Food Quality and Preference 36 (2014) 61–69

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

Better perceptual maps: Introducing explanatory icons to facilitate interpretation

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ARTICLE INFO

Article history:
Received 18 October 2013
Received in revised form 14 January 2014
Accepted 21 January 2014
Available online 6 March 2014

Keywords:
Graphical presentation
Self-explanatory icons
(Multiple) Correspondence Analysis
Principal component analysis
Multidimensional scaling
Perceptual maps

ABSTRACT

Perceptual maps are a popular tool in sensometric research. They are often used to visually study relations between two or more products and/or attributes, or to depict subjects' preferences towards products and/or product attributes. Methodology underlying perceptual maps is diverse and consequently generates diverse maps. Interpretation of a perceptual map is therefore often less straightforward than is suggested by its graphical format. In this paper, we show that many perceptual maps published in recent literature are severely flawed prohibiting meaningful interpretations. Some of the major flaws of published maps are omission of reference to the techniques that produced the map, non-unit shape parameters, and unclear labelling. Furthermore, the tendency in applied research to classify each graphical representation simply by calling it a perceptual map, ignores the heterogeneity in the underlying methodology and the corresponding heterogeneity in interpretational aspects. As readers of the maps may not be familiar with the intricacies of all available multidimensional methods, some guidance should be provided. To overcome these problems, we propose the use of icons to guide interpretation. Potentially these icons allow readers to correctly and confidently interpret a map even if they are unfamiliar with the statistical technique used to create the map.

1. Introduction

The versatility and power of graphical representations of complex high dimensional data has long been acknowledged in food science (Greenhoff & MacFie, 1999; McEwan, 1996), marketing research (Frank & Green, 1968; Green & Carmone, 1969, 1970; Stefflre, 1969) and practice (Cornelius, Wagner, & Natter, 2010; Doehlert, 1968; Huber, 2008). In the area of food science, a distinction is often made between an internal and external analysis (Carroll, 1972). An internal preference or perceptual map, depicts both products and consumers that best capture consumers' hedonic responses. In external preference maps, products, attributes and consumer are displayed according to products' sensory profiles.

Several statistical techniques exist that yield internal and/or external preference maps. In sensometric research, popular techniques used to generate perceptual maps are principal component analysis (e.g., Meullenet, Lovely, Threlfall, Morris, & Striegler, 2008; Rousseau, Ennis, & Rossi, 2012; Tubbs, Oupadissakoon, Lee, & Meullenet, 2010; Worch, Lê, Punter, & Pagès, 2012), (multiple) correspondence analysis (e.g., Ares et al., 2011; Beh, Lombardo, & Simonetti, 2011; O'Neill et al., 2003; Torres & Van de Velden, 2007; van Herk & van de Velden, 2007), canonical variate analysis (e.g., King, Dunn, & Heymann, 2013; O'Neill et al., 2003), (generalised) procrustes analysis (e.g., Albert, Varela, Salvador, Hough, & Fiszman, 2011; Veinand, Godefroy, Adam, & Delarue, 2011), unfolding analysis (e.g., Busing, Heiser, & Gleaver, 2010; Van de Velden, De Beuckelaer, Groenen, & Busing, 2013) and multidimensional scaling (e.g., Chollet, Lelièvre, Abdi, & Valentin, 2011; Courcoux, Qannari, Taylor, Buck, & Greenhoff, 2011). The common element among the statistical techniques that are used to produce perceptual maps is that they can all be termed multidimensional analyses, to indicate that, potentially, results are available in many dimensions. Overwhelmingly, however, only two dimensions are exhibited, as this gives two-dimensional maps that can be shown on a sheet of paper or on a computer screen.

Recently, Yenket, Chambers, and Adhikari (2011), compared results of different statistical techniques and software packages when applied to the same data. Noting the different results, they concluded that current practice yields misleading preference maps. The reason for the observed differences can to a large extend be

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http://dx.doi.org/10.1016/j.foodqual.2014.01.004
0950-3293/

explained by the fact that different methods focus on different aspects of the data. For example, in some methods, distances between certain points have a clear interpretation whereas in other cases, distances cannot be interpreted directly but angles are important. For proper interpretation of the maps it is therefore crucial that the correct vehicle of interpretation is either already known and understood, or is communicated to the reader together with the map. Yenket et al. (2011) focus primarily on observing that outcomes generated by different methods and/or software, yield different results. Here we shall take a more general look at perceptual maps and show that the problem is in fact more severe.

