

# A Study on the Relationship Between Form Features and Images of Concept Bicycles Using the Theory of Archetype

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**Abstract.** Two-wheel electric vehicles have gradually attracted people's attentions in recent years, thus more designers focus on styling designs to satisfy consumers' psychological demands. A product need to satisfy consumers' expectation with not only nice appearance and functions, but also a good image. A product with its definite image can create its segment in the marketplace. This study applies the archetype theory in product form design, and takes the concept bicycle as a case study. The classification of morphological features is carried out by a great deal of concept bicycle images. Then 60 samples made according the morphological chart are used for image evaluation. Finally, the relationship between form features and image perceptions is built by back-propagation artificial Neural Network (NN). According to the results, the pattern of the Innocent archetype has a similar condition as the Jester archetype. Both of them correspond to the styling with a strong sense of volume and perfectly round form. For the Explorer archetype, the riding posture has a large effect on subjects' image perceptions. Meanwhile, the handlebar and drive system have enormous effects on image perceptions as well. The image perceptions of the Sage, Outlaw, Lover, and Ruler archetypes are conducted to be different by colors, materials, and curved surfaces on the image cognition map. But, those three factors above cannot be recognized by the samples drawn in gray. Moreover, the form features for each archetype have been carried out. These would be useful for the designs of concept bicycle.

**Keywords:** Archetype theory · Form feature · Concept bicycle · Image perception · Neural network

## 1 Introduction

Design is an instrument applied to develop customer's faith in product and brand, facilitate the positioning of product and brand (Berkowitz 1987; Bitner 1992; Bloch 1995), and a means of great significance to raise product's competitiveness (Bloch 1995;

Kotler and Alexander Rath 1984). Apart from meeting customer's expectations of appearance and function, a product with a clear image is able to separate itself from others in the market, which is beneficial to marketing and the building of brand image (Mark and Pearson 2001), while the product design with aesthetics awareness receives positive comments on brand (Kreuzbauer and Malter 2005). In the context that the bicycle sports recreation prevails across the world, a growing number of consumers are willing to buy a bicycle at a higher price instead, which drives quite a few businesses to promote brands and to be dedicated to the design and development of high-end products. Having knowledge of the relationship between image feature and customer's cognition of image can help designers on the style design. In the sector of industrial design, adjective vocabulary in Kansei engineering is most used as a method for product's image description (Guo et al. 2016; Su and Li 2007; Wang 2011; Wang and Yeh 2015). Woodside et al., however, argue that a product with record may linger in people's minds (Woodside et al. 2008), finding favor with a consumer. A consumer may have a particular psychological archetype image according to the research on the bicycle of Triathlon. The image is just the idea which a designer expects to reflect in the product style design (Shieh et al. 2016). In this research, archetype theory is used to probe into the cognition of product images, so as to determine the impact of form features on the product image, and acquire consumer's image cognitions of concept bicycles. Back-propagation artificial Neural Network (NN) is applied to analysis the relationship between the form features and archetype images, thereby helping a designer with the style design.

## 2 Background

### 2.1 The Descriptions of Form Features

Style design comprises three essential factors, i.e. morphology, color and texture, of which, morphology is the first used by a consumer to know a product. Two ways, qualitative and quantitative, are normally employed for the description of morphology. In terms of the former, a product's deconstruction generally depends on the experienced expert. For example, morphological analysis features a wider range of morphology, with the disadvantage presented by subjectivity and inaccuracy. While the latter, thanks to precise description of morphology, is more used in the quantitative research on morphology. For example, curve description. The appearance demonstrated with point coordinates, however, may lead to the failure of an interviewee to have direct association with the morphology.

Morphological analysis was originated by Zwicky, a Swiss astronomer working with California Institute of Technology (Zwicky 1948). Based on structure analysis, the form features of object are listed and all variable factors can be combined in any possible manner in the morphological chart. Thanks to the objective and various combinations of product appearance, morphological analysis is seeing an extensive in the industrial filed. In the research on the appearance of bicycle, Hsiao and Ko adopted morphological analysis to establish the morphological factors table in accordance with parts of bicycle, including "handlebar", "saddle", "frame", "wheel set", and "chainwheel set an crank", and the combination of the features mentioned above may enable a large number of

design schemes (Hsiao and Ko 2013). Lai, Lin, and Yeh divided a mobile into nine design factors of shapes and outlines by morphological analysis in the research on the mobile design, totaling 27 types (Lai et al. 2005). Yang divided the design of digital camera into factors under 16 types by morphological analysis (Yang 2011). Due to the feature of the analysis in the systematic deconstruction of product form, the combination of possible solutions may offer several design ideas or proposals, which makes possible the simple and objective of handing of problem particulars, so as to understand and analyze the problem in a more correct way (Cross and Roy 1989; Jones 1992).

