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Influence of consumers' cognitive style on results from projective mapping

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Abstract

Projective mapping (PM), one of the most holistic product profiling methods in approach, is increasingly being used to uncover consumers' perception of products and packages. Assessors rely on a process of synthesis for evaluating product information, which would determine the relative importance of the perceived characteristics they use for mapping them. Individual differences are expected, as participants are not instructed on the characteristics to consider for evaluating the degree of difference among samples, generating different perceptual spaces. Individual differences in cognitive style can affect synthesis processes and thus their perception of similarities and differences among samples. In this study, the influence of the cognitive style in the results of PM was explored. Two consumer studies were performed, one aimed at describing intrinsic sensory characteristics of chocolate flavored milk and the other one looking into extrinsic (package only) of blueberry yogurts. Consumers completed the wholistic-analytic module of the extended Verbal Imagery Cognitive Styles Test & Extended Cognitive Style Analysis-Wholistic Analytic Test, to characterize their cognitive style. Differences between wholistic and analytic consumers in how they evaluated samples using projective mapping were found in both studies. Analytics separated the samples more in the PM perceptual space than wholistic consumers, showing more discriminating abilities. This may come from a deeper analysis of the samples, both from intrinsic and extrinsic point of views. From a sensory perspective (intrinsic), analytic consumers relied on more sensory characteristics, while wholistic mainly discriminated samples according to sweetness and bitterness/chocolate flavour. In the extrinsic study however, even if analytic consumers discriminated more between packs, they described the products using similar words in the descriptive step.

One important recommendation coming from this study is the need to consider higher dimensions in the interpretation of projective mapping tasks, as the first dimensions could underestimate the complexity of the perceptual space; currently, most

applications of PM consider two dimensions only, which may not uncover the perception of specific groups of consumers.

Keywords: Projective Mapping, product description, cognitive style, wholistic, analytic

1. Introduction

Holistic methodologies are increasingly used for uncovering consumers' perception of food products (Valentin, Chollet, Lelievre, & Abdi, 2012; Varela & Ares, 2012). These methodologies are based on the evaluation of global similarities and differences among samples, providing a synthetic representation of the products (Ares & Varela, 2014).

Among consumer-based descriptive methods, projective mapping can be considered as one of the most holistic in approach (Dehlholm, Brockhoff, Meinert, Aaslyng, & Bredie, 2012b). In projective mapping assessors are asked to position samples on a bi-dimensional space according to their global similarities and differences (Risvik, McEvan, Colwill, Rogers, & Lyon, 1994). This methodology allows assessors to evaluate similarities and differences among samples by considering more than one characteristic at the same time (bi-dimensional) and without the use of words, although a descriptive step can be added later on. Projective mapping has been applied to identify similarities and differences among products, as well as the sensory characteristics responsible for perceived similarity in a wide range of product categories (Albert, Varela, Salvador, Hough, & Fiszman, 2011; Bárcenas, Pérez-Elortondo, & Albisu, 2004; Hopfer & Heymann, 2013; Nestrud & Lawless, 2008; Pagés, 2005; Risvik et al., 1994; Vidal, Cadena, Antúnez, Giménez, Varela & Ares, 2014).

Projective mapping data consist of the X and Y coordinates of the samples on each of the assessors' individual maps. Considering that assessors can use different criteria to estimate similarities and differences among samples Generalized Procrustes Analysis (GPA) or Multiple Factor Analysis (MFA) are used to obtain a consensus sample configuration in 2 to 4 dimensions (Dehlholm, 2014). However, representation of the sensory characteristics of samples in a limited number of dimensions may not reflect the cognitive representation of all consumers (Summers & MacKay, 1976). In this sense, Vidal, Antúnez, Giménez, Varela, Deliza & Ares (2016) reported that the consensus

representation of samples in the first and second dimensions did not correlate with the configuration of at least one consumer segment.

In a projective mapping task, assessors should form an overall representation of the similarities and differences among samples by relying on a process of synthesis for analyzing and processing sensory information (Jaeger, Wakeling, & MacFie, 2000). This process of synthesis determines the relative importance of the perceived sensory characteristics for estimating the similarities and differences among samples. For this reason, individual differences in the criteria used by assessors to evaluate samples and complete the task are expected (Naes et al., 2017). These individual differences have been reported by several authors (Kennedy 2010; Dehlholm et al. 2012b; Hopfer & Heymann, 2013; Nestrud & Lawless, 2011; Vidal et al., 2016).

