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**Food choice motives, attitude toward and intention to adopt
personalised nutrition**

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Manuscripts

1 **Food choice motives, attitude toward and intention to adopt personalised nutrition**

2

3 **Abstract**

4 **Objective:** This study explored associations between food choice motives, attitudes towards,
5 and intention to adopt personalised nutrition **in order to** inform communication strategies
6 based on consumer priorities and concerns. **Design and Setting:** A survey was administered
7 online which included the food choice questionnaire (FCQ), and items assessing attitudes
8 towards and intention to adopt personalised nutrition. **Participants:** Nationally representative
9 samples were recruited in 9 EU countries (N=9381). **Results:** Structural equation modelling
10 indicated that the food choice motives, *weight control*, *mood*, *health and ethical concern* had
11 a positive association and *price* had a negative association with attitude towards, and
12 intention to adopt, personalised nutrition. *Health* **was** positively associated and *familiarity*
13 negatively associated with attitude toward personalised nutrition. The effects of *weight*
14 *control*, *ethical concern*, *mood* and *price* on intention to adopt personalised nutrition were
15 partially mediated by the attitude. The effects of *health* and *familiarity* were fully mediated
16 by attitude. *Sensory appeal* **was negatively** and directly associated with intention to adopt
17 personalised nutrition. **Conclusion:** Personalised nutrition providers may benefit from taking
18 into consideration the importance of underlying determinants of food choice, particularly
19 *weight control*, *mood* and *price*, in potential users when promoting services and in tailoring
20 communications that are motivationally relevant.

21 **Key words:** Personalised Nutrition; Nutrigenomics; Food Choice Motives; FCQ; Survey;
22 Food4Me; Attitudes; Intention.

23

24 **Introduction**

25 Personalised Nutrition (PN) is individualised dietary advice based on dietary habits, lifestyle,
26 health status, phenotype and genotype ^{1, 2}, and focusses on health promotion ¹. In contrast to
27 generic dietary health recommendations, PN is based on an individual's **phenotype, genotype**
28 **or combination of these**, tailored to individual lifestyle needs, and can be offered 'direct-to-
29 consumer' ³. The public have positive attitudes toward PN, perceiving advantages with regard
30 to health, body weight, and fitness ^{4, 5}, and taking control of their health ⁶. According to the
31 Theory of Planned Behaviour ⁷, attitudes are among the most important factors determining
32 intentions to execute behaviours. Positive attitudes towards PN are a strong predictor of
33 intended uptake ^{4, 8}. Determinants of food choice, in particular those which motivate specific
34 decisions, are likely to be reflected in attitudes and intention to adopt PN ⁹.

35

36 Food choices are determined by a multitude of individual, social and environmental factors ¹⁰,
37 ¹¹. The Food Choice Questionnaire (FCQ) ¹² focusses on individual determinants of food
38 choice, and assesses the importance of 9 possibly interrelated motivating factors, some **linked**
39 to health. The 9-factor FCQ has been validated in a number of different European countries
40 ¹³⁻¹⁸. Motives for food choice, assessed using the FCQ, correlate with willingness to consume
41 sustainable foods ¹⁹, GM foods ²⁰, functional foods ²¹, organic foods ^{22, 23}, vegetarian ²⁴ and
42 traditional ^{25, 26} foods.

43

44 Póinhos et al. (2014) ⁴ sought to explain attitudes toward, and uptake of, PN with reference to
45 psychological traits associated with health behaviour change. Perceived benefit, high internal
46 health locus of control, and nutrition self-efficacy determined attitudes and intention to adopt
47 PN ⁴. This previous research ⁴ has also indicated that attitude toward PN will be related to
48 intention. The current analysis, therefore, whilst not making further inferences on attitude and
49 intention to adopt PN, has included all indirect as well as direct effects, and has focused on
50 identification of salient motives for *choosing* foods and how they relate to attitudes and
51 intention toward PN. To our knowledge, no research to date has considered food choice
52 motives in relation to dietary health promoting technologies. Understanding the perceived
53 importance of specific food choice motivations in relation to attitudes and behavioural
54 intentions to adopt PN is necessary for the development of effective communication
55 strategies and/or advice in keeping with an individual's thinking around food.

56

57 **Theoretical Framework and Hypotheses**

58 The Food Choice Questionnaire ¹² comprises of nine factors which have been demonstrated to
59 motivate food choices: health, weight control, ethical concern, price, sensory appeal, mood,
60 convenience, natural content, and familiarity. Previous research using the FCQ has
61 corroborated the relationship between health as a motivation for food choice and dietary
62 health behaviours ^{12, 27, 28}. Motivation to improve health is a driver of adoption of new dietary
63 health promotion technologies ^{4, 5, 29, 30}. Individuals highly motivated in their food choices by
64 the desire to improve and maintain 'health', may be expected to have positive attitudes
65 towards, and be more likely to adopt, PN. Personalised nutrition may be adopted for a range
66 of different reasons including, *inter alia*, weight control and disease prevention.
67 Communication, therefore, will need to address different motives for adoption, and in doing
68 so could potentially address individual motives for food choice in tailoring advice.

69

70 Weight control is a factor determining attitudes and intention to adopt PN ³⁰, and has been
71 found to be the most important factor determining food choice in Germany, Spain, Greece
72 and Ireland ¹³. Given higher scores on weight control (FCQ) have been found to be associated
73 with maintenance of healthy eating regimes ³¹, it is expected to be positively related to
74 attitude and intention to adopt PN ³². Those for whom optimal body weight is an important
75 motive for food choice are predicted to have more positive attitudes towards, and greater
76 intention to adopt PN.

