set of 25 food and nonfood odors by using Likert scales from "not pleasant at all", "not intense at all", "not familiar at all", and "not edible at all" to "extremely pleasant", "extremely intense", "extremely familiar", and "extremely edible." From the results, we selected a subset of nine food and nonfood odors ranging from neutral to pleasant, having a similar level of perceived intensity and representing several olfactive families, including green, fruity, floral, and coniferous families: Peach (odorant concentration in DIPG = 50%), Linalol (50%), Tutti Frutti (20%), Geraniol (50%), Galbex® (50%), Pipol (20%), Green Tea (50%), Pine (50%), Aladinate™ (50%). The odorants were dissolved in dipropylene glycol, which was also used in the CS- condition as an odorless air stimulus.

2.3. Instrumental apparatus

2.3.1. Olfactory display system

Odors were delivered to participants through a nasal cannula by means of a computer-controlled olfactory display (Ischer et al., 2014) able to reliably release various kinds of compounds over multiple trials, without contamination from one trial to the other, at known times, and without additional noise or tactile stimulation in the nose. During the interstimulus interval (ISI), air valves were opened, thus delivering clean air to the participant's nose. During the delivery of odor, air valves were automatically closed and odor valves opened. The ISI and the odorant flow were both fixed at 1 L/min.

2.3.2. Handgrip

Mobilized effort was measured via the TSD121C hand dynamometer connected to a Biopac MP150 unit through a Biopac DA100C module (Santa Barbara, CA, USA). The handgrip signal was retrieved from Biopac module UIM100C and converted from analogue to digital form by using the module Adventech USB-4711A. The digitized signal was then transferred to the pilot PC to provide online visual feedback to the participant. The pilot PC was electrically isolated from the MP System with a USB Isolation Adapter (ExSys EX-1450), thus ensuring the participants' safety. Prior to the start of the wanting task, the handgrip was calibrated with respect to the participant's minimal and maximal grip strength. Handgrip signal input was recorded with a 60 Hz sampling rate. Prior to analysis, handgrip data were centered by subtracting the participant's minimal strength from every data points.

2.4. Procedure

Inspired by existing human PIT procedures (Chillà et al., 2019; Pool et al., 2015; Talmi et al., 2008), the *LikeWant* procedure consisted of three successive stages: (1) the Pavlovian training phase, (2) the Pavlovian check, and (3) the wanting task. The *LikeWant* procedure was preceded by the odor evaluation phase, which aimed to select the most preferred odor at an individual level.

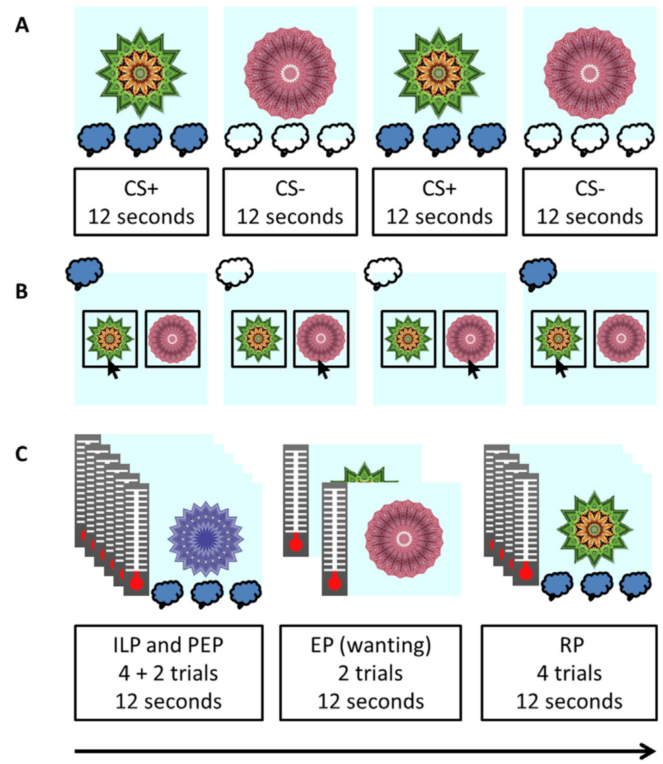

Fig. 1. (A) Pavlovian training phase, (B) Pavlovian check phase and (C) Wanting task procedure.

2.4.1. Odor evaluation phase

Visual analogue scales (range 0 to 100) were presented on the screen and participants asked to assess the pleasantness (from "extremely unpleasant" to "extremely pleasant") and intensity (from "not perceived" to "extremely strong") of nine odorants and odorless air, which were delivered for 6 s. For each participant, the odor with the highest score on the pleasantness scale was selected as the preferred odor. The odors with an intensity of less than 30 points were considered not perceived and thus automatically excluded from the selection process. The selected odor was used as a reward (UCS) in the *LikeWant* procedure that followed.

