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Validation of the Food Purchase Task (FPT) in a clinical sample of smokers with overweight and obesity

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ABSTRACT

Obesity is a major health problem associated with disease burden and mortality. In this context, analyzing food as a powerful reinforcer from a behavioral economics framework could be relevant for the treatment and prevention of obesity. The purposes of this study were to validate a food purchase task (FPT) in a clinical sample of Spanish smokers with overweight and obesity and to assess the internal structure of the FPT. We also analyzed the clinical utility of single-item breakpoint (i.e., commodity price that suppresses demand). A total of 120 smokers [% females: 54.2; M_{age} = 52.54; SD = 10.34] with overweight and obesity completed the FPT and weight/eating-related variables. Principal component analysis was used to examine the FPT structure, and a set of correlations were used to examine the relationship between the FPT, eating and weight-related variables. The FPT demonstrated robust convergent validity with other measures of eating. Higher food demand was related to higher food craving (r = .33), more binge eating problems (r = .39), more weight gain concerns (r = .35), higher frequency of both controlled (r = .37) and uncontrolled (r = .30) grazing, as well as to an eating style in response to emotions (r = .34) and external eating (r = .34). Of the demand indices, Intensity and O_{max} showed the highest magnitudes of effects. The FPT factors, persistence and amplitude, do not improve individual FPT indices; and the single-item breakpoint was not related to any eating or weight variable. The FPT is a valid measure of food reinforcement with potential clinical utility in smokers with obesity/overweight.

1. Introduction

Obesity is a major health problem associated with disease burden and mortality (Abbafati et al., 2020; Dai et al., 2020; di Angelantonio et al., 2016; Kivimäki et al., 2022). Since the 1970s, the prevalence of obesity has tripled and it is currently estimated that 1.9 billion adults are overweight, of which 650 million have obesity (WHO, 2021). In this context, analyzing food as a powerful reinforcer could be relevant for the treatment or prevention of obesity (Epstein, Paluch, et al., 2018).

From the behavioral economics framework, the demand of a reinforcer (e.g., food) refers to the strength of that reinforcer through the relationship between its consumption and the price (i.e., cost in effort, money, or time) willing to pay to consume it (Bickel, Johnson, Koffarnus, MacKillop, & Murphy, 2014). The evaluation of the demand is usually performed through the demand curve, which is characterized by five indices (i.e., breakpoint, O_{max}, P_{max}, intensity, and elasticity) which have been extensively described elsewhere (García-Pérez, Aonso-Diego, Weidberg, & Secades-Villa, 2022; Hursh, 2000). At present, hypothetical purchase tasks (HPT) developed to evaluate the demand curve for cigarettes (González-Roz, Jackson, Murphy, Rohsenow, & MacKillop, 2019), alcohol (Martínez-Loredo, González-Roz, Secades-Villa, Fernández-Hermida, & MacKillop, 2021), cocaine (Bruner & Johnson, 2014), opioids (Strickland, Lile, & Stoops, 2019), or marijuana (Aston, Metrik, & MacKillop, 2015; González-Roz et al., 2022) show a high predictive value for a multitude of relevant clinical phenomena, such as dependence severity or treatment results. These tasks have become extensive because they provide valuable, low-cost, scalable, and quantitative information about motivation, preferences, and decision-making process of consumers (Reed, Gelino, & Strickland, 2022; Roma, Reed, DiGennaro Reed, & Hursh, 2017). Recently, researchers have focused on tasks

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comprising single-item breakpoint arguing its potentiality to expedite its use in clinical contexts due to its ease of computation and interpretation (Athamneh, Stein, Amlung, & Bickel, 2019a; Hardy et al., 2021). So far, studies have yielded mixed results, with evidence of its utility for predicting nicotine dependence (Athamneh, Stein, Amlung, & Bickel, 2019b) and no evidence in substance users who use tobacco (González-Roz, Secades-Villa, Aonso-Diego, Weidberg, & Fernández--Hermida, 2021), and people who use alcohol (Hardy et al., 2021).