One of the most important factors that could largely contribute to heterogeneity in responses to projective mapping tasks is individual differences in preferred ways of processing information (Allport, 1937). Differences in consumers' cognitive structure and decision making can influence the number of characteristics that are involved in sample categorization (Malhotra, Pinson, & Jain, 2010). Cognitive styles can be defined as characteristic and stable ways in which people process and organize information (Messick, 1984). They determine how people process information, as well as how they use it for solving problems and making decisions (Hayes & Allinson, 1998). Cognitive styles refer more to a preferred mode of reasoning than to cognitive ability, cognitive complexity or creativity level (Guilford, 1980; Leek, 1997). One of the most studied cognitive styles is wholistic-analytic dimension, which separates people who have tendency to process information at the global level to get a general overview (wholistic), and those who have tendency to process information in detail and separate it in specific characteristics (analytic) (Peterson & Deary, 2006).

In this context, the aim of the present work was to assess the influence of cognitive style on results from projective mapping by evaluating differences between perceptual maps and sample descriptions from wholistic and analytic consumers.

2. Materials and methods

Two studies were conducted, one involving the evaluation of intrinsic product attributes and the other involving packages. In both studies consumers performed a Projective Mapping test and completed the wholistic-analytic module of the extended Verbal Imagery Cognitive Styles Test & Extended Cognitive Style Analysis-Wholistic Analytic Test (Extended CSA-WA) (Peterson, Deary, & Austin, 2003; 2005). The Extended CSA-WA is a higher-level, complex cognitive task comparing how long the participant takes to perform a wholistic task with how long they take to perform an analytic task (Peterson & Deary, 2006). More concretely, it involves a matching figures task and an embedded figures task. The matching figures task contains 40 pairs of geometrical figures and requires participants to indicate whether they are identical or different, involving a wholistic cognitive strategy. The embedded figures test contains 40 simple geometrical figures embedded in complex figures and requires respondents to indicate if the simple figure is contained within the complex one, involving an analytic cognitive approach. The position of an individual along the wholistic-analytic dimension can be determined by the relative speed of processing matching figures and embedded figures (Davies & Graff, 2006). Details of the studies are provided in the next sections.

2.1. Study 1 – Evaluation of intrinsic characteristics of chocolate flavoured milk

In this test, consumers performed a projective mapping to describe the sensory characteristics of chocolate flavored milk samples, basing their mapping on the evaluation of the intrinsic product properties only via blind tasting.

2.1.1. Participants

The study was carried out with 92 consumers, recruited from the consumer database of the Sensometrics & consumer science research group (Universidad de la República, Montevideo, Uruguay) based on their consumption of chocolate milk and their

availability and interest to participate. Participants ranged in age from 18 to 34 (average 22.8 years old) and were 80% female. They signed an informed consent form and received a small gift for their participation. The high proportion of women participants in the study is not expected to have an influence in the results, as gender have not been shown to have a significant influence on cognitive styles (Riding et al., 1995; Peterson et al., 2005).

2.1.2. Samples

Eight samples of chocolate flavored milk samples were formulated following a fractional factorial design (2^{4-1}) with the following variables: alkaline cocoa powder (2.5 vs. 1.5%), sugar (9.0 vs. 4.5%), vanilla (0.05 vs. 0%) and milk fat (3.2 vs. 1.6%). Sample formulation, presented in Table 1, was determined by pilot testing with trained assessors in order to have samples with perceivable differences in their sensory characteristics. Carrageenan (Ticaloid® 780 Stabilizer — Texture Innovation Center, TIC GUMS, Philadelphia, USA) at a concentration of 0.08% was used as thickener.

Samples were prepared using a Thermomix TM 31 (Vorwerk Mexico S. de R.L. de C.V., Mexico D.F. Mexico). The solid ingredients were mixed with the milk, previously heated to 70°C for 3 min. The dispersion was mixed for 1 min under gentle agitation (100 rpm), heated to 70 °C for 4 min and cooled to 20 °C. Then, samples were placed in glass containers, closed, and maintained under refrigeration temperatures (4 °C ± 1°C). They were removed from the refrigerator as needed immediately prior to sensory evaluation, and dispensed into plastic serving cups. Samples were coded using three-digit blinding codes.

Insert Table 1 around here

2.1.3. Data collection

The study took place in standard sensory booths, under white lighting, controlled temperature (22-24ºC) and airflow conditions. Data collection was carried out using *Compusense Cloud* (Compusense Inc., Guelph, Canada) in laptops. Consumers were asked to evaluate the samples and to place them on a rectangle presented on the screen, according to their similarities and differences, in a way that two samples perceived as similar should be located close together on the sheet, whereas samples perceived as very different had to be placed far from each other. They were asked to complete the task using their own criteria and they were told that there were no right or wrong answers. After locating samples, consumers were asked to provide a description of the sensory characteristics of each of the samples. Then, consumers had to try samples again and to rate their overall liking using a 9-point hedonic scale. After the projective mapping task participants completed the wholistic-analytic module of the extended Verbal Imagery Cognitive Styles Test & Extended Cognitive Style Analysis-Wholistic Analytic Test (E-CSA-WA) (Peterson et al., 2003; 2005).

