

Towards a theory-based method for evaluation of visual form syntactics

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Abstract: Achieving an aesthetically appealing product appearance is of increasing importance for attracting customers and creating valuable product experiences. In this scenario, efficient design processes for assessing appearance characteristics and evaluating visual appreciation of product form is crucial. This requires design methods that support the designer in assessing the content and structure of the product form, and evaluate the visual effect as perceived by customers. In this paper, a methodology for analysis and evaluation of visual product form is presented and implemented in a real form assessment case. The aim of the method is to formally articulate, clarify and evaluate form syntactics; the formal-aesthetic characteristics and functionality of the visual product form. The methodology contains two main parts; form syntactic analysis followed by form syntactic evaluation using empirical user clinics. The paper presents the findings from using the methods in an exploratory design evaluation project in collaboration with a large vehicle manufacturer in Sweden. In the project, the methods were refined, implemented and tested in a formal aesthetic evaluation process of the structure and effect of the visual form of a vehicle exterior. The findings indicate that the methods are potentially efficient for describing and externalizing the effect of the visual product form, and to assess the visual appearance as experienced by users.

Key words: *Design Syntactics, Form Analysis, Form Evaluation, Syntactic Functions, Methods*

1. Introduction

Contemporary industrial design processes typically employ designer driven, intuitive methods for generating and evaluating form concepts [1, 2]. There are, however, shortcomings associated with the traditional process for evaluating visual form aesthetics utilized today. Due to the subjective nature of available assessment and evaluation procedures, it is difficult to externalize and communicate the method, and to motivate the result, of the evaluation. The designer has no objective way of evaluating the aesthetics of one form concept against the other, but is referred to personal opinion, taste, and subjective assessment. One drawback of this approach is that the result is open-ended, non-verifiable, and often difficult to communicate to other stakeholders and disciplines such as engineering, marketing, etc., who lack the necessary knowledge and the ability to understand the codes of the designerly language [3, 4]. Thus, in a design evaluation situation, the result is not efficiently communicable, which may result in a situation where design decisions are not understood, nor trusted.

In an industrial product development situation, where design concepts are evaluated against technical engineering criteria, cost, etc., aspects which are readily assessed and motivated based on scientific knowledge and validated tools, the argumentation for the tacit, subjectively experienced appearance criteria becomes difficult. Thus, this work is based on the hypothesis that industrial design processes can be made more efficient and become more integrated in the product development process, by the creation of science-based phenomenon models for explanation and reasoning, shading light on the structure and behavior of visual form aesthetics; and through the implementation of theory-based methods and tools for objectively describing, evaluating and motivating form design proposals.

In this work, a provisional, objective method for the qualitative analysis and evaluation of formal aesthetics of visual product form, based on design syntactics theory [9], is proposed and presented. The method has been implemented in a formal-aesthetic study of the visual form of a truck cab from a large Swedish manufacturer [10].

The purpose of the study was to analyze and evaluate the syntactic structure and content of the product form, in order to enable a comparison of the visual characteristics of a competing truck brand. In the paper, examples from the actual study are included to illustrate the methodology. For reasons of confidentiality, specific results and recommendations based on the analysis are not included, however.

Related research

Other authors have contributed to the objective of formalizing the relation between visual product form and aesthetic appreciation. In the product semantics field, many authors have contributed with the establishment of theory and methods for the evaluation of meaning carried by product signs, see, e.g., Vihma [17], Monö [18], Wikström [19], Muller [20]. Van Breemen et al. [5] studied the relation between designers' aesthetic intent and product shape based on a theory of communication of aesthetic intents. Chen et al. [6] established a style description framework that equips the designer with the ability to analyze existing styles and to describe new styles for target markets. Chuang et al. studied the relationship between expected images and their correspondence to the critical form features of micro-electronic products [1], and examined the relationship between user preference perception of mobile phones and their form design elements [7]. In Kansei engineering, efforts have been put into creating computer based tools for assessing product form based on statistic evaluation of respondents' perception using word scales (see, e.g., Jindo et al. [8], Jindo et al. [13], Tanoue et al. [14], Nakada [15], Nagamachi [16]).