Despite its advantages, the study of the reinforcing value of food with HPT has not been generalized, and the scarce research has been carried out in North American population (Bellows, 2018; Epstein, Dearing, & Roba, 2010; Epstein, Paluch, et al., 2018; Epstein, Stein, Paluch, MacKillop, & Bickel, 2018; Feda, Roemmich, Roberts, & Epstein, 2015; Larks, 2018; O'Donnell & Epstein, 2019; Snider et al., 2021). Epstein et al. (2010) developed the first hypothetical snack food purchase task and found a relationship between hypothetical and laboratory food reinforcement, and that a high demand for snack foods was directly related to body mass index (BMI), energy intake, hunger, and dietary restraint (Epstein et al., 2010; Epstein, Paluch, et al., 2018). Nevertheless, these findings were only present in HPT where high dense energy food could be purchased (Epstein, Paluch, et al., 2018). Later, Epstein, Stein, et al. (2018) analyzed the internal structure of the HPT of snack foods, revealing two components, persistence that comprises intensity, and amplitude that comprises each of the four HPT indices, as in other studies in the field of drug demand (Aston, Farris, MacKillop, & Metrik, 2017; Bidwell, MacKillop, Murphy, Tidey, & Colby, 2012; MacKillop et al., 2009; O'Connor et al., 2016). Only the amplitude factor, explained mainly by the intensity of the demand, was related to the BMI, thus putting into question the utility of the remaining HPT indicators. Other authors have reported a relationship between food demand and BMI (Feda et al., 2015; Larks, 2018). Furthermore, other studies have highlighted the importance of context on the reinforcing value given to food. In this sense (Larks, 2018), noted that workers during working hours present a greater demand for food than when they are outside working hours, while (Snider et al., 2021) associated imagining oneself in devastated scenarios to the increase in the hedonic value of food. Finally (Bellows, 2018), related a lower reinforcing efficacy of food with greater physical activity and less sedentary time.

To date there is no study that uses HPT for food in European population. Analyzing the reinforcing efficacy of food in European countries is relevant, given that there is a great difference between the type of diet (Blundell et al., 2017; Vilarnau et al., 2019) and the prevalence of obesity (Janssen, Bardoutsos, & Vidra, 2020) in European countries in comparison to countries such as the USA. In this sense, cultural differences related to diet may make some foods more reinforcing than others (Chen & Antonelli, 2020). Furthermore, no studies have explored the reinforcing efficacy of HPT for food in specific populations, such as smokers. It is known that the combination of obesity and smoking multiplies health problems (Bush, Lovejoy, Deprey, & Carpenter, 2016; Zhou et al., 2021). The relationship between smoking and eating is especially relevant when smokers try to quit smoking, because this process can alter eating habits and appetite (Gottfredson & Sokol, 2019; Mineur et al., 2011; Stojakovic, Espinosa, Farhad, & Lutfy, 2017), which in turn can cause weight gain (Aubin, Farley, Lycett, Lahmek, & Aveyard, 2012; Jeremias-Martins & Chatkin, 2019; Pisinger, Nielsen, Kuhlmann, & Rosthøj, 2017). Post-cessation weight gain is an important challenge in smokers with obesity, since many smokers do not try to quit for this reason (Germeroth & Levine, 2018; Hsieh et al., 2019; Tuovinen et al., 2015), and if they do, weight gain appears as a determinant for smoking relapse (Salk et al., 2019).

To fill the gaps in previous research, the goals of this study were: 1) to validate a food purchase task (FPT) in a clinical sample of Spanish smokers with overweight and obesity; 2) to assess the internal structure of the FPT; and 3) to analyze the incremental validity of the single-item breakpoint on the two components of the FPT and individual demand indices in relation to weight and eating-related variable.