2.2. Study 2 – Evaluation of extrinsic characteristics of blueberry yogurts

In this test, consumers performed a projective mapping to describe the packs of yogurt samples, basing their mapping on the evaluation of the extrinsic product properties only (on-pack information) with no tasting.

2.2.1. Participants

One hundred consumers were recruited from Nofima's consumers' database, based on their frequency of consumption of yoghurt (once a week or more), and their availability and interest to participate. They were aged between 16 and 61 years old (36 years on average), half men and half women. They received a financial incentive for the participation.

2.2.2. Samples

196 Twelve commercial blueberry yogurts in individual servings were used in the
197 study, bought in local supermarkets. Samples were selected to get a wide range of
198 products in terms of type of product, brand, nutritional characteristics, and nutritional and
199 health claims on the packages. Samples represented the main characteristics of the
200 blueberry yoghurts available in individual servings the Norwegian market, covering a
201 wide range of product extrinsic factors (Table 2). Sample selection was done for covering
202 a wide range of parameters without being unbalanced towards one type. The idea was
203 to have many different and somehow “interacting” parameters, so consumers really
204 needed to engage in looking at the packs to do their maps (full fat, low fat, no sugar, with
205 sugar, with added ingredients, for special diets: soy based, lactose free, etc). As an
206 example “greek type” yogurt was included: one sample with fat, low sugar and fiber
207 added (P1), a second greek yoghurt low in fat but with sugar added and a layer of fruit
208 (P10), and a third greek yoghurt with both low fat and sugar and added muesli (P11).
209
210
211 Insert Table 2 around here
212
213 **2.2.3. Data collection**
214 Participants were instructed in the use of the projective mapping technique with
215 a descriptive step and in the experimental procedure to evaluate the different aspects or
216 characteristics of the yogurt packs. The method was explained to the participants through
217 an example employing birds of different colours, shapes and types, without any mention
218 to food. After the briefing, the participants received the eleven yoghurt packs and
219 performed the projective mapping test with the use of a computerized data collection
220 software (Eye Question). They were asked to complete the task using their own criteria
221 and they were told that there were no right or wrong answers. After locating samples,
222 consumers were asked to provide a description of the characteristics of each sample.
223 Data were collected as the X and Y coordinates of the samples on each consumer's

individual map. After finishing the task, participants completed the wholistic-analytic module of the Extended CSA-WA.

2.3. Data analysis

The strategy for data analysis was identical in the two studies and is described below.

2.3.1. Cognitive styles

The cognitive style of each consumer was determined based on his/her relative speed in the matching figures and embedded figures task (Davies & Graff, 2006). The coefficient between the median response time for the matching figures tasks (involving wholistic processing) and the median response time for the embedded figures task (involving analytic processing) was calculated. Consumers were divided in three groups of similar size based on the distribution of their median response times.

2.3.2. Projective mapping data

The X and Y coordinates of the samples on the individual consumer maps were determined by measuring their position on the bi-dimensional space used for sample evaluation, considering the left bottom corner as the origin of the coordinate system. The data from each consumer group were analysed separately using Multiple Factor Analysis (MFA), considering the coordinates from each consumer as a separate group of variables (Pagès, 2005). Confidence ellipses were constructed using partial bootstrapping (Dehlholm, Brockhoff, & Bredie, 2012). Confidence ellipses are represented around sample coordinates to represent the uncertainty of the data in the multivariate space. In the present work, the area of the bi-dimensional space where samples could be located for a 95% confidence level.

The words provided by consumers in the description phase of the projective mapping task were qualitatively analysed. Words with similar meaning were grouped into

252 categories, and their frequency was determined by counting the number of consumers
253 who used them for describing each of the samples. The frequency table was considered
254 as a group of supplementary variables in MFA (Pagès, 2005).
255 Similarity between the sample configurations of the three consumer groups with
256 different cognitive style was evaluated using the RV coefficient (Robert & Escoufier,
257 1976). The RV coefficient measures the similarity between two factorial configurations,
258 taking the value of 0 if both configurations are uncorrelated, and the value of 1 if they are
259 homothetic. The RV depends on the relative position of the points in the configuration,
260 being independent of rotation and translation (Robert & Escoufier, 1976; Vidal et al.,
261 2014).
262 All data analyses were performed in R software (R Core Team, 2015).
263 `FactoMineR` package was used for performing Multiple Factor Analysis (Lê, Josse, &
264 Husson, 2008)

265

266 **3. Results**

267

268 **3.1. Study 1 – Evaluation of intrinsic characteristics of chocolate flavoured milk**
269 The median W/A response time ranged between 0.88 and 2.34 s (Figure 1a).
270 Based on this measure of cognitive style, consumers were divided into three groups of
271 similar size: 31 wholistic consumers (median W/A response time between 0.88 and
272 1.24s), 30 intermediate consumers (median W/A response time between 1.26 and
273 1.47s), and 31 analytic consumers (median W/A response time between 1.48 and 2.34
274 s).