2.4.2. Pavlovian training phase

During the Pavlovian training phase (Fig. 1A), the preferred odor (UCS) and the odorless air were paired with two geometric neutral images. The image displayed in association with the UCS represented the CS+, whereas the image presented in association with the odorless air represented the CS-. The conditioning task consisted of six trials, in which a geometric image (CS+ or CS-) was presented on the screen for 12 s. During each trial, a target (cross) appeared three times in the center of the image. Participants were asked to click on the left mouse button as fast as possible after they perceived the target to trigger the release of the odor associated with the image presented on the screen. That is, the preferred odor was delivered for 1.5 s in CS+ trials, while the odorless air was delivered for 1.5 s in CS- trials. Notably, the odors were released for 1 s after the target onset if participants did not respond until then, thus ensuring the association between CS and UCS in the case of non-response. Participants were invited to memorize odor-image associations. Because of the instrumental component, the Pavlovian training phase should be considered a hybrid of Pavlovian and discriminative instrumental training, rather than pure Pavlovian learning (Pool et al., 2015). Successive trials were separated by a fixation cross for a variable interval of 0.8–1.2 s.

2.4.3. Pavlovian check phase

In the Pavlovian training phase, participants learned to associate neutral images with the preferred odor (UCS) and the odorless air. Composed of six trials, the Pavlovian check phase (Fig. 1B) was introduced to assess participants' association learning. In each trial, participants were first exposed to an odor (preferred odor or odorless air) for 4 s. After that, both CS+ and CS- images were simultaneously presented on the screen, one next to the other. Participants were asked to click on the image that had previously been associated with the odor just perceived. Finally, immediate feedback was provided that informed participants about the correctness of their answers, allowing them to learn from their mistakes during the whole task. Successive trials were separated by a fixation cross for a variable interval of 4–6 s.

2.4.4. Wanting task

In the wanting task (Fig. 1C), participants had to squeeze the handgrip dynamometer with their dominant hand to trigger the release of odors. Geometric neutral images were sequentially presented in the center of the screen for 12 s. During this presentation, a real-time visual feedback was displayed as a red fluid level moving up and down in a thermometer presented on the left side of the screen, informing participants on the force being exerted on the hand grip at each moment during the trial. The horizontal bar at the top of the thermometer represented 50% or 70% of their maximal grip strength. This threshold was randomly chosen for each data point recorded by the handgrip. Participants were instructed to squeeze the handgrip and release it immediately after filling the thermometer to trigger the release of the odor associated with the image presented on the screen. The wanting task consisted of four successive stages: the instrumental learning phase (ILP), the partial extinction phase (PEP), the extinction phase (EP), and the reconditioning phase (RP). In the ILP and PEP, participants learned to squeeze the handgrip dynamometer to trigger the release of their preferred odor. The ILP and PEP consisted of four and two trials, respectively, in which an unfamiliar geometric neutral image – i.e. an image not previously used in the Pavlovian Training phase – was presented on the screen. In ILP, three time windows rewarded participants with the release of the preferred odor: when participants correctly squeezed the handgrip during these windows, a black asterisk appeared in the center of the geometric image and the preferred odor was released for 1.5 s. In the PEP, only two time windows triggered the release of the preferred odor for 1.5 s. The EP and RP consisted of two and four trials, respectively, in which CS images were presented on the screen and therefore replaced the unfamiliar geometric image used in the ILP and PEP. Notably, no rewarding window was provided in the EP, allowing us to avoid primary (UCS) reinforcement and thus to experimentally dissociate wanting from liking. In the RP, three time windows triggered the release of the preferred odor or the odorless air, depending on the geometric image presented on the screen – the preferred odor for the CS+ trials and the odorless air for the CS- trials. Successive trials were separated by a fixation cross for a variable interval of 0.8–1.2 s.

2.5. Results

2.5.1. Odor evaluation

For each participant, we selected his or her preferred odor from the pleasantness and intensity scores. Tutti Frutti was the most selected preferred odor (n = 12), followed by Pipol (n = 6), Pine (n = 5), Linalol (n = 4), Peach (n = 3), Aladinate™ (n = 3), Galbex® (n = 2), and Green Tea (n = 1). Preferred odors obtained an average (± SD) score of 79.68 ± 11.81 on the pleasantness scale and 59.60 ± 16.84 on the intensity scale. Odorless air obtained an average score of 52.85 ± 9.84 on the pleasantness scale and 20.23 ± 23.39 on the intensity scale. Not surprisingly, the preferred odors were assessed as being more pleasant ($t(35) = 14.94$, $p < .001$, $d = 2.49$, 95% CI [1.86, 3.12]) and intense ($t(35) = 8.63$, $p < .001$, $d = 1.44$, 95% CI [0.91, 1.97]) than the odorless air.

2.5.2. Pavlovian training and Pavlovian check

According to the results observed in the Pavlovian check phase, 16 participants responded correctly to all six trials, 13 participants made one mistake, four participants made two mistakes, two participants made three mistakes, and one participant made four mistakes. A one sample *t*-test revealed that the average number of correct answers (5.14 ± 1.02) was significantly higher than chance (i.e. three correct answers out of six; $t(35) = 12.60$, $p < .001$, $d = 2.10$, 95% CI [1.51, 2.69]); suggesting that participants successfully learned CS-UCS contingences.