2. Method

2.1. Participants

This study included 120 Spanish smokers with overweight and obesity who participated in a clinical trial (identifier: NCT04332029) for smoking cessation and weight gain prevention. The inclusion criteria were: a) being over 18 years old, b) having smoked 10 cigarettes a day or more during the previous year and not using electronic devices, c) meeting the criteria for nicotine dependence according to DSM-5 (American Psychiatric Association, 2013), and d) having a BMI greater than or equal to 25. The exclusion criteria were: a) being pregnant, breastfeeding or in the six-month postpartum period, b) receiving another treatment to stop smoking or weight control, c) being diagnosed with a current severe psychiatric disorder, d) having an eating disorder other than binge eating disorder, e) having a substance use disorder other than tobacco use disorder, f) having a health condition that requires a specialized diet or that affects eating, g) not being able to attend all the sessions of the treatment, and h) using any medication that impacts on weight (e.g., diabetes drugs, glucocorticoids, antihistamines, etc.).

The study was approved by the local Research Ethics Committee of the Principality of Asturias (nº329/19) and all participants provided informed consent before taking part in the study.

2.2. Instruments and variables

During the intake session, which lasted approximately 90 minutes, participants completed a clinical history that collected sociodemographic variables (e.g., sex, age, and educational level), tobacco use-related variables (e.g., cigarettes per day, age of smoking onset, urine cotinine) and weight/eating-related variables (e.g., BMI, years with overweight, weight gain concern). Weight gain concerns were assessed with the following item "How concerned are you about gaining weight after quitting?" (Perkins, Marcus, Levine, Miller, & Broge, 2001). Response options ranged between 0 and 100, with 100 being an extreme concern about gaining weight.

Nicotine dependence was assessed with the Spanish version (Becoña, 1998) of the Fagerström Test for Cigarette Dependence (FTCD) (Heatherton, Kozlowski, Frecker, & Fagerström, 1991). FTCD scores established the follow levels of nicotine dependence: low (0–3), moderate (4–7), and high (8–10).

The Spanish validation (Cebolla, Barrada, van Strien, Oliver, & Baños, 2014) of the Dutch Eating Behavior Questionnaire (DEBQ (van Strien, Frijters, Bergers, & DEfares, 1986), was used to assess eating styles. This questionnaire consists of 33 items on a five-point scale that evaluates three dimensions: emotional eating (eating in response to arousal states), external eating (eating in response to environmental food cues) and restrained eating (attempts to inhibit eating).

Binge eating was assessed through the Spanish validation (Escrivá-Martínez, Galiana, Rodríguez-Arias, & Baños, 2019) of the Binge Eating Scale (BES, (Gormally, Black, Daston, & Rardin, 1982). This scale is made up of 16 items that assess the severity of behavioral manifestations, feelings and cognitions of binge eating. Scores below 18 points indicate minimal binge eating problems, scores between 18 and 26 points indicate moderate binge eating problems, and scores above 26 points indicate severe binge eating problems (Marcus, Wing, & Hopkins, 1988).

The Spanish validation (Lobera, Bolaños, Carbonero, & Blanco, 2010) of the Food Craving Inventory (FCI (White et al., 2002), was used to assess the frequency of cravings for 28 food items using a five-point scale. This inventory is composed of three factors, grouped in a single general factor: simple sugar/trans fats, complex carbohydrates/proteins, and saturated fats/high calorie content (fast food).

The Short Inventory of Grazing (SIG (Heriseanu, Hay, & Touyz, 2019), was used to evaluate the frequency of grazing. This inventory

consists of two items using a seven-point scale. The first item assesses the frequency of grazing in general, while the second item assesses the frequency of uncontrolled grazing.

Trait food demand (i.e., demand for a 24-h day) was assessed using two behavioral economic tasks: a FPT adapted as of the Food purchasing questionnaire of Epstein et al. (2010), and one single-item assessing the breakpoint. Using the Brief Assessment of Alcohol Demand (BAAD (Owens, Murphy, & MacKillop, 2015), as a reference, the participants answered the following breakpoint question: "How much would you pay at most for a snack (preferred snack food within a list of options)?".