275

276 Insert Figure 1 around here

277

Figure 2 shows sample configurations in the first four dimensions of the MFA for each of the three consumer groups. Sample configurations showed moderate to high agreement in both the first and second dimensions (RV=0.85-0.90) but low agreement in the third and fourth dimensions (RV=0.27-0.52).

As shown in Figures 2a-c, the first dimension of the MFA was positively related to sweetness for the three consumer groups, whereas the second dimension sorted samples according to their chocolate flavour. This suggests that sweetness and chocolate were the main characteristics responsible for differences among samples regardless of the cognitive style. The main difference between the three consumer groups was related to the groups' ability to discriminate among samples. Sample configurations in the first two dimensions from analytic consumers provided the best discrimination of samples according to their sugar and cocoa concentration (Figure 2c), whereas the other two consumer groups partially discriminated among samples with different cocoa concentration. Wholistic consumers clearly separated sample 6 from the rest of the samples, and sample 5 from sample 3 according to their chocolate concentration (Figure 2a). Meanwhile, consumers with intermediate behaviour only discriminated samples according to their chocolate flavour when they contained high sugar concentration (Figure 2b).

Sample configurations in the third and fourth dimensions provided different information for the three consumer groups. These dimensions are less reliable than the first two; this was reflected in the size and overlapping of the ellipses, as discussed in depth in Naes et al. (2017). In the case of wholistic and intermediate consumers, higher dimensions did not provide information about differences among samples in additional sensory characteristics. Instead, they were also related to sweetness, chocolate flavour and bitterness and increased sample discrimination according to their sugar and cocoa concentration (Figures 2a and 2b). In the case of the analytic consumer group, the bisector of the third and fourth dimension sorted samples formulated with vanilla flavour (2, 3, 4 and 7) apart from samples formulated without this ingredient (1, 6, 5 and 8)

306 (Figure 2c). However, it is worth stressing that the description of these groups of samples
307 did not stress *vanilla flavour*. Instead, references to chocolate flavour intensity or other
308 flavours were used in the descriptions: *no chocolate flavour* in the vanilla added and
309 *intense chocolate* in the ones without vanilla; *sweet and aftertaste* in the vanilla added;
310 *artificial flavour* and *disgusting* in the samples without vanilla,. This could be the effect of
311 the vanilla on the overall perception, through flavour enhancement or multisensory
312 interactions (sweet-vanilla, for example), even if the consumers did not name the vanilla
313 attribute, they perceived the affects and were able to separate the samples accordingly.
314
315 Insert Figure 2 around here
316
317 **3.2. Study 2 – Evaluation of extrinsic characteristics of yogurts**
318 The median W/A response time ranged between 0.83 and 3.16 s (Figure 1b).
319 Based on this measure of cognitive style, consumers were divided into three groups of
320 similar size: 33 wholistic consumers (median W/A response time between 0.83 and
321 1.23s), 33 analytic consumers (median W/A response time between 1.62 and 3.16s),
322 and 34 intermediate consumers (median W/A response time between 1.32 and 1.59s).
323 Sample configurations in the first two dimensions of the MFA were highly similar
324 for the three consumer groups (RV=0.91-0.95). Regardless of cognitive style consumers
325 tended to sort yogurt packages in three main groups (Figure 3a-c). One of the groups
326 was composed of samples P4, P5 and P11, mainly described using words related to
327 *cereal, snack* and *muesli*. Samples P2, P6, P8 and P9 composed another group of
328 samples due to their association with the words *wrapped* and *allergy*. Wholistic and
329 intermediate consumers included sample P7 in this group, whereas analytic consumers
330 included it with the third group, composed of samples P1, P3, P10 and P12, which were
331 described using words such as *small*, *thick*, *dessert* and *greek*. Nevertheless, the analytic
332 and intermediate groups reached a better separation of the samples than the wholistic
333 consumers in the first two dimensions of the MFA.

Insert Figure 3 around here

4. Discussion and Conclusions

Projective mapping relies on the evaluation of global differences among samples, which requires assessors to create an overall representation of samples based on their characteristics by a process of synthesis (Jaeger et al., 2000). Individual differences in information processing are expected to play a key role in this process and consequently to influence results from projective mapping tasks. In the present study, the influence of wholistic/analytic cognitive style on results from projective mapping with consumers was evaluated.