77

78 Concern about the ethics of food (i.e. country of origin and environmental aspects of
79 packaging) has been associated with greater fruit and vegetable consumption ²³ and
80 vegetarianism ²⁴. Assuming the general public is likely to associate personalised diets with
81 the promotion of more healthy foods, ethical concern, therefore, is predicted to relate to
82 positive attitudes and intention to adopt PN.

83

84 Food prices are another determinant of food choice, particularly for those on low incomes ³³,
85 ³⁴. Price was reported to represent a barrier to healthy food choice for 15% of a nationally-
86 representative sample from across the 15 EU member states ^{34, 35}. The FCQ motive 'price'
87 has been associated with less frequent purchasing of healthier food ^{10, 12, 24}. Previous research

3

88 into factors determining adoption of PN has suggested price is an important consideration for
89 some consumers ³⁶, and the general public may not accept personalised nutrition at a higher
90 cost than conventional nutrition programmes ³⁷. Those for whom price is an important
91 motivation for food choice, therefore, could be expected to hold more negative attitudes
92 towards PN and be less likely to adopt it ³⁷, if they also perceive that healthy foods and
93 recommended diets will be more expensive ^{38,39}.

94

95 Sensory appeal is an important determinant of food preference ⁴⁰ and choice ^{5, 18}, and for
96 many consumers, more important than health in making food choice decisions ^{10, 41, 42}. The
97 perception that the sensory attributes of healthier foods are less appealing is potentially
98 detrimental to the purchasing of healthy and functional foods ^{21, 28}. Personalised nutritional
99 advice may recommend foods based on health and functional benefits rather than on taste,
100 thus the general public may expect personalised diets to contain less appealing foods. Those
101 for whom sensory appeal is an important motivation for food choice are expected to hold less
102 positive attitudes and less intention to adopt PN.

103

104 Previous research has suggested that food choices can be used to influence mood (i.e. coping
105 with stress, enhancing alertness or relaxing) ⁴³⁻⁴⁶. Conversely, foods consumed have been
106 shown to influence one's mood ⁴⁶. **Given that mood has been shown to be a determinant of**
107 **both healthy and less healthy food choices** ^{46, 47}, it is difficult to predict if the food choice
108 motive mood will be positively or negatively associated with attitudes towards and intention
109 to adopt PN.

110

111 Convenience is an important determinant of food choice ^{10, 48} likewise adoption of PN will
112 depend upon perceived convenience ⁹. Since the food choice motive convenience is a driver
113 of unhealthy food choices ⁴⁹ and that healthy food offered as part of PN could be perceived as
114 inconvenient suggests that those for whom convenience is an important motivation for food
115 choice, may hold less favourable attitudes toward PN and be less inclined to adopt it.

116

117 Perceptions that a food is 'natural' may motivate some consumers to consider it in specific
118 food choices ^{31, 50}. Perceptions of 'naturalness' are associated with the degree to which foods
119 are perceived to have been processed (including the use of additives and artificial

120 ingredients), with food that has undergone greater processing considered less natural ⁵¹.
121 Personalised diets could be expected to encompass functional foods bearing health claims to
122 meet specific individual dietary health needs. Functional food products bearing health claims,
123 if highly processed, are considered less natural ⁵². Some individuals for whom ‘natural
124 content’ is an important motive for food choice report lower consumption of functional foods
125 ^{21, 28}. **Personalised diets, however, would be adjusted to accommodate a preference for natural
126 foods.** ‘Natural content’, therefore, is expected to be related to attitudes toward and intention
127 to adopt PN, **although the direction of association is difficult to determine.**

128

129 Many people prefer and choose foods that are familiar ⁵³, and familiarity tends to be
130 associated with tradition ^{25, 54, 55}. Personalised nutrition may not be adopted if advice deviates
131 from the usual diets of the users ^{9, 56}. This is further impacted if individuals find it difficult to
132 adhere to nutritional advice if recommended foods ^{55, 57} and brands ⁵⁸ that are unfamiliar.
133 There may be the expectation among potential consumers that recommended foods may not
134 always be familiar to them. It is predicted, therefore, that those for whom familiarity is an
135 important determinant of food choice will hold more negative attitudes and intention toward
136 PN.

137

138 In summary, it is hypothesised that people for whom price, sensory appeal, convenience and
139 familiarity are important drivers of food choice will hold less favourable attitudes to PN and
140 have less intention to adopt it. Those for whom health body weight and natural content are
141 important motivators of food choice are expected to hold favourable attitudes and intentions
142 to adopt PN. Mood will be associated attitudes and/or intention toward PN, although the
143 direction is difficult to predict.

144

145 **Methods**

146 Ethical approval for the online survey was granted by Newcastle University Research Ethics
147 Committee. Data collection was part of a larger survey on PN. The questionnaire was
148 administered (N=9381) during February and March 2013. Participants were recruited through
149 research agencies in **nine** European countries (Germany, Greece, Ireland, Poland, Portugal,
150 Spain, the Netherlands, the UK, and Norway) in each country’s national language **using
151 quotas stratified to be representative of their country population in terms of age and sex.**

152 There were no exclusion or inclusion criteria, although given the survey was on-line, all were
153 IT literate. There was a 31.9% response rate. The resultant sample was 50.6% male of whom:
154 22% were aged 18-29 years; 23.4% were aged 30-39 years; 34.8% were aged 40-54 years;
155 and, 19.8% were aged 55-65 years. Using the International Standard Classification of
156 Education Level, 28.7 % were classified as low, 38.9% as middle and 32.4% as highly
157 educated. A detailed account of the development of the online survey tool, sampling and
158 procedure are reported previously⁴.