Regardless of what specific statistical method is used, the purpose of the map is to display complex information in an engaging graphical manner. Clear perceptual maps powerfully add weight to assertions in accompanying text about relationships between and within (possibly latent) attributes. By avoiding difficult statistical concepts (e.g., *p*-values, confidence intervals, hypotheses testing etc.), and relying on the human ability to deal effectively with graphical data, perceptual maps are very appealing to applied researchers. Indeed such maps might be the primary means a reader uses to assess the message that the article is conveying. Maps tend to stand out from the page, and are used as part of the summary information given by some electronic journal databases. Thus, it is crucial that perceptual maps are presented in such a way that the information within them can be quickly and correctly assimilated and attention is drawn to any limitations.

Unfortunately, as we will show in this paper, the graphical presentation of perceptual maps both in the methodological literature and in applications is often defective. In a literature study covering recent academic publications we found many problems that either defied or considerably complicated interpretation of perceptual maps. Obviously, these problems severely undermine the main advantages of graphical representations: rapid interpretation and communication of complex information. To overcome these problems, we provide guidelines for producing good maps. Although several of our suggestions may seem obvious, the current state of affairs proves the need for such guidelines. Furthermore, the tendency in applied research to classify each graphical representation simply by calling it a perceptual map, ignores the fact that there are many types of map, each with its own characterstics that should be taken into account when constructing and interpretating maps. However, readers may not be familiar with the variations found among multidimensional methods, and may benefit from some guidance. In this paper, we introduce a set of icons that can be added to the map to guide interpretation. Potentially, these icons allow readers to correctly and confidently interpret a map even for those who may be unfamiliar with the statistical technique used to create the map. Note that, we shall not concern ourselves with the question whether or not an inappropriate analysis has been used; rather, our aim is to ensure that whatever the analysis underpinning the map, it is presented with clarity.

The remainder of this paper is organised as follows: In the next section, we first provide some general principles or desiderata for perceptual maps. Using these desiderata, we explore the extent to which these ideals appear to be met in academic research. Our findings suggest that there is much room for improvement. To facilitate an immediate interpretation of different maps, we introduce an aid to map interpretation in Section 3; the use of self explanatory icons to indicate permissible interpretation strategies. Finally, in Section 4 we give our conclusions.

2. Current situation

There exist several important and useful references that describe general graphical principles (e.g. Cleveland & McGill, 1987; Tufte, 1983; Wainer, 2005). However, these treatises do not address issues specific to the multidimensional methodology frequently encountered in the literature of perceptual maps. We fill this gap by providing the following desiderata for perceptual maps based on multidimensional analysis. The desiderata are summarized in Box 1. More details on these desiderata will follow in our assessment of recently published maps.

Box 1. Desiderata for perceptual maps

1. Include a caption or title indicating the method used to generate the map.
2. Include a legend or key when there are two or more types of points or lines.
3. Ensure that the shape parameter, that is, the ratio of the length of one unit along the y axis to the length of one unit along the x axis, equals 1.
4. Indicate the origin when it is required for interpretational purposes.
5. Label points.
6. Avoid clutter.

That these are desiderata for good maps may seem obvious. However, as will be shown, the majority of published perceptual maps in recent business and marketing literature, exhibit one or more serious flaws that undermine, and often defy, meaningful interpretation.

We conducted a survey of recent articles in scientific publications in the field of business research, including journals in the field of sensometrics, with the aim of seeing how often published perceptual maps currently match our desiderata. For the survey, a Google Scholar (http://scholar.google.com/) search was conducted to identify articles published between 2005 and 2012 that contained perceptual maps. The search term was ''perceptual map'' and we constrained our results to results from the (Google Scholar) subject areas ''Business, Administration, Finance, and Economics'' (this includes publications in the food research domain such as Food Quality and Preference). After elimination of non academic publications this yielded 107 papers that contained a total of 212 perceptual maps that were examined in detail. These 212 plots can be split up according to the methodology used. We categorised the methods as follows: CA, correspondence analysis, 50 (24%) plots in total; MCA, multiple correspondence analysis, 11 (5%) plots; PCA, principal component analysis (including categorical PCA and factor analysis), 32 (15%) plots; MDS, multidimensional scaling, 57 (27%) plots. Miscellaneous, maps based on generalised Procrustes analysis, discriminant analysis, nonlinear canonical correlation analysis, neural networks and some undetermined methodology referenced in the paper, 32 (15%) plots. Finally, we include a category ''Unknown'' for those perceptual maps when we could not establish which method had been used; there were 30 (14%) such plots. Note that our categorisation of the methods used is based on what the authors claimed they were doing.

In our appraisal, we restricted ourselves to observable flaws with respect to the desiderata given in Box 1. Obviously, some degree of subjectivity is unavoidable when recording the flaws. In particular, deciding whether the legend and labels are sufficient and if the chart is cluttered, always depends to some degree on the reader's subjective judgement. We recorded these desiderata as conservatively as possible and, in case of doubt, we did not record a problem. The results are summarised in Table 1 where the relative frequencies of occurrences are classified by method.