Across the two studies, analytic consumers showed a better discrimination among samples than wholistic consumers. This matches expectations as analytic consumers are expected to process information in more detail (Peterson & Deary, 2006). This is based in dual-process theories of reasoning, which assume that there are two different processing routes: System 1, intuitive, rapid, automatic and holistic that allows individuals to take decisions mainly relying in the context, without a detailed analysis; and System 2, a more controlled, conscious, slow and analytic processing style (McElroy & Seta, 2003; Evans, 2008). There are inter individual differences (Evans, 2008) as well as cultural differences in thinking styles (Nisbett et al., 2001).

Kim, Dessirier, van Hout, and Lee (2015) reported similar results to the ones described in the present work, when studying the influence of thinking style on affective discrimination. These authors evaluated thinking style using the Cognitive Reflection Test and reported that high reflection thinkers, which are usually more analytic, showed higher affective discrimination than low reflection thinkers, which are more wholistic in the way in which they search for and process information. Similarly, Kinner & Borgartz (2015) reported that slow thinkers (predominance of system 2 for decision making) have

362 a higher ability to discriminate between samples than fast thinkers (system 1), in a
363 retrospective analysis of 10 serial monadic consumer tests in central locations.

364 In Study 1, involving the evaluation of chocolate flavoured milk samples which
365 differed in specific sensory characteristics, analytic consumers seemed to rely on more
366 sensory characteristics than wholistic consumers. In this study, sample configurations of
367 wholistic and intermediate consumers mainly discriminated samples according to their
368 sweetness and bitterness/chocolate flavour, in both the first two and the first four
369 dimension. However, sample configuration of analytic consumers identified three main
370 sources of variation among samples and enabled their discrimination according to their
371 sugar, cacao and vanilla concentration. According to Peterson & Deary (2006) analytic
372 people tend to process information in detail by separating it in specific characteristics
373 instead of getting an overall picture as wholistic people. Therefore, analytic consumers
374 may have found it easier to form their overall representation of samples in a larger
375 number of sensory characteristics. In addition, results suggest that analytic consumers
376 may have used strategies to represent three dimensions in the bi-dimensional sheet of
377 paper. This is exemplified in Figure 4 using the evaluation sheet of one of the analytical
378 consumers in Study 1. As shown, samples were not positioned on the sheet of paper
379 according to two sensory dimensions; instead samples were grouped in the space
380 according to multiple sensory characteristics, associated with their formulation. Samples
381 were clearly sorted into two groups according to their sugar content. Within each group,
382 the consumer used different strategies to sort samples according to their cacao and
383 vanilla concentration. In the group of samples with 4.5% sugar, two groups were
384 identified according to their cacao concentration. In addition, within each of the groups,
385 the vertical dimension was used to represent increasing vanilla concentrations. Similar
386 strategies have been reported before by Nestrud & Lawless (2011), who reported that
387 some participants used the “radial dimension” to represent and additional sensory
388 dimension in projective mapping tasks. Similarly, Dehlholm (2014) reported that

389 projective mapping assessors use categorical projections and double linear projection to
390 represent samples, which could be also used to represent three sensory dimensions.
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392 Insert Figure 4 around here
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394 In Study 2, involving yogurt packages that spanned the whole category of
395 blueberry yogurts in the Norwegian market, results also highlighted an increased
396 discrimination between samples by the analytic consumers, based on extrinsic
397 characteristics only. Previous studies on consumers' perception of food extrinsic factors
398 have highlighted differences on information processing; Ares at al. (2014) studied the
399 influence of rational and intuitive thinking styles on consumer choice in a conjoint task
400 using yogurt labels, concluding that consumers who predominantly relied on analytical-
401 rational thinking engaged on a greater information search. In the same lines, Varela et
402 al. (2014) observed in a projective mapping task on cereal packs (extrinsic information
403 only), that consumers evaluated the packs differently in terms of attentional capture,
404 some consumers reading more thoroughly the information, claims and nutritional info
405 than others, that evaluated the samples in a more rough, faster way. Nevertheless, they
406 observed that even when focusing more in depth in certain pack information, consumers
407 not always used that information to locate or to describe similarities and differences
408 among products. This is in agreement with the results of the present study, analytic
409 consumers discriminated more between packs in the projective mapping task,
410 suggesting they might have engaged in a deeper analysis of the yogurt packs; however,
411 they described the products using similar words in the descriptive step (Figure 2,
412 projection of the terms). A similar conclusion might be drawn for the chocolate flavoured
413 milk study based on intrinsic product cues; the descriptive step did not highlight striking
414 differences among groups in the words used.
415 Results from the present work reinforce the idea that different consumer groups
416 may have different representation of the overall similarities and differences of samples,