159

160 **Measures**

161 Personalised nutrition was defined at commencement of the survey as ‘healthy eating advice
162 that is tailored to suit an individual based on their own personal health status, diet, physical
163 activity and/or genetics’.

164

165 *Food Choice Questionnaire (FCQ)*

166 The Food Choice Questionnaire¹³ comprises 9 factors. Each factor is measured by multiple
167 items asking respondents to rate the importance they attach to motives for choosing food.
168 Responses were on a 5-point rating scale from 1 = ‘Not at all important’ to 5 = ‘Extremely
169 important’. For a full list of items see Supplementary Table 1. The validation of the FCQ for
170 the purpose of this study is referred to in Markovina et al.¹³.

171

172 *Attitude towards PN*

173 Attitude towards PN was measured on four individual semantic differential 5-point rating
174 scales adapted from Crites et al.⁵⁹, with responses ranging from ‘PN is: Very worthless to
175 Very valuable; Very unpleasant to Very pleasant; Very boring to Very interesting; and, Very
176 bad to Very good. For validation of this scale in the current data set, refer to Póinhos et al.⁴.

177

178 *Intention to Adopt PN*

179 The items measuring intention to adopt PN were adapted from Melnyk et al.’s⁶⁰ behavioural
180 intention scale, in turn adapted from Oliver et al.’s⁶¹ intention scale. Specific items were
181 adapted for intention to adopt PN. Respondents were asked to ‘Please indicate the extent you
182 agree or disagree with the following statements: ‘I intend to adopt PN’; ‘I would consider
183 adopting PN’; and, ‘I am definitely going to adopt PN’. Responses were on a 5-point Likert

184 scale ranging 1 = ‘Completely disagree’ to 5 = ‘Completely agree’. Validation of this scale in
185 the current data set has been reported in Póinhos et al. ⁴.

186

187 **Statistical Analysis**

188 Data analysis was conducted using IBM SPSS Statistics for Windows (Version 22.0.
189 Armonk, NY: IBM Corp.) and *MPlus* (Version 7.3) (Muthén & Muthén, 1998-2011). Multi-
190 group confirmatory factor analysis (MG-CFA) and **multi-group structural equation modelling**
191 (MG-SEM) were conducted across the **nine** EU countries **to assess**: attitudes towards PN;
192 intention to adopt PN; and food choice motives. **This enabled assessment of** the measurement
193 model for each individual construct. Validity and reliability of the food choice motives in
194 nine European countries has been reported in Markovina et al ¹³. Direct causal and indirect
195 relations between the latent constructs were tested using MG-SEM.

196

197 *Confirmatory Factor Analyses*

198 Two multi-group one-factor models were constructed with country of residence as group. The
199 first focused on attitude towards PN, the second on intention to adopt PN. The food choice
200 motives were analysed in one combined multi-group nine-factor model. Metric and scalar
201 measurement invariance ^{62, 63} were tested in a step-wise process. Modifications (e.g. relaxing
202 the equalities on country-specific factor loadings or intercepts) were added to the model,
203 based on large modification indices until model fit indices were acceptable. The factor
204 ‘ethical concern’ was compiled of 3 items, including ‘comes from countries I approve of
205 politically’ which had a lower factor loading (0.584) than the other items, and a lower
206 correlation with the other 2 ethical concern items. This item was, allowed to deviate from
207 equality constraints (on the item intercept) in the measurement part of the model. Model fit
208 indices presented include: Satorra-Bentler corrected Chi-square (χ^2); Root Mean Square Error
209 of Approximation (RMSEA); Standardized Root Mean Square Residual (SRMR); Tucker-
210 Lewis Index (TLI); and, Comparative Fit Index (CFI). Values <0.07 for RMSEA, <0.08 for
211 SRMR, and >0.95 for TLI and CFI, suggest an acceptable model fit ^{64, 65}.

212

213 *Structural Equation Model*

214 In order to detect differences between countries, a multi-group structural equation model was
215 performed in six steps that consecutively added cross-country equality constraints. The

216 structure of the model was tested through 1) configural invariance (Model i), 2) metric
217 invariance (Models ii and iii) and 3) scalar invariance (Models iv, v, and vi). For each, the
218 following modifications were added to the model: Model i) path coefficients between latent
219 constructs were allowed to vary across countries; Model ii) path coefficients between latent
220 constructs were held equal (i.e. not allowed to vary across countries); Model iii) variances
221 and covariances amongst exogenous latent constructs (FCQ items) were held equal; Model
222 iv) regression intercepts for Attitude towards PN and Intention to adopt PN were held equal;
223 Model v) means for the 9 exogenous latent variables (FCQ) were held equal; and Model vi)
224 the proportion of variance (R^2) in attitudes towards PN and intention to adopt PN was held
225 equal. A number of constraints were relaxed in the model, based on large modification
226 indices, until model fit indices were acceptable. Model fit indices presented included:
227 Satorra-Bentler corrected Chi-square (χ^2); Root Mean Square Error of Approximation
228 (RMSEA); Standardized Root Mean Square Residual (SRMR); Tucker-Lewis Index (TLI);
229 and, Comparative Fit Index (CFI). Values <0.07 for RMSEA, <0.08 for SRMR, and >0.95 for
230 TLI and CFI, suggest an acceptable model fit^{64,65}.

231

232 **Results**

233 *Sample Description*

234 A detailed description of the sample has previously been reported⁴. A total of 29450
235 individuals were contacted of whom 9381 volunteered and completed the online
236 questionnaire, equating to a response rate of 31.9%. The sample was 50.6% male with a
237 modal age of 40-54 years (34.8%).