The specific instructional set is presented in supplementary materials (see Supplementary Table 1). All participants answered the following question: "How many portions [≈ 200 kcal portion (36–111 g)] of preferred snack food would you eat if they were ___ each?". The following 14 prices were considered: zero (free), €0.05, €0.10, €0.25, €0.50, €1, €1.5, €2, €2.5, €3, €4, €5, €10, and €20. Participants could choose from the following snack foods portions: a small serrano ham sandwich (111 g), donut (50 g), croissant (50 g), ten ounces of milk chocolate (36 g), a small bag of chips (40 g), and a scoop of chocolate ice cream (90 g). The instructions were accompanied by representative images of snack food portions to facilitate the participants' choice.

2.3. Data analysis

Five indices were derived from the FPT task, including: 1) intensity of demand: snack demand at zero cost; 2) O_{max}: maximum amount of money spent on snacks; 3) P_{max}: price associated to the maximum amount of money spent on snacks (i.e., O_{max}); breakpoint: first price at which demand is suppressed; 5) elasticity of demand: proportional change in the demand in relation to the proportional change in its unit price. We calculated observed demand for intensity, O_{max}, P_{max} and breakpoint, whereas the elasticity of demand was estimated using an exponentiated equation (1) (Koffarnus, Franck, Stein, & Bickel, 2015).

$$Q = Q_0 \times 10^{k(e^{-\alpha Q_0 C}-1)} \quad (1)$$

In equation (1), Q is consumption at the given price, Q_0 is consumption at zero price, k is the range of the dependent variable, C is the price, and α the elasticity of demand (i.e., the slope of the demand curve). The *k* value used in this study for all participants was .66. In accordance with Farris, Aston, Zvolensky, Abrantes, and Metrik (2017) recommendations, the k value was determined by subtracting the log10-transformed average consumption at the highest price (€20.00) from the log10-transformed average consumption at the lowest price (€0.00).

There was no presence of nonsystematic data in the FPT because the software used to administer the task automatically detected trends, bounces, and reversals to zero (Stein, Koffarnus, Snider, Quisenberry, & Bickel, 2015) and warned the user to check the response. FPT data were transformed if they were identified as outliers. FPT data were considered outliers if they presented a critical value of $Z = \pm 4$. Ten outliers were identified and transformed as the highest non-outlying value plus one unit.

A descriptive analysis was performed for all variables included in this study. Principal component analysis (PCA) with oblique rotation (oblimin) was realized to examine the structure of the FPT. In order to ensure data adequacy for PCA, Barlett's sphericity and Kaiser-Meyer-Olkin tests were calculated. Log transformed breakpoint, O_{max}, P_{max}, intensity and elasticity were entered in the analysis. Based on the sample size, FPT indices with factor loadings ≥.51 were considered for factor interpretation (Stevens, 2009). The regression method was used to estimate factor scores. Since this is a PCA, all the FPT indices were used to calculate each factor score (each with its relative weight) in order not to lose information. In addition, Pearson, Point Biserial and Spearman correlations were used to analyze the relationship between food demand and other variables (demographics, smoking and weight/eating related variables). The Benjamini-Hochberg method was used to minimize the probability of making a Type I error in correlations analyses (Benjamini & Hochberg, 1995). Lastly, to examine the incremental predictive capability of FPT indices over other relevant variables, we conducted a series of hierarchical regressions predicting eating-related variables (i.e., binge eating, food craving, eating styles, weight gain concern, and grazing). In the first step of each hierarchical regression, sex, age, income, BMI and cigarettes per day were entered. In the second and third steps of the regression, O_{max} and intensity of food demand were included respectively. These FPT indices were chosen based on the linear relationships found with eating-related variables.

Analyses were conducted using the GraphPad Prism 6.0 (La Jolla, California), and the SPSS software (version 24, SPSS Inc., Chicago IL, USA). Significance for all statistical comparisons was defined as $p \leq .05$. The analytic plan was pre-specified and discussed prior to analysis.

3. Results

3.1. Sample and demand curve characteristics

Table 1 shows the characteristics of the sample. Participants reported smoking around a pack of cigarettes per day ($M_{CPD} = 21.34$) and presented obesity ($M_{BMI} = 31.75$).