417 as previously reported by Vidal et al. (2016) and Torri et al. (2013). Therefore,
418 practitioners are encouraged to more frequently explore segmentation when analyzing
419 data from projective mapping tasks. The most common approach so far has been to do
420 segmentation based on the correlations between consumers and the MFA components
421 (Vidal et al, 2016). It may, however, be more natural to consider procrustes based
422 methods as discussed in Berget et al. (2016). A straightforward approach for doing this
423 is the proclustrees method (Dahl & Næs, 2004) which is hierarchical clustering on the
424 distance matrix obtained by computing the Procrustes distance between all pairs of
425 consumers. Another option is to modify the Fuzzy C means (FCM, Bezdek, 1981)
426 criterion to minimize the GPA loss for each group. The FCM algorithm can then be
427 combined with the noise clustering modification (Dave, 1991) in such a way the clusters
428 are found sequentially. The advantage of the sequential approach is that the most distinct
429 clusters are identified first whereas consumers not contributing to the clustering structure
430 remain in a "rest" cluster.

431 Another methodological recommendation that emerged from the data relies on
432 the need to consider higher dimensions in the interpretation of projective mapping tasks,
433 as recently recommended by Næs et al. (2017). The first dimensions usually
434 underestimates the complexity of the sensory space as they are expected to mainly
435 discriminate samples according to two main sensory dimensions. However, most
436 applications of projective mapping only consider two dimensions without further
437 considering the information included in the third and fourth dimension, which may
438 represent the perception of specific groups of consumers (Vidal et al., 2016).

439

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References

Albert, A., Varela, P., Salvador, A., Hough, G., & Fiszman, S. (2011). Overcoming the issues in the sensory description of hot served food with a complex texture. Application of QDA®, flash profiling and projective mapping using panels with different degrees of training. *Food Quality and Preference*, 22, 463–473.

Allport, G. W. (1937). *Personality: a psychological interpretation.* New York: Holt & Co.

Ares, G., & Varela, P. (2014). Comparison of Novel Methodologies for Sensory Characterization.*In P. Varela & G. Ares (Eds.), Novel Techniques in Sensory Characterization and Consumer Profiling (pp.* 365-389). Boca Raton: CRC Press.

Ares, G., Mawad, F., Giménez, A., & Maiche, A. (2014). Influence of rational and intuitive thinking styles on food choice: Preliminary evidence from an eye-tracking study with yogurt labels. *Food Quality and Preference*, 31, 28-37.

Bárcenas, P., Pérez Elortondo, F. J., & Albisu, M. (2004). Projective mapping in sensory analysis of ewes milk cheeses: A study on consumers and trained panel performance. *Food Research International,* 37, 723–729.

Berget, I., Næs, T., Varela, P. (2016) Clustering data from projective mapping. *13th Sensometrics Conference*. Brighton, 2016-07-27–2016-07-29

Dahl, T. & Næs, T. (2004). Outlier and group detection in sensory panels using hierarchical cluster analysis with the Procrustes distance. *Food Quality and Preference*, 15, 195-208.

Dave, R. N. (1991). Characterization and Detection of Noise in Clustering. *Pattern Recognition Letters,* 12, 657-664.

Davies, J., & Graff, M. (2006). Wholist-analytic cognitive style: A matter of reflection. *Personality and Individual Differences*, 41, 989–997.

Dehlholm, C. (2014). Chapter 9: Projective mapping and Napping. In P. Varela & G. Ares (Eds.), *Novel techniques in sensory characterization and consumer profiling*. Boca Raton, FL: CRC Press

Dehlholm, C., Brockhoff, P. B., & Bredie, W. L. P. (2012a). Confidence ellipses: A variation based on parametric bootstrapping applicable on multiple factor analysis results for rapid graphical evaluation. *Food Quality and Preference*, 26, 278–280

Dehlholm, C., Brockhoff, P. B., Meinert, L., Aaslyng, M. & Bredie, W.L.P. (2012b). Rapid descriptive sensory methods – Comparison of Free Multiple Sorting, Partial Napping, Napping, Flash Profiling and conventional profiling. *Food Quality and Preference,* 26 267–277.

Evans, J. S. B. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. Annu. Rev. Psychol., 59, 255-278.

Guildford, J.P. (1980). Cognitive styles: what are they? *Educational and Psychological Measurement*, 40, 715-735.

Hayes, J., & Allinson, C.W. (1998). Cognitive style and the theory and practice of individual and collective learning in organizations. *Human Relations,* 51, 847-871.

Hopfer, H. & Heymann, H. (2013). A summary of projective mapping observations – The effect of replicates and shape, and individual performance measurements. *Food Quality and Preference*, 28, 164–181.