238 *Aggregate mean (SD) attitude toward PN was 3.46 (0.67). Mean (SD) attitude toward PN for*
239 *each country was: Poland - 3.64 (0.70); Portugal - 3.59 (0.62); Ireland - 3.58 (0.65); Spain -*
240 *3.56 (0.68); UK - 3.46 (0.070); Greece - 3.43 (0.61); Germany - 3.34 (0.69); Norway - 3.33*
241 *(0.74); Netherlands - 3.19 (0.54). Aggregate mean (SD) intention to adopt PN across*
242 *countries was 2.98 (0.92). Mean (SD) intention to adopt PN for each country was: Poland -*
243 *3.23 (0.91); Spain 3.2 (0.81); Greece - 3.18 (0.77); Portugal - 3.16 (0.77); Ireland - 3.16*
244 *(0.82); Germany - 2.96 (0.97); UK - 2.93 (0.89); Netherlands - 2.68 (0.82); Norway - 2.35*
245 *(1.07).*

246

247 *Confirmatory Factor Analyses*

248 Consistent with previous analysis using this survey sample⁴, single factor models for attitude
249 towards PN and intention to adopt PN were assumed. Metric invariance could be assumed for
250 attitude towards PN across country, and partial metric invariance could be assumed for the
251 food choice motives (FCQ scores) and intention to adopt PN across countries (Table 1).
252 Partial scalar invariance held for all constructs, when equality of item loading or intercepts
253 was relaxed in the case of large modification indices. Compared to recommended cut-off
254 values, good model fit was demonstrated for all constructs in relation to SRMR. In relation to
255 the model fit indices CFI and TLI, the FCQ scores and intention to adopt PN met the
256 recommended cut-off values. Attitude towards PN was marginally below cut-off values
257 (CFI=0.92, TLI=0.93). No cross-factor loadings were evident above the recommended cut off
258 of 0.4 in the FCQ nine-factor model. The FCQ scores met the criteria for optimal fit for
259 RMSEA. The fit of the factor models for both attitude towards PN, and intention to adopt PN,
260 were above the cut-off values. The measurement models developed in each of the three factor
261 models were then combined into a multi-factor model. Compared to recommended cut-off
262 values, model fit indices of this partial scalar model suggested good model fit (Table 1). That
263 indicators of configural, metric and scalar invariance were satisfactory suggests that
264 constructs had similar meaning for respondents from different countries and that any
265 differences found in subsequent analyses have probably not been influenced by cultural or
266 country specific differences in measurements.

267

268 **Insert Table 1 here**

269

270 *Structural Equation Model*

271 Compared to recommended cut-off values the final partial scalar structural model (Model vi)
272 showed good model fit when a number of means of the latent variable (FCQ) were allowed to
273 deviate (Table 2). Standardised path coefficients in the structural equation for Intention to
274 Adopt Personalised Nutrition differed between countries proportional to differences in R^2 ,
275 with the R^2 in Poland being closest to the mean R^2 (Supplementary Table 3). **Given the large
276 number of observations, the 0.01 level of significance has been assumed.**

277

278 **Insert table 2 here**

279

280 There was a strong positive association between attitude toward PN and intention to adopt PN
281 (Figure 1).

282

283 Direct Associations with Attitude toward Personalised Nutrition

284 Taking the 0.01 level of significance, the food choice motives (FCQ) weight control
285 (Estimate = 0.184; SE = 0.017; $P = 0.000$), mood (Estimate = 0.181; SE = 0.029; / $P = 0.000$),
286 health (Estimate = 0.130; SE = 0.027; $P = 0.000$), and to a lesser degree and ethical concern
287 (Estimate = 0.053; SE = 0.017; $P = 0.002$) were positively and directly related to attitude
288 toward PN (Figure 1). Price (Estimate = -0.058; SE = 0.017; $P < 0.01$ / $P = 0.001$) and
289 familiarity (Estimate = -0.079; SE = 0.018; $P = 0.000$) were directly and negatively
290 associated with attitude towards PN. There was no direct association between attitude toward
291 PN and natural content (Estimate = 0.039; SE = 0.018; $P = 0.037$), convenience (Estimate =
292 0.040; SE = 0.022; $P = 0.068$) or sensory appeal (Estimate = 0.007; SE = 0.002; $P = 0.726$)
293 (Figure 1).

294

295 Direct Associations with Intention to Adopt Personalised Nutrition

296 Taking the 0.01 level of significance, the food choice motives mood (Estimate = 0.090; SE =
297 0.024; $P = 0.000$), weight control (Estimate = 0.159; SE = 0.015; $P = 0.000$) and ethical
298 concern (Estimate = 0.055; SE = 0.014; $P = 0.000$) all had a significant direct positive
299 association with intention to adopt PN. Sensory appeal (Estimate = -0.068; SE = 0.016; $P =$
300 0.000) and price (Estimate = -0.043; SE = 0.014; $P = 0.003$) had a significant direct negative
301 association with intention to adopt PN. There was no direct association between intention to
302 adopt PN and health (Estimate = 0.030; SE = 0.022; $P = 0.175$), convenience (Est = 0.036;
303 SE = 0.018; $P = 0.047$), natural content (Estimate = -0.029; SE = 0.016; $P = 0.063$) or
304 familiarity (Estimate = 0.004; SE = 0.015; $P = 0.795$) (Figure 1).