2.6. Wanting task

The normality of the three indicators extracted throughout the wanting task was assessed by visual inspection and tested through multiple Shapiro-Wilk's tests. Since the distributions were not normally distributed, nonparametric tests were preferred over parametric tests. Aiming to evaluate participants' instrumental learning, we analyzed the squeeze frequency over the instrumental learning phase (four trials) and the partial extinction phase (two trials). Paired Wilcoxon signed rank tests revealed that the number of squeezes observed in the second trial of the PEP (median = 6.5, interquartile range (IQR) = 2.75–13) was significantly higher than the number of squeezes measured in the first (median = 5, IQR = 2.75–10; $V = 316.5$, $Z = 2.15$, $p = .03$, $r = 0.36$), second (median = 3, IQR = 1.75–7.0; $V = 408$, $Z = 2.70$, $p = .01$, $r = 0.45$), and third trials (median = 4.5, IQR = 2.75–8.5; $V = 347.5$, $Z = 2.38$, $p = .02$, $r = 0.40$) of the ILP, suggesting that participants progressively learned to squeeze the handgrip to trigger the release of their preferred odor (Fig. 2).

Recall that the extinction phase is similar to the ILP and PEP, with two differences. First, the EP was carried out under extinction, i.e. olfactory rewards were not delivered. Second, the CSs were displayed on the screen, thus allowing us to assess their ability to enhance participants' instrumental action, i.e. the transfer effect. Critically, paired Wilcoxon signed rank tests revealed an effect of the CSs on the exerted force ($V = 461$, $Z = 2.01$, $p = .04$, $r = 0.34$), suggesting that participants exerted more effort when CS+ was presented on the screen (median = 2.48 V·s, IQR = 0.98– 3.25) than they did in the CS- trial (median = 1.84 V·s, IQR = 0.68–2.97; Fig. 3A and C). An effect of the CSs was also found on the force surpassing 50% of the maximal force ($V = 486$, $Z = 2.40$, $p = .02$, $r = 0.40$), with participants exerting more unnecessary effort when CS+ was presented on the screen (median = 0.38 V·s, IQR = 0.16–0.62) than they did in the CS- trial (median = 0.22 V·s, IQR = 0.11–0.48; Fig. 3B and D). Moreover, no significant effect of the CSs was found on the squeeze frequency ($V = 340.5$, $Z = 1.44$, $p = .15$, $r = 0.24$).

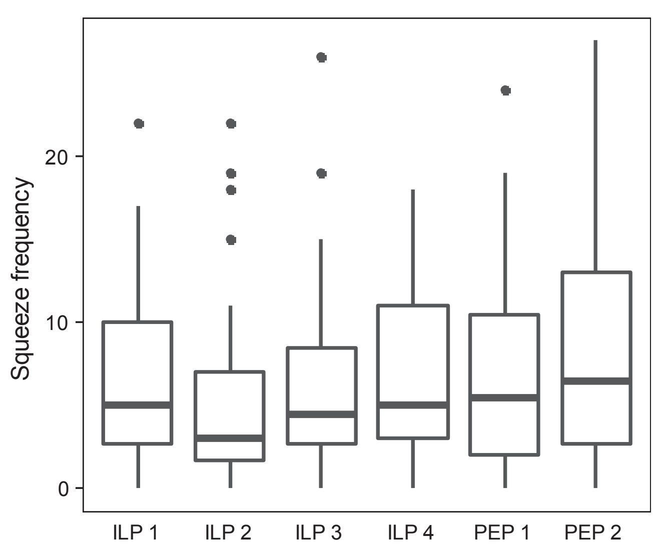

Fig. 2. Experiment 1: Squeeze frequency in instrumental learning phase (ILP) and partial extinction phase (PEP). The boxes range from the first quartile to the third quartile of the distributions. The median is indicated by a line across the box. The whiskers extend to the most extreme data points (Q1 − 1.5 × interquartile range (IQR) and Q3 + 1.5 × IQR).

2.7. Discussion experiment 1

Existing human PIT studies showed that participants invest more effort during the presentation of a cue previously associated with the reward, CS+, than they do for a cue associated with its absence, CS- (Pool et al., 2015; Talmi et al., 2008). This effect was also reproduced in our first experiment. In this study, participants learned to associate their preferred odor (UCS) and the odorless air with two initially neutral images, namely CS+ and CS-. Wanting was measured in two critical trials of the wanting task under extinction and in the presence of CSs. Critically, we found that participants exerted more effort in the CS + trial than they did in the CS- trial. In addition – and contrary to the principle of least effort – participants exerted more superfluous, unnecessary, irrational effort when the CS+ was presented on the screen than they did in the CS- trial. Taken together, these results suggested that the *LikeWant* procedure is able to measure wanting for a pleasant odor by using a neutral condition – i.e. the odorless air – as a control. In the second experiment, we investigated whether the *LikeWant* procedure is sensitive enough to discriminate between two perfumes from their wanting value.