Fig. 1 shows the food demand curve. The most chosen snack in FPT was the small serrano ham and tomato sandwich (46.7%), followed by ten ounces of milk chocolate (18.3%), a small bag of chips (13.3%), donut (11.7%), croissant (8.3%) and a scoop of chocolate ice cream (1.7%). At zero cost (i.e., intensity), smokers with obesity would buy 2.45 snacks. Maximum expenditure on snacks (O_{max}) was €3.57, and the average price at which demand would cease for most participants was

Table 1
Characteristics of the sample.

Variables	Total Sample (n = 120)
Demographics	
Age (years)[a]	52.54 ± 10.34
Sex (% women)	54.2
Years of education (%)	
10 or less	26.6
11 to 15	45.0
16 or more	28.4
Marital status (% married)	55.8
Smoking-related variables	
FTND[a]	5.43 ± 2.06
Cigarettes per day[a]	21.33 ± 8.79
Years of regular smoking[a]	30.85 ± 10.66
Age at smoking onset [a]	15.15 ± 4.17
Cotinine[a]	2,278.8 ± 1,220.5
Eating-related variables	
BMI[a]	31.75 ± 4.31
Years with overweight[a]	14.56 ± 11.09
Years with obesity[a]	7.37 ± 10.48
FCI[a]	21.73 ± 15.16
BES[a]	9.97 ± 8.32
DEBQ	
Emotional eating[a]	26.26 ± 12.07
External eating[a]	25.92 ± 7.12
Restrained eating[a]	22.66 ± 8.13
SIG grazing (% > 3 grazing per week)	22.6
SIG uncontrolled grazing (% > 3 grazing per week)	10.0
Weight gain concern[b]	70.0 (100)
Demand indices	
Intensity[a]	2.45 ± 2.36
Breakpoint[a]	4.47 ± 5.12
O^a_{max}	3.57 ± 3.09
P^a_{max}	2.10 ± 2.56
Elasticity[a]	.87 ± 6.13
Single-item breakpoint[a]	5.43 ± 24.27

Note. [a] mean ± standard deviation; [b] median (mode); FTND = Fagerström Test for Nicotine Dependence; BMI = body mass index; FCI = Food Craving Inventory; BES = Binge Eating Scale; DEBQ = Dutch Eating Behavior Questionnaire; SIG = Short Inventory of Grazing.

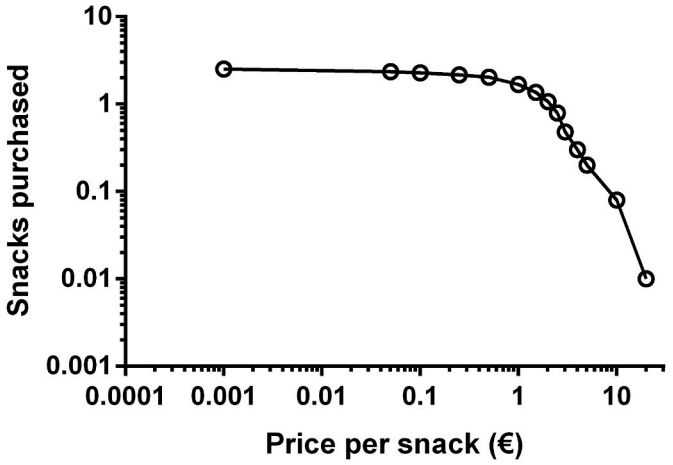

Fig. 1. FPT demand curve of the sample. The x-axis provides price in euros (€) and the y-axis provides self-reported consumption of snacks. Circles illustrate hypothetical mean snack consumption at a given price.

€4.47. There were no statistically significant differences in any FPT index according to the type of snack chosen.