305

306 Indirect Associations with Intention to Adopt Personalised Nutrition

307 Taking the 0.01 level of significance, there were significant indirect positive associations via
308 attitude between intention and the food choice motives health (Estimate = 0.077; SE = 0.016;
309 $P = 0.000$), mood (Estimate = 0.107; SE = 0.016; $P = 0.000$), weight control (Estimate =
310 0.109; SE = 0.010; $P = 0.000$) and ethical concern (Estimate = 0.031; SE = 0.010; $P = 0.002$).
311 There were significant indirect negative associations via attitude between intention and the

312 food choice motives price (Estimate = -0.034; SE = 0.010; $P = 0.001$) and familiarity
313 (Estimate = -0.047; SE = 0.011; $P = 0.000$). There was no indirect association between
314 intention to adopt PN and **natural content** (Estimate = 0.024; SE = 0.011; $P = 0.037$),
315 convenience (Estimate = 0.024; SE = 0.013; $P = 0.068$) or sensory appeal (Estimate = 0.004;
316 SE = 0.012; $P = 0.726$).

317

318 **Insert Figure 1 here**

319

320 All model-based internal consistency reliabilities⁶⁵ were above the 0.7 cut-off value¹³, with
321 all (except for 'ethical concern' in Greece) above 0.8. The proportion of variance (R^2) in
322 attitudes towards PN and intention to adopt PN was >0.350 in all countries (Figure 1;
323 Supplementary Table 3).

324

325 Large positive correlations were observed between 'health' and 'mood' ($r=0.797$), and
326 between 'natural content' and 'ethical concern' ($r=0.649$). More moderate correlations were
327 observed between 'mood' and 'sensory appeal' ($r=0.599$), weight control and familiarity
328 ($r=0.595$), sensory appeal and convenience ($r=0.590$), mood and natural content ($r=0.573$),
329 and health and weight control ($r=0.550$) (Supplementary Table 4). High composite model-
330 based internal consistency reliability reliabilities (>0.80) and large sample size ($N=9381$),
331 however, should have protected against any effect of multi-collinearity⁶⁶.

332

333 **Discussion**

334 This analysis considered the degree to which attitudes toward, and intention to adopt PN are
335 associated with motives for food choice, measured using the food choice questionnaire (FCQ)
336¹². The question we have asked is *whether* and in *what way* food choice motives are
337 associated with attitudes towards, and intention to adopt, PN. As would be predicted by the
338 Theory of Planned Behaviour^{7, 67}, the results suggest that individuals with more positive
339 attitudes towards PN would be more likely to intend to adopt it. This is reflected in both
340 direct and indirect (through attitude) associations between certain motives for food choice,
341 and attitudes towards, and intention to adopt, PN (Figure 1).

342

343 A number of studies utilising the FCQ have identified the desire to maintain and improve
344 health as an important motive for food choice in various EU populations ^{13, 15, 68}. Prior
345 qualitative research conducted by the authors ³⁰ indicated that the European public held
346 favourable views on PN. It was hypothesised, therefore, that health as a food choice motive
347 would be positive related to attitudes and intention to adopt PN. As expected, those highly
348 motivated by health were more likely to hold a positive attitude towards PN, exerting an
349 indirect influence upon intended adoption. The health motivation, however, did not have a
350 direct effect on intended adoption. This may be because, as suggested by qualitative research
351 ^{6, 30}, individuals for whom health concerns were an important motivation for food choice,
352 despite holding positive attitudes to PN, may already believe they eat a healthy diet and
353 therefore do not consider that adoption of PN would provide benefits over and above their
354 existing healthy eating habits. Another possible explanation is that in this sample health was
355 only the 4th most important motivation for food choice after price, sensory appeal and natural
356 content ¹³, implying that recommended foods would need to be affordable, tasty and natural
357 before health benefits would be taken into account. The indirect effect on intention to adopt
358 PN suggests that those for whom improving and maintaining health is an important driver of
359 food choice may need to be convinced of the added health benefits of PN, so that these
360 positive attitudes toward PN can be translated into adoption of PN.

361

362 As predicted, where weight control was an important motive for food choice which was
363 strongly directly associated with attitudes towards PN, and both directly and indirectly (*via*
364 attitude) associated with intention to adopt PN. This finding corroborates the results of the
365 qualitative analysis conducted previously ³⁰, which suggested that achieving weight loss was
366 a potential motivator for engagement with PN. Weight control was correlated with health
367 suggesting that these constitute related motives for uptake of PN ³⁰. Those for whom weight
368 control was an important motive for food choice held more positive attitudes towards PN and
369 indicated that they would be likely to adopt the service, implying that PN should target and
370 aim to meet the needs of those seeking to control body weight. Weight control, however, was
371 rated relatively low as 7th most important motivation for food choice ¹³. That weight control
372 was relatively important for food choice in Greece and Portugal ¹³ suggests that PN has
373 greatest potential to help people control body weight in these countries.

374

375 Those who indicated that mood was an important motive for food choice were more likely to
376 have a positive attitude towards, and (both directly and *via* attitude) report intention to adopt,
377 PN. Mood and health motivations were strongly related and to a greater degree than other
378 analyses of the FCQ have reported ^{12, 24, 69}. Our comparatively larger sample size suggests
379 these results are probably more reliable. Mood and sensory appeal were also correlated
380 implying that seeking mood enhancement through the eating experience could be a potential
381 motivator for, or deterrent to adoption of PN. Meanwhile, those seeking to adopt PN may
382 require foods and diets to match mood-driven preferences suggesting that mood as a motive
383 for food choice should be taken into account in the design of foods and diets. Mood is an
384 important motive for food choice, and should be considered when devising personalised
385 dietary recommendations and, if made prominent when promoting PN, could render attitudes
386 and intention toward PN more positive.