3. Experiment 2

3.1. Method

All the experience data and analysis scripts used are available on the OpenScience Framework platform at: https://osf.io/6ywk2/.

3.1.1. Participants

Thirty-five participants (mean age = 35.5 ± 12.2 years, 66% female, French and/or Swiss citizenships) were recruited from different departments of Firmenich SA and took part in the experiment. The sample consisted of 24 internal panelists and 11 trainees. Each participant gave written informed consent. They were not paid for their participation. The experiment was conducted in accordance with the ethical principles regarding human experimentation expressed in the Declaration of Helsinki.

3.2. Materials

3.2.1. Visual stimuli

We used the same images as in the first experiment.

3.2.2. Olfactory stimuli

Two fine fragrances (Perfume 1 and Perfume 2 hereafter) were selected for this experiment from preexisting marketing insights produced by Firmenich SA.

3.3. Instrumental apparatus

The instrumental apparatus was identical to that used in the first experiment, except that olfactory stimuli were delivered to participants through sterilized stainless steel tips instead of through cannulas as used in the first experiment.

3.3.1. Procedure

As in the first experiment, the *LikeWant* procedure consisted of three

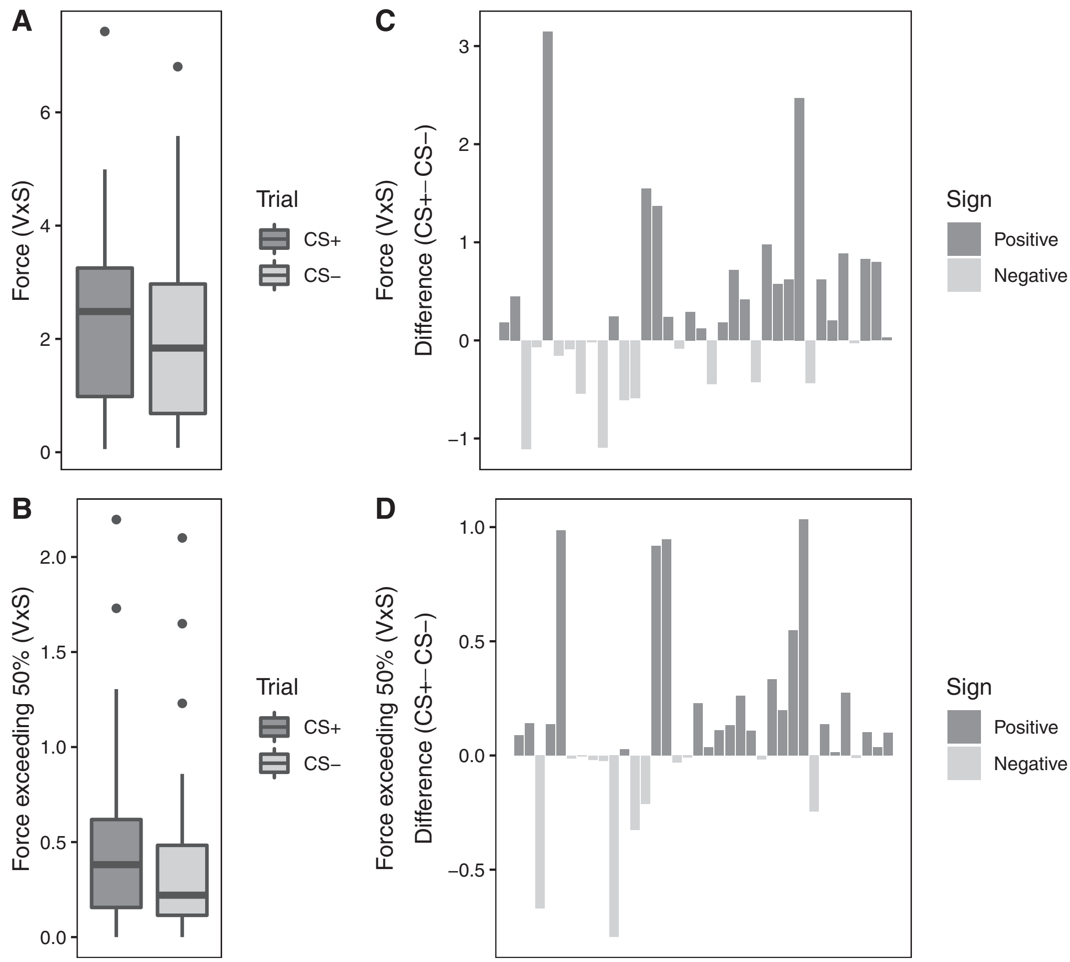

Fig. 3. Experiment 1: Significant wanting indicators measured in the critical extinction phase. (A) Total force and (B) unnecessary effort exerted by participants as a function of the trial (CS +, CS-). The boxes range from the first quartile to the third quartile of the distributions. The median is indicated by a line across the box. The whiskers extend to the most extreme data points (Q1 − 1.5 × interquartile range (IQR) and Q3 + 1.5 × IQR). (C) and (D) represent the effects of the CSs on the total force (C) and on the unnecessary effort (D) observed at an individual level. Each bar represents the participant's difference score between trials (CS + minus CS-).

successive stages: the Pavlovian training phase, the Pavlovian check, and the wanting task. The *LikeWant* procedure was preceded by the odor evaluation phase.