3.2. Components of the FPT

Sample adequacy for the PCA was confirmed by the Bartlett's sphericity test [$\chi^2(10) = 630.98$; $p < .001$] and Kaiser-Meyer-Olkin index value (KMO = .72). The PCA showed that the two components of the FPT yielded a good fit (see Table 2 for factor loadings). The first component (persistence) included mainly breakpoint, O_{max}, P_{max} and elasticity, and accounted for 71.25% of the variance. The second component (amplitude) encompassed predominantly intensity and explained 22.69% of the variance. The two-component solution explained 93.94% of the total variance of the FPT indices. The correlation between amplitude and persistence was not statistically significant ($r = .10$, $p = .32$), so no evidence of overlapping between both components.

3.3. Relationship between FPT, single-item breakpoint, weight and eating-related variables

Pearson's and Spearman's correlations are shown in Table 3. All demand indices and both FPT components, persistence and amplitude, presented a statistically significant relationship with eating-related variables. In contrast, the single-item breakpoint was not related to any variable.

Specifically, by FPT indicator, intensity and O_{max} presented the highest magnitudes of correlations (r's ranged between .27 and .39, all p values $< .003$) with eating-related measures. Higher intensity and O_{max} were related to higher food craving, more binge eating problems, more concerns about gaining weight, higher frequency of both controlled and uncontrolled grazing, as well as poorer eating styles. On the other hand, breakpoint was related only to weight gain concerns and uncontrolled grazing. Lastly, elasticity and P_{max} were not related to any eating-related measure. Compared to intensity and O_{max}, persistence and amplitude did not evidence more relationships with the eating-related variables nor greater magnitude of effects. The single-item breakpoint was not linearly related to any weight and eating-related measure.

Table 2
Factor loadings of FPT factors.

	Factor 1 (persistence)	Factor 2 (amplitude)
1. Breakpoint	**.97**	−.09
2. O_{max}	**.93**	.23
3. P_{max}	**.93**	−.29
4. Elasticity	**−.92**	−.23
5. Intensity	.02	**.98**

Note. Factor loadings (i.e.,> .51) are highlighted in bold.

3.4. Incremental validity of FPT indices

Hierarchical regression with the most relevant FPT indices, intensity (step 3) and O_{max} (step 2), and demographics, cigarettes per day and BMI (step 1) were used to predict eating-related variables (Table 4). In step 2, the results showed that O_{max} adds predictive value (over demographics, cigarettes per day, and BMI) on five of the eight dependent variables, specifically on food craving ($B_{Omax} = 1.031$, $p = .030$), binge eating problems ($B_{Omax} = .585$, $p = .016$), external eating ($B_{Omax} = .537$, $p = .009$), restrained eating ($B_{Omax} = .471$, $p = .048$), and weight gain concerns ($B_{Omax} = 1.859$, $p = .036$). In step 3, intensity added predictive value (over demographics, cigarettes per day, BMI and O_{max}) on four of the eight dependent variables, specifically on food craving ($B_{intensity} = 1.919$, $p = .003$), binge eating problems ($B_{intensity} = .686$, $p = .024$), emotional eating ($B_{intensity} = 1.031$, $p = .025$), and controlled grazing ($B_{intensity} = .137$, $p = .030$). In this last step, O_{max} was not statistically significant since the eating-related variables variance was better explained by intensity. In step 1, results showed that being female, younger or having income variations leads to more binge eating problems, poorer eating styles, more grazing and weight gain concerns.

4. Discussion

This is the first study to validate a food demand task in a European population, specifically in a sample of Spanish smokers with overweight and obesity. The three main findings of this study are: 1) the FPT has demonstrated robust convergent validity with other measures of eating (even controlling for the effect of other variables), with intensity and O_{max} being the indices that showed the strongest relationships; 2) the FPT components, persistence and amplitude, did not show more relationships, nor more strength than intensity and O_{max} in relation to eating-related variables; and 3) the single-item breakpoint was not related to any eating or weight variable.