## 2.2 The Application of Neural Network in Form Design

Back-propagation artificial NN is a most universal and typical network in the NN for the structure of Supervised Learning Network. Many scholars use NN to conduct the research related to the association between product form features and images. Chen and Chang held that the network, compared with conventional statistics and analysis technology, boasts priority in the independent and dependent variables. As a result, it used to establish the predication model of “design feature of cutter” and “consumer’s image cognition” (Chen and Chang 2014a). In terms of decreased independent variable, the model still delivers a good performance by the combination of back-propagation NN and multiple linear regression (Chen and Chang 2014b). Lai et al., by the combination of grey prediction and NN to establish the predication model, which enables the best combination of design factors for an ideal product image. Apart from allowing a designer to put more focus on the design factors of product itself by a simplified NN, it can deliver a better performance in predication than those of conventional NN (Lai et al. 2005).

## 2.3 Archetype Theory

To explain the personality and motivations, Carl Jung, a psychiatrist, proposed the concept of archetypes. People thought that Jungian archetypes were collectively and unconsciously hidden in an individual’s deeper gradation of sub-consciousness. It was shown in various “symbols”, such as dreams, myths, arts, religions, etc. In many ancient myths, tribal legends and primitive art, the common symbols were found existing in different civilizations and nationalities repeatedly. These symbols were combining with instinct, archetypes, and archetype images commonly and widely. The archetype was a kind of tendency to form various meanings and appearances, which kept the basic pattern yet transformed the details. Campbell, the myth pundit, had found that the contents of hero stories in different cultures were not always the same but the story plots could follow the same archetype. Hence, every type of archetype has its own symbols to present the specific images in different situations (Campbell 2008).

Based on Jungian psychology, twelve kinds of archetypes, including “Hero”, “Ruler”, “Sage”, “Creator”, “Magician”, “Explorer”, “Lover”, “Caregiver”, “Innocent”, “Jester”, “Outlaw”, and “Regular Guy”, have been defined by Mark and Pearson. They pointed out the possibility of applying the archetypes on products’ brand designs.

Brands could have distinctive images by making appropriate marketing strategies through the archetypes to arouse consumers' brand recognition and then deepen and strength the meaning of brands. When a brand has a strong meaning, it could be more distinguished than other brands, and it could even affect the decision making and self-development of consumers (Mark and Pearson 2001). Take two worldwide famous brands for examples: "Explorer" is a brand image of a famous jeans, Levi's, and it creates the concept of maintaining independence; "Hero" is a brand image of a famous sports brand, NIKE, and it conveys the concept of acting courageously.

The relationship between the extended self and possessions had been proposed by Belk. Consumers would regard products as one part of themselves, and then products could help build their self-identities. "Ownership" could symbolically extend the self, so that individuals are convinced that they are more unique than the others who do not own this possession (Belk 1989). When a consumer owns a product of a brand, the meaning of the product or the brand could bring him some feeling. The further extension of the meaning of a brand cannot only produce the identification, objects, and behavior of the personal, but also help him achieve his goals and get the spiritual power to symbol himself.