3.3.1.1. Perfume evaluation phase. Following the same procedure as in the first experiment, participants had to evaluate the pleasantness and intensity of the tested fine fragrances. In contrast to the first experiment, however, perfumes were not selected for a *LikeWant* procedure that followed. In fact, the second experiment aimed to measure wanting simultaneously for these two perfumes.

3.3.1.2. Pavlovian training phase. Similar to the first experiment, the perfumes (UCS_1 and UCS_2) were paired with two geometric neutral images (CS_1 and CS_2). Four parameters were adapted to strengthen Pavlovian learning. First, we increased the number of trials from six to eight (four trials for each CS-UCS association). Second, we increased the presentation time of the CSs from 12 to 16 s. Third, we increased the presentation time of the olfactory stimuli from 1.5 to 2 s. Finally, we increased the presentation time of the inter stimulus interval from between 0.8 and 1.2 s to between 4 and 6 s to decrease the risk of contamination and sensory adaptation.

3.3.1.3. Pavlovian check phase. As in the first experiment, participants had to select the image (CS_1 or CS_2) that had been associated with the perfume just perceived (UCS_1 or UCS_2). The number of trials was increased from six to eight to reinforce Pavlovian associations via the immediate feedback provided to participants that informed them about the correctness of their answers.

3.3.1.4. Wanting task. As in the first experiment, participants had to squeeze the handgrip dynamometer with their dominant hand to trigger the release of the perfumes. Participants were instructed to squeeze the handgrip and release it immediately after filling the thermometer to trigger the release of the odor associated with the image presented on the screen. In the ILP and PEP, an unfamiliar neutral image (an image not previously used in the Pavlovian Training phase) was presented on the screen. In the ILP (4 trials) and PEP (2 trials), three time windows and two time windows, respectively, rewarded participants with the release of the perfumes: 50% UCS_1 and 50% UCS_2. The EP consisted of two trials in which the CSs (CS_1 and CS_2) were presented on the screen and therefore replaced the unfamiliar image used in the previous phases. Notably, no rewarding window was provided in the EP, allowing us to experimentally dissociate wanting from liking. In the RP, three time windows triggered the release of the two perfumes – Perfume 1 for CS_1 trials and Perfume 2 for CS_2 trials. Aiming to decrease the risk of panelists' awareness of the EP, we increased the number of trials in the RP from four to six (three trials for each CS-UCS association). Similar to the Pavlovian Training Phase, we also increased the presentation time of the inter stimulus interval from between 0.8 and 1.2 s to between 4 and 6 s to decrease the risk of contamination and sensory adaptation.

3.4. Results

3.4.1. Perfume evaluation

Perfume 1 obtained an average (± SD) score of 78.99 ± 17.27 on the pleasantness scale and 70.93 ± 17.25 on the intensity scale. Perfume 2 obtained an average score of 71.17 ± 17.88 on the pleasantness scale and 61.22 ± 19.70 on the intensity scale. Interestingly, liking ($t(34) = 2.25$, $p = .03$, $d = 0.38$, 95% CI [-0.10, 0.86]) and perceived intensity ($t(34) = 3.31$, $p = .002$, $d = 0.56$, 95% CI [0.07, 1.05]) were significantly higher for Perfume 1 than for Perfume 2. From these results, we expected enhanced wanting for Perfume 1 (UCS_1). Four participants did not perceive one or both perfumes (intensity less than 30 points) and were excluded from the sample. Further *LikeWant* data analysis was thus performed for the remaining 31 participants.

3.5. Pavlovian training and Pavlovian check

According to the results of the Pavlovian check task, 20 participants responded correctly to all eight trials, four participants made one mistake, five participants made two mistakes, one participant made three mistakes, and one participant made four mistakes. A one sample *t*-test revealed that the average number of correct answers (7.32 ± 1.08) was significantly higher than chance (i.e. four correct answers out of eight; $t(30) = 17.18$, $p < .001$, $d = 3.09$, 95% CI [2.33, 3.84]); suggesting that participants successfully learned CS-UCS contingences.