The FPT indices are significantly related to other measures of eating. Specifically, in line with prior research (Epstein et al., 2010; Epstein, Paluch, et al., 2018), intensity were related to hunger or food cravings. This makes sense given that overweight smokers could have problems controlling their intake (Chao, White, Grilo, & Sinha, 2017) and often resort to the consumption of highly palatable foods to manage their emotional state (Sinha & Jastreboff, 2013). Also, since the cost of accessing these products is not excessively high, it is feasible that this indicator, intensity, is the most closely related to food cravings.

Additionally, this study adds new evidence on the relationship of FPT indices with other eating-related variables. In this sense, higher food demand was related to higher severity of binge eating, higher weight gain concerns, a higher frequency of both controlled and uncontrolled grazing, as well as to an eating style in response to emotions and food-related stimuli. Intensity and O_{max} were the two indices that showed the strongest relationship with the different measures of eating and weight. These results are consistent with those found by other authors using HPT for food (Epstein et al., 2010; Epstein, Paluch, et al., 2018b; Epstein, Stein et al., 2018a) and even for substances other than food such as alcohol (Martínez-Loredo et al., 2021) or nicotine (González-Roz et al., 2019). Breakpoint were related to only some of the variables evaluated, and always with a lower magnitude compared to intensity and O_{max}.

Specifically, intensity and O_{max} were related to binge severity. This finding is congruent with the Bjorlie et al. (2022) study which found that hyper-palatable foods, considered to be potent reinforcers, are more related to binge episodes and to a higher frequency of these episodes. In the same line, intensity, O_{max} and breakpoint were related to the

Table 3
Correlations among food demand and weight/eating-related measures.

	Intensity	Omax	Pmax	Elasticity	Breakpoint	Single-item breakpoint	Persistence	Amplitude
Age	−.24	−.28*	−.18	.07	−.18	−.18	−.27*	−.24
Sex	−.22	−.12	−.03	.08	−.01	−.02	−.06	−.22
CPD	−.10	.10	.10	−.10	.08	.01	.01	−.19
FTND	−.06	.18	.13	.01	.14	−.01	.23	−.11
BMI	.18	.15	−.01	.08	.06	.10	.10	.20
FCI	.33*	.23	.08	.00	.05	.12	.08	.26
BES	.39*	.36*	.11	−.03	.16	.16	.25	.43*
DEBQ emotional	.34*	.29*	.07	−.10	.14	.10	.15	.34*
DEBQ external	.34*	.32*	.16	−.19	.18	.09	.29*	.31*
DEBQ restrained	.12	.21	.12	.02	.14	−.11	.13	.14
Weight gain concern	.35*	.29*	.17	−.23	.25*	.15	.20	.24
SIG grazing	.37*	.23	.13	−.16	.18	.18	.08	.24
SIG uncontrolled grazing	.30*	.27*	.19	−.21	.25*	.16	.16	.17

Note. CPD = Cigarettes per day; FTND = Fagerström Test for Nicotine Dependence; BMI = body mass index; FCI = Food Craving Inventory; BES = Binge Eating Scale; DEBQ = Dutch Eating Behavior Questionnaire; SIG = Short Inventory of Grazing.
*$p < .007614$ (Benjamini-Hochberg adjusted p-value criterion).

Table 4
Predictive value of intensity and O_{max} vs demographics variables, CPD and BMI over eating-related variables.

	Step 1[a]	Step 2[b]			Step 3[c]		
	R^2	ΔR^2	F change (df = 1, 112)	*p*-value	ΔR^2	F change (df = 1, 111)	*p*-value
FCI	.028	.040	4.848	**.030**	.072	9.224	**.003**
BES	.306**	.042	7.204	**.008**	.030	5.269	**.024**
DEBQ emotional	.261**	.022	3.442	.066	.032	5.145	**.025**
DEBQ external	.175**	.048	6.968	**.009**	.026	3.874	.052
DEBQ restrained	.167**	.029	3.995	**.048**	.000	.010	.922
Weight gain concern	.184**	.032	4.511	**.036**	.022	3.244	.074
SIG grazing	.160**	.018	2.431	.122	.034	4.810	**.030**
SIG uncontrolled grazing	.118*	.012	1.530	.219	.001	.083	.774