387

388 As hypothesised, high scores on the ethical concern motive were positively related to
389 attitudes towards, and (both directly and *via* attitude) to intention to adopt, PN. Ethical
390 concern was less strongly associated with attitudes and intention compared to weight control,
391 in line with other studies using the FCQ, where ethical concern was ranked one of the least
392 important food choice motives ^{13, 15, 18}. Here ethical concern appears important to those who
393 have positive attitudes and intend to adopt PN. Method of production and related ethical
394 issues should therefore be considered in nutritional advice provided under the auspices of a
395 PN service.

396

397 As predicted, higher scores on price as a motive for food choice were associated with less
398 favourable attitudes towards, and (both directly and *via* attitude) with lower intention to
399 adopt, PN. Research into food choice has suggested that monetary considerations are among
400 the main reasons for not buying healthy foods ^{12, 35, 36}. **The most important motivation for**
401 **food choice in this sample was price** ¹³. These data indicate **only** moderate associations
402 between price, attitudes and intention, reflecting existing qualitative research **and** some
403 consumers are willing to pay a premium for PN ³⁰. The negative direct effect on intention to
404 adopt PN suggests that individuals concerned with the price of food may perceive that they
405 are unable to afford the foods needed to deliver PN, **despite having** a favourable attitude.

406

407 The food choice motive ‘familiarity’, as expected, was associated with more negative
408 attitudes towards PN. To **diminish the impact of familiarity**, providers of PN should
409 emphasize that individual advice will take into account existing dietary practices. Familiarity,
410 despite the absence of a direct effect on intention to adopt PN, had an indirect effect on
411 intention to adopt PN *via* attitudes towards PN. This lack of direct effect in attitudes could be
412 because whereas attitudes relate to others as well as oneself, intention is personal. Familiarity
413 is **also down to personal** prior experiences. Familiarity items on the FCQ may have tapped
414 into the perception that PN itself was unfamiliar, thereby influencing responses.

415

416 We hypothesized that convenience would be negatively associated with attitude toward, and
417 intention to adopt, PN. Contrary to expectation, the results of this study indicated that
418 convenience was unrelated to attitude, and despite existing evidence suggesting that
419 convenience may be important to uptake of PN ⁹, **was unrelated** to intention to adopt PN.
420 **That those who view PN favourably and intend to take it up do not rate convenience**
421 **important to food choice suggests that personalised diets will not necessarily need to**
422 **prioritise convenience.**

423

424 It was hypothesised that those for whom sensory appeal was an important driver of food
425 choice would have less favourable attitudes towards, and be less likely to intend to adopt PN.
426 There was no association between sensory appeal and attitude to PN, however, those who
427 were more highly motivated by sensory appeal had lower intentions to adopt PN. The
428 assumption that foods prescribed as part of a personalised plan may be selected on grounds
429 other than sensory appeal may have impacted negatively on intention to adopt PN. Again,
430 whereas attitudes could relate to the individual as well as others, intention is individual.
431 **Sensory appeal was the second most important motivation for food choice in this sample ¹³,**
432 **suggesting that** for PN services to be adopted, providers need to assure potential clients that
433 diet plans take into account their sensory preferences.

434

435 **Natural content was ranked third most important food choice motive but was unrelated to**
436 **attitudes toward or intention to adopt PN.** This contrasts with previous research implying that
437 ‘natural content’ is associated with detrimental attitudes to highly processed foods such as
438 GM ²⁰ and functional food ^{21, 28}, which could be expected to be a component of personalised

439 diets. Those who hold positive attitudes toward and intend to adopt PN may be aware that
440 natural foods such as fruit and vegetables may be recommended to provide functional
441 benefits. Natural content was positively and strongly correlated with ethical concern implying
442 the motives are intertwined.

443

444 **Study Limitations**

445 As with any self-reported data, there may have been response biases whereby respondents
446 sought to project a socially desirable image in relation to their food choice motives ⁷⁰. Added
447 to this is the positive bias inherent in the FCQ such that the questionnaire may not have
448 accurately captured the relative importance of each factor ¹². The established validity of the
449 FCQ, however, suggests that this does not offer a major barrier to interpretation of the results.
450 Results from this analysis support the assumption of partial metric and indicate scalar
451 measurement invariance ¹³, which is in line with studies that support the cross-cultural
452 validity and use of the FCQ across Europe ^{15, 26}. Another limitation of the FCQ, is that it is
453 focussed on individual determinants of food choice to the neglect of social factors and the
454 environment. It is also possible that since the questionnaire was translated into different
455 languages, questions may have had subtly different meanings which may have contributed to
456 differences between countries. Although well-validated for the measurement of individual
457 factors determining food choice ¹³, the FCQ might also benefit from some revision in the
458 light of nutritional knowledge and current issues in food production. The 'low fat' item
459 within the weight control factor, for example, could consider the type of fat and the ethical
460 factor could include an item on animal welfare. The cross-sectional nature of the survey
461 limits the ability to draw information on causality ⁷¹. In addition, because the survey was
462 conducted *via* the Internet, the sample was biased toward those who are more computer
463 literate and spend time online. Individuals who have computers at home are likely to be more
464 affluent and may prioritise food choice motives differently. Personalised nutrition in the
465 Food4me project is (in part) a digital offering, which renders the sample appropriate to
466 answer our research question on food choice motives, attitudes and intention to toward PN.
467 Further research is needed to consider the needs of more disadvantaged societal groups and
468 how to serve them through PN ⁷². Another potential limitation is that because panellists were
469 quota sampled and then stratified to be representative of their country population in terms of
470 age and sex, it has not been possible to determine if those who responded differed

471 demographically from those who did not. There was between country variation in attitude
472 toward and intention to adopt PN which could have affected the results. Attitude was most
473 positive and intention to adopt PN highest in Poland implying potential for PN in Poland.