3.6. Wanting task

The normality of the three indicators extracted throughout the wanting task was assessed by visual inspection and tested through multiple Shapiro-Wilk's tests. Since the distributions were not normally distributed, nonparametric tests were preferred over parametric tests. In the wanting task, panelists had to squeeze the handgrip with their dominant hand to trigger the release of the tested fine fragrances. As in the first experiment, the squeeze frequency was analyzed over the ILP and PEP to assess participants' instrumental learning. Paired Wilcoxon signed rank tests revealed that the number of squeezes observed in the second trial of the PEP (median = 6.0, IQR = 3.5–10.0) was statistically significantly higher than the number of squeezes measured in the first (median = 3.0, IQR = 1.0–5.5; $V = 368$, $Z = 3.77$, $p < .001$, $r = 0.68$), second (median = 4.0, IQR = 3.0–6.5; $V = 287$, $Z = 3.36$, $p < .001$, $r = 0.60$), third (median = 5.0, IQR = 2.0–8.0; $V = 296.5$, $Z = 3.09$, $p = .002$, $r = 0.56$), and fourth trial of the ILP (median = 5.0, IQR = 3.0–6.5; $V = 284$, $Z = 2.30$, $p = .02$, $r = 0.41$), indicating that participants learned to squeeze the handgrip to trigger the release of the fragrances (Fig. 4).

In the critical EP, participants' instrumental action was measured in the presence of the CSs and under extinction, thus allowing us to assess the transfer effect by avoiding primary (UCS) reinforcement. Critically, paired Wilcoxon signed rank tests revealed an effect of the CSs on the exerted force ($V = 351$, $Z = 2.02$, $p = .04$, $r = 0.36$), suggesting that participants exerted more effort when CS_1 was presented on the screen (median = 1.79 V·s, IQR = 0.96–2.31) than they did in the CS_2 trial (median = 1.62 V·s, IQR = 0.75–2.31). A marginal effect of the CSs was also found on the squeeze frequency ($V = 232.5$, $Z = 1.90$, $p = .06$, $r = 0.34$), with participants tending to squeeze the handgrip at a higher frequency when CS_1 was presented on the screen (median = 8.0, IQR = 5.5–12.0) than they did in the CS_2 trial (median = 8.0, IQR = 4.0–11.0). Although these effects were not easily identifiable by observing the shape of the distributions (Fig. 5A and B), individual bar plots clarify their nature (Fig. 5C and D). An additional analysis revealed that most participants produced more effort (71%) and squeezed at a higher frequency (61%) in the CS_1 trial than they did in the CS_2 trial. Finally, no significant effect of the CSs was observed on the force exceeding 50% of the participants' maximal grip strength ($V = 289$, $Z = 1.16$, $p = .25$, $r = 0.21$).

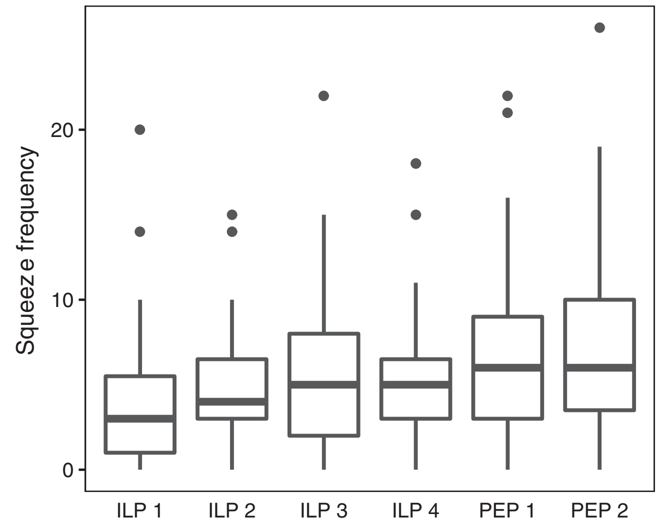

Fig. 4. Experiment 2: Squeeze frequency in instrumental learning phase (ILP) and partial extinction phase (PEP). The boxes range from the first quartile to the third quartile of the distributions. The median is indicated by a line across the box. The whiskers extend to the most extreme data points (Q1 − 1.5 × interquartile range (IQR) and Q3 + 1.5 × IQR).

3.7. Discussion experiment 2

In the second experiment, we assessed the ability of the *LikeWant* procedure to simultaneously measure wanting for two fine fragrances. At the explicit level, Perfume 1 was perceived as being slightly, but significantly, more pleasant than Perfume 2. We thus predicted enhanced wanting for Perfume 1. During the Pavlovian training phase, participants learned to associate two perfumes (UCS_1 and UCS_2) with two CS images (CS_1 and CS_2, respectively). In the wanting task, wanting for both perfumes was assessed under extinction while CS_1 and CS_2 were presented on the screen in two critical trials. Critically, we found that participants exerted more effort when CS_1 was presented on the screen than they did in the CS_2 trial. Recall that UCSs were no longer presented under extinction. Participants' mobilization of effort (wanting) was then not confounded with the experience of pleasure during UCSs consumption (liking). Our result strongly suggests an enhanced wanting for Perfume 1. The *LikeWant* procedure thus seems to be sensitive enough to discriminate between two fine fragrances on the basis of their rewarding properties.