Jaeger, S.R., Wakeling, I.N., & MacFie, H.J.H. (2000). Behavioural extensions to preference mapping: the role of synthesis. *Food Quality and Preference*, 11, 349-359.

Kennedy, J. (2010). Evaluation of replicated projective mapping of granola bars. *Journal of Sensory Studies,* 25, 672–684.

498 Kim, M.-A., Dessirier, J. M., van Hout, D., & Lee, H.-S. (2015). Consumer context-specific
499 sensory acceptance tests: Effects of a cognitive warm-up on affective product
500 discrimination. *Food Quality and Preference*, 41, 163–171.
501 Lê, S., Josse, J., & Husson, F. (2008). FactoMineR: An R package for multivariate
502 analysis. *Journal of Statistical Software*, 25, 1–18.
503 Leek, S. (1997). *An investigation of consumers' decision processes and styles.* PhD
504 Thesis.: Birmingham, UK; The University of Birmingham.
505 Malhotra, N.K., Pinson, C., & Jain, A.K. (2010). Consumer cognitive complexity and the
506 dimensionality of multidimensional scaling configurations. *Review of Marketing*
507 *Research,* 7, 199-254.
508 McElroy, T., & Seta, J. J. (2003). Framing effects: An analytic–holistic perspective.
509 Journal of Experimental Social Psychology, 39(6), 610-617.
510 Messick, S. (1984). The nature of cognitive styles: problems and promise in educational
511 practice. *Educational Psychologist,* 19, 59–74.
512 Næs, T., Berget, I., Liland, K.H., Ares, G., Varela, P. (2017). Estimating and interpreting
513 more than two consensus components in projective mapping: INDSCAL vs.
514 multiple factor analysis (MFA). *Food Quality and Preference*, 58, 45-60.
515 Nestrud, M., & Lawless, H. (2008). Perceptual mapping of citrus juices using projective
516 mapping and profiling data from culinary professionals and consumers. *Food*
517 *Quality and Preference,* 19, 431–438.
518 Nestrud, M. A., & Lawless, H. T. (2011). Recovery of subsampled dimensions and
519 configurations derived from napping data by MFA and MDS. *Attention, Perception,*
520 *& Psychophysics*, 73, 1266-1278.
521 Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of
522 thought: holistic versus analytic cognition. Psychological review, 108(2), 291.
523 Pagès, J. (2005). Collection and analysis of perceived product inter-distances using
524 multiple factor analysis: Application to the study of 10 white wines from the Loire
525 valley. *Food Quality and Preference,* 16, 642–649.

526 Peterson, E.R., Deary, I.J., Austin, E.J. (2005). Are intelligence and personality related
527 to verbal-imagery and wholistic-analytic cognitive styles? Personality and
528 Individual Differences, 39, 201-213.
529 Peterson, E.R., & Deary, I.J. (2006). Examining wholistic–analytic style using
530 preferences in early information processing. *Personality and Individual*
531 *Differences,* 41, 3-14.
532 Peterson, E. R., Deary, I. J., & Austin, E. J. (2003).The reliability of the Cognitive Styles
533 Analysis test. *Personality and Individual Differences*, 34, 881-891
534 Peterson, E. R., Deary, I. J., & Austin, E. J. (2003). On the assessment of cognitive style:
535 Four red herrings. *Personality and Individual Differences,* 34, 899-904.
536 Peterson, E. R., Deary, I. J., & Austin, E. J (2005). A new reliable measure of verbal-
537 imagery cognitive style. *Personality and Individual Differences*, 38, 1269-1281
538 Peterson, E. R., & Deary, I. J. (2006). Examining wholistic–analytic style using
539 preferences in early information processing. *Personality and Individual*
540 *Differences*, *41*(1), 3-14.
541 R Core Team. (2016). *R: A language and environment for statistical computing.* Vienna,
542 Austria: R Foundation for Statistical Computing.
543 Riding, R. J., & Watts, M. (1997). The effect of cognitive style on the preferred format of
544 instructional material. Educational Psychology, 17, 179–183.
545 Risvik, E., McEvan, J. A., Colwill, J. S., Rogers, R., & Lyon, D. H. (1994). Projective
546 mapping: A tool for sensory analysis and consumer research. *Food Quality and*
547 *Preference,* 5, 263–269.
548 Robert, P., & Escoufier, Y. (1976). A unifying tool for linear multivariate statistical
549 methods: The RV coefficient. *Applied Statistics*, 25, 257–265.
550 Summers, J.O., & McKay, D.B. (1976). On the Validity and Reliability of Direct-Similarity
551 Judgments, *Journal of Marketing Research*, 13, 289-95.