474 Despite an operational definition of PN having been provided at the beginning of the survey
475 questionnaire, lack of direct experience with PN may explain the moderate response rate
476 (31.9%). The low number of partially completed questionnaires (4.0%) suggests that those
477 who did respond fully understood the concept and the questions. A lack of direct experience
478 with PN services was expected across the sample, since the technology was still in its infancy
479 at the time the study was conducted, the dependent variable was intended adoption, rather
480 than actual behaviour (i.e. actual uptake of the service). The association between intended
481 adoption and actual behaviour may require further analysis. Future research may need to
482 consider actual users of this novel technology to ascertain the potential for food choice
483 motives to act as motivators and barriers to adoption and compliance of PN interventions.

484

485 **Conclusion**

486 These results provide insights into how motivators of food choice relate to attitudes towards
487 PN and intention to adopt it, in nine European countries. People who differ in the importance
488 they attribute to the various food choice motives may have different needs and will require
489 varying approaches to the marketing and delivery of personalised recommendations. Those
490 for whom weight control, ethical concern and mood were important motives for food choice
491 exhibited more positive attitudes towards PN, and reported that they were more likely to
492 consider adopting the service. These factors need consideration in the design and
493 implementation of individualised plans. Communication strategies to encourage adoption of
494 PN should focus on how it can take account of food choice motives, and convey the
495 possibility of personalised plans to control body weight and enhance mood. While
496 emphasising healthy content of recommended diets may instil positive attitudes toward PN,
497 prioritising the sensory appeal of recommended foods should promote uptake. Determinants
498 of food choices such as price and familiarity, associated with negative attitudes toward PN,
499 may need to be taken into consideration when designing personal plans, so that PN advice is
500 more likely to be followed. Reassurances should be provided that personalised plans will
501 prescribe foods that are familiar to the individual and which routinely take into account
502 sensory preferences as well as individual financial constraints.

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700 **Figure 1.** Standardised path coefficients for Direct Associations with Attitude toward
701 Personalised Nutrition and Intention to Adopt Personalised Nutrition (Model vi) in Poland
702
703 Conven, Convenience; EC, Ethical Concern; Fam, Familiarity; NC, Natural Content; SA,
704 Sensory Appeal; WC, Weight Control.
705 P<0.01*, P<0.001**
706

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Table 1. Fit measures for factor models

Factor model	Metric invariance	Scalar invariance	SB χ^2	CFI	TLI	RMSEA			SRMR
						Value	90%LB	90%UB	
Food Choice Motives	Partial ^a	Partial ^a	9172.111	0.96	0.95	0.037	0.036	0.038	0.046
Attitude towards personalised nutrition	Yes	Partial ^b	505.23	0.92	0.93	0.097	0.091	0.104	0.067
Intention to adopt personalised nutrition	Partial ^c	Partial ^c	200.94	0.97	0.96	0.090	0.079	0.100	0.070

^a Health: Equality of item loading relaxed for 4th item in Poland. Equality of item intercepts relaxed for 1st item in Germany, for 2nd item in Spain, Poland, the UK and the NL, for 3rd item in Poland and Portugal, for 4th item in Germany and the NL, for 5th item in Norway and the NL and for 6th item in Spain. Mood: Equality of item loading relaxed for 4th item in Poland. Equality of item intercepts relaxed for 2nd item in Spain and Greece, for 4th item in Norway, Germany, Spain, Greece, Poland and Portugal, for 5th item in Norway, Germany, Greece and Poland and for 6th item in Norway and Germany. Convenience: Equality of item intercepts relaxed for 2nd item in Greece, for 3rd item in Norway, Germany, Poland, the UK and Ireland, for 4th item in Norway, Germany, Spain, Greece, Poland, the NL and Portugal and for 5th item in Norway, Greece, Poland, the NL and Portugal. Sensory Appeal: Equality of item loading relaxed for 4th item in Spain. Equality of item intercepts relaxed for 1st item in Greece and the UK, for 2nd item in Spain, the NL and Portugal, for 3rd item in Portugal and for 4th item in Spain. Natural Content: Equality of item intercepts relaxed for 1st item in Norway and for 2nd item in Greece and Poland. Price: Equality of item loading relaxed for 1st item in Norway, for 2nd item in Spain. Equality of item intercepts relaxed for 1st item in Norway, for 2nd item in Norway, Spain, the UK and Ireland and for 3rd item in Germany. Weight Control: Equality of item loading relaxed for 1st item in Norway. Equality of item intercepts relaxed for 1st item in Norway and Germany, for 2nd item in the NL and for 3rd item in Spain and Portugal. Familiarity: Equality of item loading relaxed for 2nd item in Greece. Equality of item intercepts relaxed for 1st item in Norway, Germany, Greece, the UK and Ireland, for 2nd item in Norway, Greece, Greece and Portugal and for 3rd item in Poland and the NL. Ethical Concern: Equality of item intercepts relaxed for 1st item in Spain, Greece and the UK, for 2nd item in the UK, the NL and Portugal and for 3rd item in Poland.

^b Equality of item intercept relaxed for third item in the NL.

^c Equality of item loading (and intercept) relaxed for second item in Spain. Equality of item intercept relaxed for first item in Greece, for second item in Norway, Germany, and the NL, and for third item in Germany.