3.8. General discussion

In this paper, we presented two experiments that aimed to validate *LikeWant* procedure as a short and efficient way to measure wanting for flavors and fragrances. The results suggested that the *LikeWant* procedure has the potential to measure implicit wanting for both food and nonfood odors, extending its application from flavors to fragrances. The *LikeWant* procedure can thus be applied to measure wanting for rewarding stimuli that are not critical for the survival of the individual and the species (e.g. food and sex), enabling potentially its broader adoption in consumer studies. The procedure can be successfully implemented in two different cases, each offering benefits and drawbacks. First, the *LikeWant* procedure can measure wanting for a pleasant odor with odorless air as a neutral control (Experiment 1). When used as a standard, the neutral control has the advantage of providing an absolute wanting measure, thus further enabling comparisons between different *LikeWant* experiences. For this reason, this approach should be preferred when the investigator's objective is to assess and compare wanting for a large panel of products. Second, the *LikeWant* procedure is sensitive enough to discriminate between two products on the basis of their rewarding properties (Experiment 2). Although experimentation

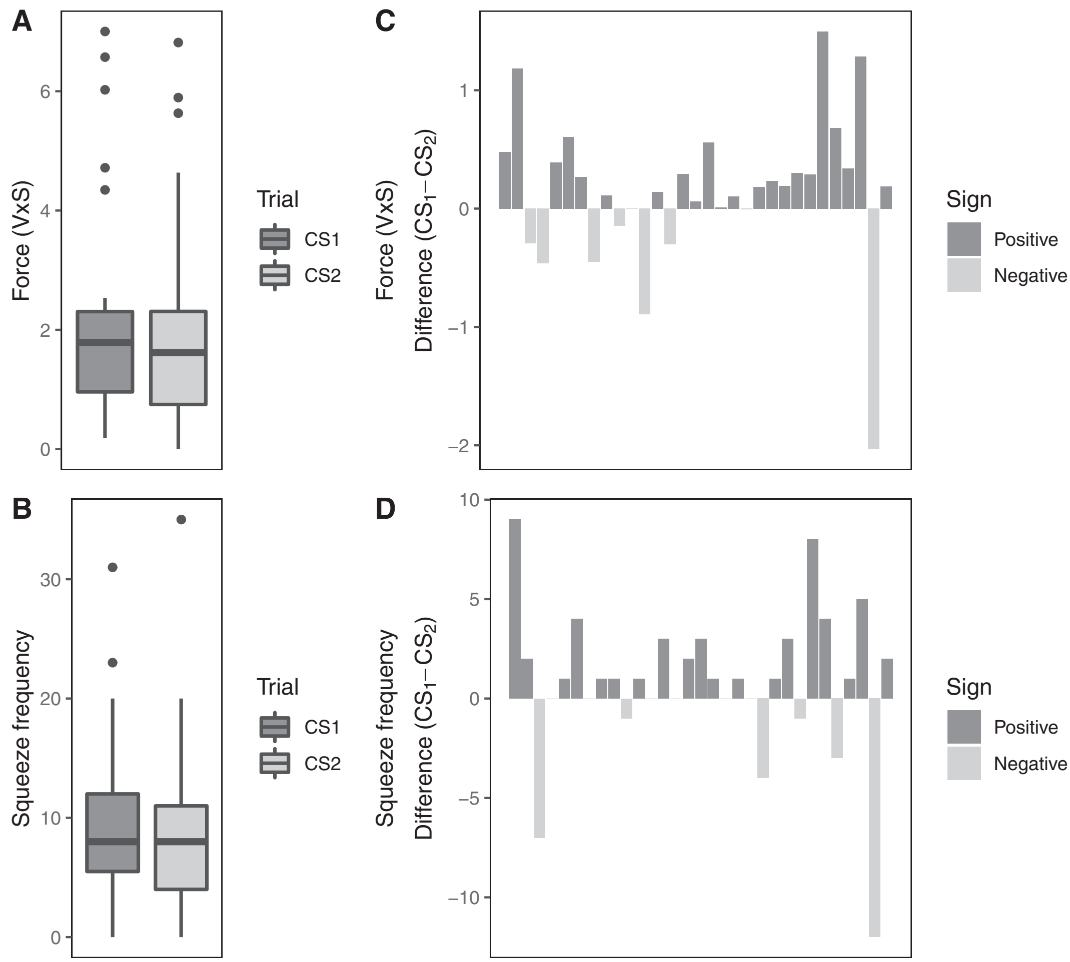

Fig. 5. Experiment 2: Significant and marginally significant wanting indicators measured in the critical extinction phase. (A) Total force exerted by participants and (B) squeeze frequency as a function of the trial (CS_1, CS_2). The boxes range from the first quartile to the third quartile of the distributions. The median is indicated by a line across the box. The whiskers extend to the most extreme data points (Q1 − 1.5 × interquartile range (IQR) and Q3 + 1.5 × IQR). (C) and (D) represent the effects of the CSs on the total force (C) and on the squeeze frequency (D) observed at an individual level. Each bar represents the participant's difference score between trials (CS_1 minus CS_2).