### 3 Proposed Approach


































#### 3.1 Form Analysis and Features Coding of Concept Bicycles

Thanks to the demonstration of most design features, the lateral view of bicycle is determined as the object to be probed into in this research. Meanwhile, a total of 146 lateral view pictures of concept bicycles released by manufacturers, works winning award in the design contest and works of designer are collected. In this research, such structure systems with distinctive features of a bicycle as frame, drive, wheel and control are used as bases for the selection of representative parts. The design feature of a bicycle is subject to the function. The conventional bicycle employs gear disc and chain as the drive system, while part of concept bicycle integrates the drive system and frame, which makes it not easy to identify in terms of appearance, or the spoke-less wheel, which leads to the great difference in form. As a result, the appearance of a concept bicycle is discussed in the three parts as follows: "**Frame**", "**Wheel set**" and "**Handlebar**", of which, due to great variation of concept bicycle in form, the "**Frame**" is divided into 25 categories. In terms of the "**Drive system**" of concept bicycle, the form of gear disc unit and spoke is an important factor having a direct bearing on the design of appearance and an impact on the product image. It comes into four categories of "Chain drive", "Shaft drive", "Gear-to-gear drive" and "Shaft drive(Spoke-less)", of which, the latter two are in spoke-less form. In terms of "**Riding-posture**", the category of bicycle normally reflect the function hereof. For example, the tracing bicycle differs greatly from the leisure in appearance. By the rider's demands for the speed of bicycle, the riding postures may be divided into four categories from low to high as follows: "Aerodynamic", "Aggressive", "Relaxed", and "Very-Relaxed", the first two require higher tilt while the latter call for lower one. As the "**Wheel diameter**" and "**Wheel base**" of a bicycle have a direct bearing on the interval between the handlebar and the

rider, the diameter of the front wheel also have an impact on the height of the handlebar, thereby determining the riding posture. As a result, the diameters of front and rear wheel and the distance between the two wheels can be divided into three grades separately: “Small” (12–16 in.), “Medium” (18–22 in.) and “Large”(24–29 in.) and “Small”, “Medium” and “Large” respectively. Catalano proposed that the positions of “Volume” and “Barycenter” have a great impact on the product style (Catalano 2004). As the research on bicycle design is normally based on a lateral view, despite the influence on weight imposed by the adopted material, this research is not to focus on the detailed size of frame and the bicycle area indicated in the view are used a condition for volume. In this research, work out the area of bicycle frame following the outlined bicycle by AutoCAD, and then, divided the volumes of all samples into three degrees: “Small”, “Medium” and “Large”. The distance of “Barycenter” between the front and rear wheels is divided into three grades: “Front”, “Medium” and “Tail”.

According to the morphological analysis, the form features of concept bicycles are listed as the above ten elements, and their categories are shown in Table 1. Sixty

**Table 1.** The morphological chart of concept bicycle.

Item	Elements	1	2	3	4	5
1	Frame					
		6	7	8	9	10
						
		11	12	13	14	15
						
		16	17	18	19	20
						
21	22	23	24	25		
						
26	27	28	29	30		
Item	Elements	1	2	3	4	5
2	Handlebar					
3	Wheel set					
4	Drive system	Chain drive	Shaft drive	Gear-to-gear	Spoke-less	
5	Riding-posture	Aerodynamic	Aggressive	Relaxed	Very-relaxed	
6	Front wheel diameter	Small	Medium	Large		
7	Rear wheel diameter	Small	Medium	Large		
8	Wheelbase	Short	Medium	Long		
9	Frame volume	Small	Medium	Large		
10	Barycenter	Front	Middle	Tail		

concept bicycle samples are decoded by this morphological chart. Let's take sample S1 for example. S1 is combined with category 1 of feature "Frame", category 2 of feature "Handlebar", category 1 of feature "Wheel set", category 1 of feature "Drive system", category 2 of feature "Riding-posture", category 2 of feature "Front wheel diameter", category 2 of feature "Rear wheel diameter", category 2 of feature "Wheelbase", category 1 of feature "Frame volume", and category 2 of feature "Barycenter". Therefore, the form features of sample S1 are coding as 1211222212. These codes are the input data for NN models.

### 3.2 Samples of Concept Bicycle

In this research, a total of 146 pictures of concept bicycle are collected, and three product designers with practical experience are invited to help classify the collected samples according to the 10 features planned above and design 60 combinations as the samples for the research following the principle that each category shall be used once at least, of which, 25 concept bicycles are originated by the designers. In order to ensure the unified system and size of the sample pictures, such 60 samples are drawn once again by Adobe Illustrator, and the surface coating is removed with gray colors. In addition, add paper-cut silhouette into them to help the interviewee understand the actual size and riding posture of a bicycle.