For the research carried out in this study, the emphasis is not on applying quantitative statistical methods to establish correlations between perceived product appearance and the characteristics of the form. Neither is the objective of this research to create computer support for purposes of evaluating visual form aesthetics. Rather, the purpose of this paper is to present a theory-based, objective approach to assessment and evaluation of visual product form. It is claimed that many of the studies carried out in previous research efforts lack a fundamental component to the research agenda, that is, the creation of a solid theoretical basis as an outset for subsequent development of models, methods, and tools. We recognize and acknowledge the methods for statistical data analysis used in previous studies, but believe that commencing the development of any tools, computer-based or not, without a rigorous, science-based theoretical framework as a foundation for experimental studies is like groping about in the dark, without a guiding light.

2. Description of the design syntactics theory

Design syntactics theory [9] describes the visuo-spatial structure and content of product form, denoted form syntactics, and explains the visual effect of the product form with functional and perception theory, the syntactic functionality. Design syntactics theory aims at providing a formal and objective explanation of formal aesthetics.

The method presented in this paper is based on the principles of design syntactics theory. The theory includes phenomenon models describing the two main research objects; the human perception of visual form and the experience of visual effect; and the visual form of the product, described by constitutive models of the structure and configuration of visual product form, and behavior models, describing the functional properties of the product form. Thus, the theory models the human perception as part of a visually interactive system, reacting upon the

visual form of the product, producing visual effects created by the syntactic functionality, being a property of the constitution of the visual form. The theoretical construct renders it possible to create a mapping of the content and structure of the product form to the human appreciation of the form; a fundamental requirement in order to develop any applications such as methods and tools, for implementation in industrial design processes.

According to design syntactics theory, all elements of a product form are part of a visual system. Changing one design element (form element, visual theme, or visuo-material characteristics) unconditionally affects the visual appreciation of the whole system, i.e. the surrounding design elements and the whole product gestalt. Furthermore, according to the theory, every single design element has at least one syntactic function [11]. As part of a system of visually interacting design elements, each design element also contributes to syntactic functionality on a superior system level. This explains why individual visuo-spatial elements cannot be isolated from the totality of a product form, which is a major reason why product form design is such a complex and sensitive activity.

The syntactic functionality of the product form creates the visual effects, which are perceived by the human observer during aesthetic appreciation. Such visual effects are, e.g., the perception of balance, groupings, or visual continuity in product form. These effects have been extensively studied in gestalt psychology. A more significant design element has a stronger syntactic function (it fulfils more visual “performance” criteria) than an insignificant design element, which has a smaller visual effect and is less easily perceived (fulfils only basic visual requirements). Thus, according to the theory, the aim of product styling designers is to achieve the desired visual effect, by creating a suitable syntactic functionality, carried by the product form. The effects perceived in aesthetic appreciation are thus the operators of the aesthetic intent of the designer. Thus, only through a properly designed product form, carrying the desired syntactic functionality, can the correct visual effects be created and the communication of design intent be achieved.

3 Description of the form syntactics methodology

In order to operationalize the theory, a “designer’s toolbox” is under development. The toolbox consists of a number of tools supporting activities of specification, analysis, evaluation, and synthesis during the form design process. These tools comprise the building blocks of the Design Syntactics Methodology and create the backbone of a complete design procedure, ranging from initial steps of form analysis research to form synthesis support, according to Figure 1. The methods are intended for use in design and planning activities on both operative and strategic design levels.

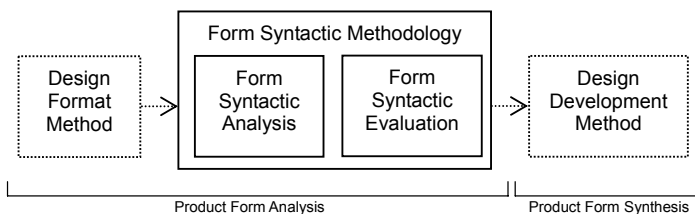


Figure 1. The framework of the design syntactics methodology, showing the principal methodological steps. In this paper, the Form Syntactic Methodology is treated.

The first step of the complete procedure is the Design Format Method, including a matrix-based analysis tool allowing for weighed pair-assessment of the visual ingredients of a product form [12]. Here, we define the product form as consisting of geometrical shape, dimensions, compositional structure, and surface characteristics

(including color). During format analysis, the most significant design elements of the visual product form are identified and valued in relation to each other. The method provides an initial understanding and overview of the visual constituents of the product form, based on perceptual significance. Based on the format analysis, conclusions about the appearance of a product can be made with regard to semantic as well as syntactic aspects of the visual product form. The results of the analysis can be used for operational design planning as well as for strategic development purposes, such as visual positioning in relation to competing products on the market.