costs can be reduced by measuring wanting for two products without using a neutral control, this approach provides relative wanting data (one product compared with another), making difficult further comparisons with data gathered from other experiences (except when a benchmark is used as a standard through different experiences). This approach should be preferred in cases in which the investigator's objective is to identify the product that maximizes the rewarding properties between two, and only two, competing candidates. Nevertheless, recent studies claimed that PIT procedures may lack sensitivity for discriminating between two odors that have similar rewarding properties (Chillà et al., 2019). For this reason, more evidence should be provided to recommend the use of the *LikeWant* procedure for measuring wanting for two products in the same experience.

One of the main objectives of this paper was to compare the sensitivity of three wanting indicators: (1) squeeze frequency, (2) total force, (3) force exceeding 50% of the participants' maximal grip strength. Although the squeeze frequency indicator is often used in the literature to measure wanting in humans (Pool et al., 2015; Talmi et al., 2008), we suggest that force indicators could represent a valid alternative for two major reasons. First, the explicit instructions ("squeeze the handgrip in order to smell odors") drew the attention of the participants to their squeeze frequency and not directly to the effort that they produced on the handgrip. Participants may thus be unaware that complex force measurements are being conducted. Second, unlike squeeze frequency, the force exerted on the handgrip cannot be easily controlled by conscious processes. We suggest that the force exceeding 50% of the participants' maximal grip strength could be a privileged implicit wanting indicator. Indeed, any effort exceeding this threshold should be considered superfluous, unnecessary, irrational, and contrary to the principle of least effort (Zipf, 1949). In the first experiment, the wanting effect was supported by force indicators and not by the squeeze indicator, with participants producing more (necessary and unnecessary) effort in the CS+ trial than in the CS- trial. In the second experiment, an enhanced wanting for Perfume 1 was supported by the total force produced by participants, while the squeeze indicator appeared to be only marginally significant. Taken together, these results suggest that force indicators may be more sensitive than squeeze frequency. Similar conclusions were drawn by Chillà et al. (2019). Interestingly, participants produced more superfluous, unnecessary, irrational effort to obtain the most rewarding stimulus in the first experiment, but not in the second. This difference could potentially reflect differences in expertise between the two populations investigated: novices in the first experiment, experts in the second. Indeed, novices could be more (implicitly) motivated to obtain odorants as a reward in a laboratory setting than are panelists working in the flavor and fragrance industry, who can *effortlessly* obtain pleasant olfactory stimuli in their daily work. To the best of our knowledge, this is the first study to propose unnecessary effort as an implicit wanting indicator. We believe that this indicator warrants further investigation in fundamental human PIT research.

Since classic PIT procedures end with a long series of trials performed under extinction, they cannot handle a within-subjects design. The *LikeWant* method was designed with the intent to overcome this limitation. This was done by (1) reducing the exposure of participants to the extinction phase (by measuring wanting for each CS in a critical trial under extinction) and (2) by adding the reconditioning phase immediately after the extinction phase. The results observed in both experiments clearly suggested that wanting for products can be measured in a critical trial under extinction. Moreover, at this stage of method development, it is still unclear whether the *LikeWant* procedure could successfully be applied in within-subjects designs. Further research is needed to address this question. Finally, there are several barriers to the broader adoption of the *LikeWant* procedure in consumer research. First, the experimental setup required to carry out the procedure (i.e. olfactometer and Biopac systems) is relatively complex and expensive. Second, despite our efforts to reduce the execution time of the procedure, *LikeWant* requires 15 min to measure wanting for one (or two) products, which still represents a considerable cost. Additional research is thus needed to further optimize the procedure.

4. Conclusion

In this paper, we presented and validated the *LikeWant* procedure, a new methodology to measure consumers' implicit wanting for flavors and fragrances. Compared with existing PIT procedures, the *LikeWant* procedure is likely to suit the following consumer research requirements: reduced experimentation costs, performance assessment at an individual level, and the ability to enable repeated measures design. We conducted two studies to advance the validation process of the procedure. The results showed that the *LikeWant* procedure is able to (1) measure wanting for a pleasant odor with odorless air as a neutral control condition and (2) discriminate between two fine fragrances on the basis of their rewarding properties.

5. Declaration of competing Interest

The author(s) declared no potential conflicts of interests with respect to the authorship and/or publication of this article.

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7. Authorship responsibility

The submission is a truthful, original work without fabrication, fraud or plagiarism, and contains no libelous or unlawful statements. It has not been published previously except in abstract form. The manuscript is not under consideration for publication, nor will it be submitted for publication, elsewhere until a final decision has been made by this journal. The undersigned certify that each author has participated sufficiently in the work to take responsibility for its truthfulness and validity and has read the complete manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2019.103829.

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