### 3.3 Image Perceptions of Concept Bicycle Samples

Twelve senior graders majoring in design, who have finished the fundamental design courses, are selected to conduct the focus group method. Members in the group collect related material and discuss mutually, so as to probe into the application of 12 archetypes in product design, and attempt to describe the association between the form features applied to a product and the archetypes with design technique of archetype image by the drill of front end engineering. The contents of group are scheduled to be performed in three phases, which is conducted for around three hours per week within months. **Phase I** mainly covers the outline of the features of 12 archetype theory and images, and provides the adjective vocabulary and image cognition map used by Shieh et al. to describe the archetypes (Shieh et al. 2016), so as to allow the members to know the archetypes in a faster manner. **Phase II** is aimed at extracting the features of cognition or emotion from the material of archetype images, and describing such relatively abstract archetypes by concrete vocabulary or things. The members collect the materials concerning the archetype images of non-product, which features visual forms such as picture or film, and then discuss the material by referring to the features and the vocabulary (Shieh et al. 2016). In **Phase III**, to conduct the image cognition maps with pictures for archetypes. The members discuss in groups, collect the pictures or films of the products related to the archetype and make an analysis of the cause of particular archetype feature, and then mark it with slogan or noun and adjective and raise such other features that the product has. Finally, to sort out the form features that the product shows in the appearance, including line, curve surface, construction form, color, material, surface preparation and texture.

The image of concept bicycle are evaluated with Likert scale, which requires the interviewee to rate the 60 samples with archetype recognition, which comes in seven levels, with the highest of 7, and lowest 1. The 30 interviewees are of the background related to design, with male 17, and female 13. This study only targets at the impact of form on the images. The identification of materials and non-color samples are difficult for none design-background people. Hence, the interviewees are limited to senior grades of design-background students Ahead of the questionnaire, the researcher briefs the interviewee the 12 archetypes and the related image cognition maps got in focus group method, so as to raise their understanding of the archetype for a better performance in the evaluation.

**3.4 Using NN Models to Build the Relationship Between Form Features and Archetypes**

NN is applied to the analysis of the association between the design features and archetypes. Its basic structure comprises input, conceal and output layer. In the input layer of NN are the sample codes of the classified form and form features, and output layer offers a rate of each archetype responding to the particular sample. The Mean Square Error (MSE) are used to verify NN models with several drills. Following the interviewee’s image evaluation of the 60 concept bicycle samples, standardization of the questionnaire’s results are conducted so as to allow the values to be between 0 and 1. These codes are the output data for training NN models. Fifty out of the 60 samples are used for drill, while the rest 10 for verification. Then NN models for each archetype are built and verified. In order to allow the MSE to be a reasonable range, the weighted value and partial weight value offered each time are determined at random in the training of NN models. Follows couples of training, choose the minimum value as the optimum convergence value. After the completion of the drill of all 12 NN models, take 10 out of them for verification, so as to work out the average error and accuracy rates shown in the Table below (Table 2).

**Table 2.** The accuracy rates of NN models for 12 archetypes.

Num.	Type	Average of MSE	Average of correct rate
1	Innocent	13.6%	86.4%
2	Explorer	14.7%	85.3%
3	Sage	6.1%	93.9%
4	Hero	13.6%	86.4%
5	Magician	10.0%	90.0%
6	Outlaw	11.8%	88.2%
7	Lover	7.4%	92.6%
8	Regular guy	10.5%	89.5%
9	Jester	15.6%	84.4%
10	Caregiver	16.8%	83.2%
11	Creator	9.4%	90.6%
12	Ruler	11.2%	88.8%

### 3.5 The Image Perception and Form Features of Archetypes

After the rating of the 60 samples by the interviewee, take a sample with the highest average evaluation of each archetype and use them as the representative samples of 12 archetypes. See the Table below for the representative samples of these archetypes and the form features hereof (Table 3).

**Table 3.** Representative samples and their form features of each type of archetype.

Archetype	Representative sample	Image evaluation	Frame	Handlebar	Wheel set	Drive system	Riding-posture	Front wheel diameter	Rear wheel diameter	Wheel-base	Frame volume	Bary center
Innocent	9	0.78	9	1	5	4	3	1	3	1	3	3
Explorer	54	0.83	15	3	5	4	1	2	2	2	2	1
Sage	41	0.68	3	1	5	3	2	3	3	1	1	2
Hero	2	0.74	2	3	1	2	2	2	2	2	2	3
Magician	11	0.72	11	1	1	2	3	1	1	2	3	2
Outlaw	2	0.65	2	3	1	2	2	2	2	2	2	3
Lover	14	0.61	14	1	2	1	3	2	2	2	1	2
Regular guy	48	0.89	1	2	3	1	2	2	2	2	1	2
Jester	9	0.87	9	1	5	4	3	1	3	1	3	3
Caregiver	8	0.76	8	1	1	2	3	1	1	2	3	1
Creator	11	0.78	11	1	1	2	3	1	1	2	3	2
Ruler	34	0.69	2	3	4	2	2	2	2	2	2	3