552 Torri, L., Dinnella, C., Recchia, A., Naes, T., Tuorila, H., & Monteleone, E. (2013).
553 Projective mapping for interpreting wine aroma differences as perceived by naïve
554 and experienced assessors. *Food Quality and Preference,* 29, 6–15.
555 Valentin, D., Chollet, S., Lelievre, M., & Abdi, H. (2012). Quick and dirty but still pretty
556 good: a review of new descriptive methods in food science. *International Journal*
557 *of Food Science and Technology,* 47, 1563–1578.
558 Varela, P., & Ares, G. (2012). Sensory profiling, the blurred line between sensory and
559 consumer science. A review of novel methods for product characterization. *Food*
560 *Research International,* 48, 893–908.
561 Varela, P., Antúnez, L., Cadena, R. S., Giménez, A., & Ares, G. (2014). Attentional
562 capture and importance of package attributes for consumers' perceived similarities
563 and differences among products: A case study with breakfast cereal packages.
564 *Food Research International,* 64, 701-710.
565 Vidal, L., Cadena, R.S., Antúnez, L., Giménez, A., Varela, P., & Ares, G. (2014). Stability
566 of sample configurations from projective mapping: How many consumers are
567 necessary? *Food Quality and Preference*, 34, 79-87.
568 Vidal, L., Antúnez, L., Giménez, A., Varela, P., Deliza, R., & Ares, G. (2016). Can
569 consumer segmentation in projective mapping contribute to a better understanding of
570 consumer perception? *Food Quality and Preference,* 47, 64-72.
571

572 **Figure captions**

573

574 **Figure 1.** Distribution of the coefficient between the median response time for the
575 matching figures tasks (involving wholistic processing) and the median response time for
576 the embedded figures task (involving analytic processing) for consumers who
577 participated in Study 1 (chocolate flavoured milk) (a) and Study 2 (yogurt packages) (b).

578

579 **Figure 2.** Sample configurations and projection of the terms in the first four dimensions
580 of the Multiple Factor Analysis performed on projective mapping data of consumer
581 segments with different cognitive styles in the chocolate flavoured milk study: (a)
582 wholistic consumers (n=31), (b) intermediate consumers (n=30) and (c) analytic
583 consumers (n=31). The size of the font of the descriptive terms reflects the frequency of
584 mention of each term in the PM task.

585

586 **Figure 3.** Sample configurations and projection of the terms in the first two dimensions
587 of the Multiple Factor Analysis performed on projective mapping data of consumer
588 segments with different cognitive style in the yogurt study: (a) wholistic consumers
589 (n=33), (b) intermediate consumers (n=34) and (c) analytic consumers (n=33). The size
590 of the font of the descriptive terms reflects the frequency of mention of each term in the
591 PM task.

592

593 **Figure 4.** Example of the individual evaluation sheet of one of the analytic consumers in
594 Study 1. Dotted ellipses represent groups of samples with similar characteristics in terms
595 of formulation (sugar and cacao concentration), whereas the arrows represent increasing
596 vanilla concentration.

Tables

Table 1. Concentration (%) of cocoa, sugar, vanilla and fat of eight samples of chocolate flavored milk samples, formulated following a 2^{4-1} fractional factorial design.

Sample	Cocoa	Sugar	Vanilla	Milk fat
1	1.5	9.0	0	3.2
2	1.5	4.5	0.05	3.2
3	1.5	9.0	0.05	1.6
4	2.5	4.5	0.05	1.6
5	2.5	9.0	0	1.6
6	2.5	4.5	0	3.2
7	2.5	9.0	0.05	3.2
8	1.5	4.5	0	1.6

602 **Table 2.** Characteristics of the yogurt packages included in Study 2.

Sample	Samples' Characteristics
P1	Greek yoghurt, 2% fat, Low Sugar, «protein 14g», «90kcal», «source of fibre»
P2	Yoghurt, Lactose free, Wholefat, w/Sugar
P3	Cultured milk, Fat free, Sugar free, «16g protein», «original Icelandic cultures»
P4	Fat free, Sugar free, w/muesli, «rich in protein and fibre»
P5	Bifidus-culture, w/Sugar, 2,8% fat, w/cornflakes, «actiregularis»
P6	Soy fermented product, w/Sugar, 2% fat, «with yoghurt cultures», «naturally lactose free»
P7	Yoghurt, Wholefat, w/Sugar, «Extra blueberry»
P8	Yoghurt, Fat free, Sugar free, «fruit yoghurt with fibre»
P9	Bifidus-culture, w/Sugar, 2,8% fat, «actiregularis»
P10	Greek yoghurt, Fat free, w/Sugar, «thick and creamy», «a layer of blueberry pieces»
P11	Greek yoghurt, Fat free, Low Sugar, w/muesli, «protein 14g», «source of fibre»
P12	Curd, Wholefat, w/Sugar

603