CFI, Comparative Fit Index; NL, the Netherlands; RMSEA, Root Mean Square Error of Approximation; SB χ^2 , Satorra-Bentler corrected Chi-square; SRMR, Standardized Root Mean Square Residual; TLI, Tucker-Lewis Index; UK, United Kingdom

Table 2. Fit measures for multi-factor model and structural equation models

	SB χ^2	CFI	TLI	RMSEA			SRMR
				Value	90% LB	90% UB	
Multi-factor model							
Partial scalar measurement invariance ^a	13318.68	0.95	0.95	0.036	0.035	0.037	0.045
Structural equation models							
<i>i. Configural structural invariance ^a</i>							
	13318.68	0.95	0.95	0.036	0.035	0.037	0.045
<i>Metric structural invariance</i>							
<i>ii. equal path coefficients ^a</i>							
	13559.10	0.95	0.95	0.036	0.035	0.036	0.048
<i>iii. also partially equal (co-) variances among exogenous latent variable's ^{ab}</i>							
	14679.28	0.95	0.95	0.037	0.036	0.037	0.072
<i>Scalar structural invariance</i>							
<i>iv. equal regression intercepts ^{abc}</i>							
	14797.84	0.95	0.95	0.037	0.036	0.038	0.072
<i>v. + equal means exogenous latent variable's ^{abcd}</i>							
	14704.84	0.95	0.95	0.037	0.036	0.037	0.079
<i>vi. + equal R² Attitude ^{abcd}</i>							
	14753.52	0.95	0.95	0.037	0.036	0.037	0.080

^a Relaxations on item loadings and intercepts adopted from measurement models (see Table 2).

^b Equality restriction relaxed for variance for Price in Norway.

^c Equality restriction relaxed for regression intercept for Intention in Norway and for Attitude in the NL.

^d Equality restrictions relaxed for means of Health in Spain and Portugal, for Mood in Greece, the UK and the NL, for Convenience in Germany, Spain, Greece, Poland and the NL, for Sensory Appeal in Germany, Spain, the UK and the NL, for Natural Content in Greece, Poland, the UK, Ireland and the NL, for Price in Greece and Portugal, for Weight Control in Germany and the NL, for Familiarity in the UK, Ireland, the NL and Portugal, and for Ethical Concern in Greece, the NL and Portugal

CFI, Comparative Fit Index; NL, the Netherlands; RMSEA, Root Mean Square Error of Approximation; SB χ^2 , Satorra-Bentler corrected Chi-square; SRMR, Standardized Root Mean Square Residual; TLI, Tucker-Lewis Index; UK, United Kingdom

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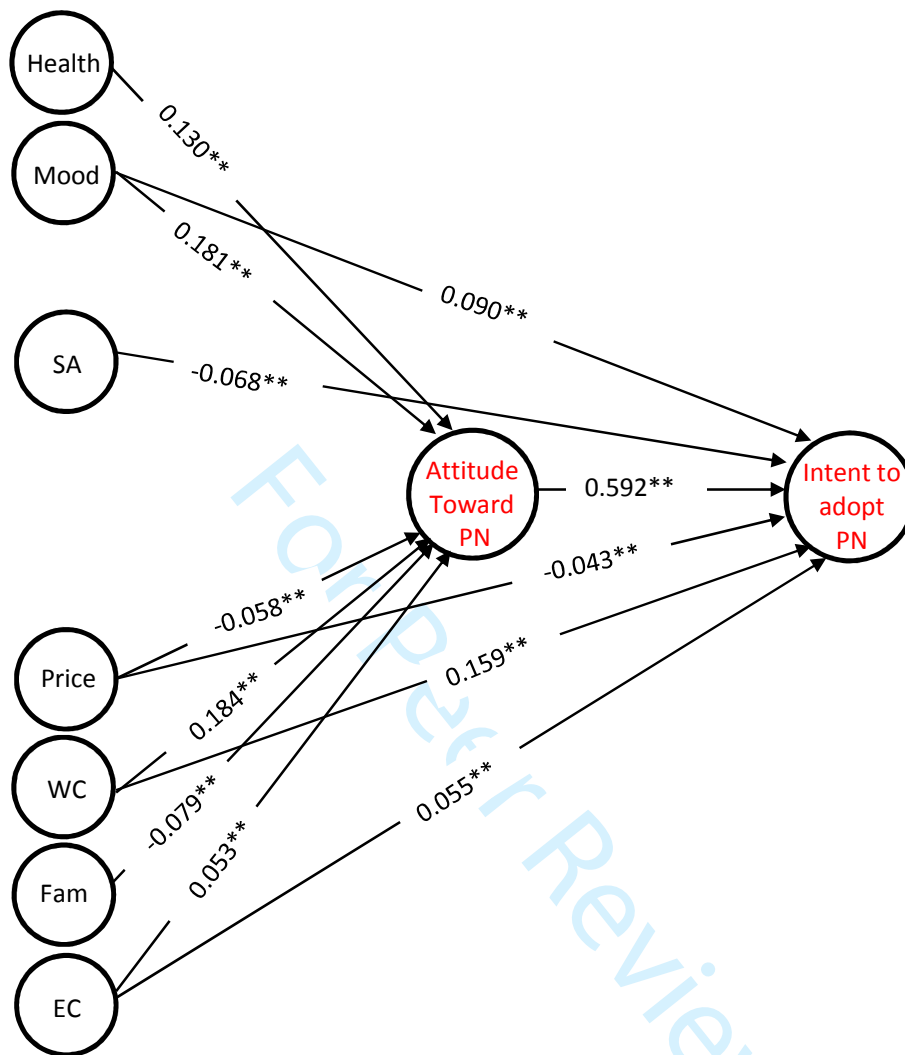


Figure 1. Standardised path coefficients for Direct Associations with Attitude toward Personalised Nutrition and Intention to Adopt Personalised Nutrition (Model vi) in Poland

Conven, Convenience; EC, Ethical Concern; Fam, Familiarity; NC, Natural Content; SA, Sensory Appeal; WC, Weight Control.

P<0.01*, P<0.001**

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