As the 60 samples cannot cover all the sample combination of morphological chart, the possible solutions for samples are up to 1,458,000(=  $25 \times 3 \times 5 \times 4 \times 4 \times 3 \times 3 \times 3 \times 3 \times 3$ ), of which, the feasible is 317,844, from which, obtain the highest rate of each archetype, and these solutions with the highest rates are deemed as the optimum sample combination. Analyze and break the combinations above in terms of form. See Table 4 for morphological chart to understand the image cognition of each form combination.

**Table 4.** The highest evaluation of samples for each archetype and their form features.

Archetype	Image evaluation	Frame	Handlebar	Wheel set	Drive system	Riding-posture	Front wheel diameter	Rear wheel diameter	Wheel-base	Frame volume	Barycenter
Innocent	0.98	1	1	4	2	4	1	1	1	1	3
Explorer	0.94	5	3	5	4	1	3	1	1	2	3
Sage	0.85	5	1	5	4	1	3	1	1	1	3
Hero	0.91	4	1	4	1	1	3	1	3	3	2
Magician	0.92	3	1	5	4	2	1	1	3	3	3
Outlaw	0.98	5	3	5	3	1	3	1	3	2	1
Lover	0.83	1	1	4	1	1	3	3	1	1	3
Regular guy	0.99	1	1	1	1	4	1	3	3	1	1
Jester	0.87	4	1	1	2	4	3	1	1	1	3
Caregiver	0.98	1	1	1	1	4	3	1	2	1	3
Creator	0.9	2	3	1	2	1	3	1	2	3	3
Ruler	0.97	2	3	1	2	1	1	1	3	3	1



## 4 Results of Form Design

Comparing the conclusions reached by focus group method and the results of the questionnaire, it can be found that: (1) the form features summarized by “Innocent” archetype comprise: the outline of product is prone to smooth curve, and the sense of “Innocent” archetype is likely to raise with the “variation” and “dissymmetry” of the basic geometric shapes. The “dissymmetry” may raise to the extent that falls into the image of “Jester” archetype. In the result of image evaluation, the images of “Innocent” and “Jester” archetypes all correspond to this design feature. As a result, the form features of “Innocent” archetype are small-diameter front wheel, big-diameter rear wheel, large wheel base, big volume and visual focus titling to the rear. (2) all the image evaluations of “Sage”, “Outlaw”, “Lover”, and “Ruler” archetypes are less than 0.7. These might be caused by that the effective factors of these four archetypes are color, texture, surface composing factors of “overlap of surfaces” or “projected or cut prism surface”. As a result, the presence of only outline discourages the interviewee from showing strong image sense.

According to the comparison the results of the questionnaire and the form analysis of sample: (1) samples S54 and S15 differ from features only in terms of “**Ridding-posture**”, but the gap of rate is up to 0.46. As the sample S54 can most represent “Explorer” archetype, “**Ridding-posture**” can be deemed as the key to influence the image cognition of “Explorer” archetype. (2) “**Handlebar**” poses an extremely great influence on the archetype image. For example, the forms of sample S3 and S11 differ from the form features only in terms of “**Handlebar**”, while the gap between the evaluations by “Sage” archetype is up to 0.31. As a result, the change in the form of “**Handlebar**” affects the image as a whole. (3) among the form features of “**Drive system**”, the frame featuring spoke-less wheel is relative concise and its evaluation result may be prone to the image perceptions of “Magician”, “Sage”, and “Creator” archetypes.

## 5 Discussion and Conclusion

In this research, form analysis and NN models are used to establish the association between the form features of concept bicycle and image. Apart from the result mentioned in the previous section, the 12 archetypes analyzed in focus group method and the design factors of image cognition maps are good references to a designer, who may combine the categories for the ten elements of the form analysis, and obtain the image evaluation value by the predication models, or fix a particular form feature, conduct the design image evaluation of concept bicycle by alteration of local form features, thereby helping the designer to conduct the design in a diversified and more correct manner. The archetype image cognition maps obtained in focus group method are not confined to concept bicycle. Although the local design depends on product function under some circumstance, for example, drive system of concept bicycle, styles for other parts still make possible good image designs. As a result, designs of other products may still refer to the image cognition maps in this research for the establishment of product image.