Note. CPD = cigarettes per day; BMI = body mass index; FCI = Food Craving Inventory; BES = Binge Eating Scale; DEBQ = Dutch Eating Behavior Questionnaire; SIG = Short Inventory of Grazing.
* Regression model in step 1 significant at $p < .05$; ** Regression model in step 1 significant at $p < .01$.
$p < .05$ indicated in bold font.
[a] Step 1 in regression model included sex, age, BMI, income and cigarettes per day.
[b] Step 2 in regression model included O_{max}. ΔR^2 implies the added predictive value of O_{max} over sex, age, income, BMI and CPD in the prediction of eating variables.
[c] Step 3 in regression model included intensity. ΔR^2 implies the added predictive value of intensity over sex, age, income, BMI, CPD and O_{max} in the prediction of eating variables.

frequency of grazing. This result indicates that a higher reinforcing efficacy of food is related to overeating. This aspect was also found by Fay, White, Finlayson, and King (2015), such that a higher sensitivity to food reward was related to the amount of food eaten in people who initiated snacking. On the other hand, concern about weight gain after smoking cessation was again related to intensity, O_{max} and breakpoint. This result is indirectly related to previous literature (Boswell & Kober, 2016), given that food cravings may contribute to eating behavior and weight gain. Finally, eating in response to emotions and food-related stimuli was associated with food demand. It is common that emotional eating tends to co-occur with external eating (Cebolla et al., 2014). In this sense, a stimulus that is highly reinforcing, such as food, will tend to be more salient than other stimulus and therefore trigger eating behavior with the aim of relieving emotional distress.

FPT factors, persistence and amplitude, did not demonstrate greater utility than the FPT indices separately, as in the Epstein, Stein, Paluch, MacKillop, and Bickel (2018) study. Thus, although decreasing the redundancy of demand indices provides notable methodological advantages, a better strategy would be to use the indices that best capture the reinforcing nature of the food, intensity and O_{max}.

Finally, the single-item breakpoint did not demonstrate any clinical utility in relation to measures of eating or weight, unlike the classic breakpoint, so its use is discouraged in the future. This result is consistent with the findings of other studies using brief alcohol (Hardy et al., 2021) and tobacco (González-Roz et al., 2021; Murphy et al., 2019) demand tasks.

This study has several limitations. First, although studying food demand in smokers with overweight is of clinical interest, the generalization of these results to other populations should be made with caution. Second, the amount of food that the participants had eaten before responding to the task was not controlled. Third, culturally adapted snack options (i.e., typical Spanish food) could have been expanded for this study. Fourth, the relatively small sample size of this study may have made it difficult to find statistically significant outcomes in some of the statistical analyses. Finally, the task used is hypothetical in nature, which may affect its validity. Nevertheless, the use of hypothetical tasks has shown to be as reliable as laboratory tasks (Epstein et al., 2010).

Despite these limitations, our study shows that the FPT is a valid measure of food reinforcement with potential clinical utility in smokers with obesity/overweight. Future studies should study the predictive value of FPT with respect to weight control treatment outcomes, as well as differences in the reinforcing efficacy of food as a function of the presence of certain characteristics such as smoking, depression, and other related weight-variables.

Ethical Statement for Solid State Ionics

Hereby, I Ángel García-Pérez consciously assure that for the manuscript Validation of the Food Purchase Task (FPT) in a clinical sample of smokers with overweight and obesity the following is fulfilled:

1) This material is the authors' own original work, which has not been previously published elsewhere.
2) The paper is not currently being considered for publication elsewhere.
3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
5) The results are appropriately placed in the context of prior and existing research.
6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

The violation of the Ethical Statement rules may result in severe consequences.

To verify originality, your article may be checked by the originality detection software iThenticate. See also http://www.elsevier.com/editors/plagdetect.

I agree with the above statements and declare that this submission follows the policies of Solid State Ionics as outlined in the Guide for Authors and in the Ethical Statement.

Declarations of competing interest

None.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2023.106549.

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