## References

- Belk, R.W.: Extended self and extending paradigmatic perspective. *J. Consum. Res.* **16**(1), 129–132 (1989)
- Berkowitz, M.: Product shape as a design innovation strategy. *J. Prod. Innov. Manag.* **4**(4), 274–283 (1987)
- Bitner, M.J.: Servicescapes: the impact of physical surroundings on customers and employees. *J. Mark.* **56**(2), 57–71 (1992)
- Bloch, P.H.: Seeking the ideal form: product design and consumer response. *J. Mark.* **59**(3), 16–29 (1995)
- Campbell, J.: *The Hero with a Thousand Faces*, vol. 17. New World Library, Novato (2008)
- Catalano, C.E.: Feature-based methods for free-form surface manipulation in aesthetic engineering. Unpublished doctoral dissertation, University of Genoa, Italy (2004)
- Chen, H.-Y., Chang, Y.-M.: Development of a computer aided product-form design tool based on numerical definition scheme and neural network. *J. Adv. Mech. Des. Syst. Manuf.* **8**(3), JAMDSM0033 (2014a)
- Chen, H.-Y., Chang, Y.-M.: Incorporating the multiple linear regression with the neural network to the form design of product image. Paper Presented at the Natural Computation (ICNC), 2014 10th International Conference on Natural Computation, pp. 174–180 (2014b)
- Cross, N., Roy, R.: *Engineering Design Methods*, vol. 2. Wiley, New York (1989)
- Guo, F., Liu, W.L., Cao, Y., Liu, F.T., Li, M.L.: Optimization design of a webpage based on Kansei engineering. *Hum. Factors Ergon. Manuf. Serv. Ind.* **26**(1), 110–126 (2016)
- Hsiao, S.-W., Ko, Y.-C.: A study on bicycle appearance preference by using FCE and FAHP. *Int. J. Ind. Ergon.* **43**(4), 264–273 (2013)
- Jones, J.C.: *Design Methods*. Wiley, Hoboken (1992)
- Kotler, P., Alexander Rath, G.: Design: a powerful but neglected strategic tool. *J. Bus. Strategy* **5**(2), 16–21 (1984)
- Kreuzbauer, R., Malter, A.J.: Embodied cognition and new product design: changing product form to influence brand categorization. *J. Prod. Innov. Manag.* **22**(2), 165–176 (2005)
- Lai, H.-H., Lin, Y.-C., Yeh, C.-H.: Form design of product image using grey relational analysis and neural network models. *Comput. Oper. Res.* **32**(10), 2689–2711 (2005)
- Mark, M., Pearson, C.S.: *The Hero and the Outlaw: Building Extraordinary Brands Through the Power of Archetypes*. McGraw Hill Professional, New York (2001)
- Shieh, M.-D., Hsu, F.-C., Tian, J.-S., Chen, C.-N.: A study of product form design using the theory of archetypes. In: Antona, M., Stephanidis, C. (eds.) UAHCI 2016. LNCS, vol. 9737, pp. 327–339. Springer, Cham (2016). doi:[10.1007/978-3-319-40250-5\\_32](https://doi.org/10.1007/978-3-319-40250-5_32)
- Su, J., Li, F.: Research of product styling design method based on neural network. Paper Presented at the Natural Computation, ICNC 2007, Third International Conference on Natural Computation (2007)
- Wang, K.-C.: A hybrid Kansei engineering design expert system based on grey system theory and support vector regression. *Expert Syst. Appl.* **38**(7), 8738–8750 (2011)
- Wang, T.-H., Yeh, Y.-E.: A study on extraction of consumer affective factor for Kansei engineering. *J. Interdisc. Math.* **18**(6), 667–679 (2015)
- Woodside, A.G., Sood, S., Miller, K.E.: When consumers and brands talk: storytelling theory and research in psychology and marketing. *Psychol. Mark.* **25**(2), 97–145 (2008)
- Yang, C.-C.: A classification-based Kansei engineering system for modeling consumers' affective responses and analyzing product form features. *Expert Syst. Appl.* **38**(9), 11382–11393 (2011). doi:[10.1016/j.eswa.2011.03.008](https://doi.org/10.1016/j.eswa.2011.03.008)
- Zwicky, F.: Morphological astronomy. *Observatory* **68**, 121–143 (1948)