The partial methodology described in this paper, the Form Syntactic Methodology, has two main methods; form syntactic analysis, and form syntactic evaluation. These will be described in the following.

Form syntactic analysis

The knowledge achieved from the design format analysis is used as partial input to the next step, the form syntactic analysis. The main objective of the form syntactic analysis is to clarify the visual effect of the constituent design elements of the analyzed product, in order to identify the *syntactic functionality* of the form [9]. In the case study, the purpose of clarifying the visual effect of the form syntax was dual; to identify *the role of each design element* in itself and in relation to other design elements, and to *evaluate the elements* as constituents of the whole form design.

The procedure consists of the following main steps:

1. Selection of design elements to be studied
2. Generation and implementation of syntactic variations of selected design elements
3. Assessment of visual effect achieved by each variation
4. Evaluation and conclusion regarding syntactic functionality

Each step is described in detail in the following.

Step 1: Selection of design elements to be studied

The selection of design elements for the syntactic study is based on the visual content identified in the design format analysis. Normally, the most significant design elements (those ranked highest in the design format assessment) are selected. Figure 2 shows examples of design elements selected and analyzed in the truck cab study. Selecting just any design elements in an “ad hoc” manner, without a prior analysis of visual significance, would render an analysis based on pure chance with an unknown quality of validity.



Fig. 2. Examples of selected design elements of the truck cab, indicated by contour patterns.

Step 2: Generation and implementation of syntactic variations of selected design elements

Following the selection of design elements for the study, appropriate manipulations of each design element were generated. The purpose of varying the form syntax was to determine the visual effect, either for each element by itself, or in relation to other elements. According to design syntactic theory, the variation introduced to each element produces visual stimuli in our perception of the form, which is used for clarifying the role of the element in terms of syntactic functionality. In the study, types of variations of selected design elements included repositioning of elements in relation to each other and removal of elements to test visuo-structural effects, and the variation of dimensions and proportions of singular design elements to test individual effects.

The syntactic variations were applied systematically in a series of alterations in order to allow a structured analysis and assessment of the resulting visual effects. This step can be greatly enhanced using a standard digital graphics software package. Variations are introduced and elaborated to render distinct instances of visual alterations, as exemplified by Figure 3.



Fig. 3. Three examples of syntactic variations implemented for establishing visual effect of design elements. Far left: original appearance. Alterations from left to right: set of grilles repositioned; logotypes and emblems removed; shut lines, body lines, and set of grilles removed.

Step 3: Assessment of visual effect achieved by each variation

The visual alterations arrived at in Step 2 are now analyzed and the visual effect of each respective manipulation is clarified and assessed. The visual effect answers the question “what does the design element (or group of elements) do to the form syntax?”. According to design syntactics theory, the analysis is inevitably dependent on assessing each alteration in relation to the whole, since visual appreciation is a phenomenon based on gestalt perception and, hence, the visual effects occurring between interacting design elements.

Step 4: Evaluation and conclusion regarding syntactic functionality

The last step of the analysis procedure includes the formulation of syntactic functions based on the visual effects identified in Step 3. Each syntactic function answers the question “what is the purpose of the visual effect?”. In an analytical process, the formulation of syntactic functions is mainly clarifying. For specification and synthesis activities, the formulation of syntactic functions serves purposes of aiding form generation and elaboration, i.e., as a creative tool [11]. According to design syntactics theory, there are a number of syntactic functions, including, but not limited to, the verbs stated in Table 1.

Table 1. Syntactic functions, visual effects, and examples.

Syntactic function	Visual effect	Examples
Connecting	Creates visual couplings between design elements or groups	Resembling and reappearing shape, material, surface characteristics, or chromatics
Balancing	Stabilizes one design element or group in relation to another design element or group	Symmetry, balanced asymmetry, counteraction
Discerning	Separates one design element or group from the whole	Differentiating shape, material, surface characteristics, or chromatics
Referring	Relating to design elements found in other products, e.g., in other members of the brand or product family	Form elements, themes, signifiers, materiality, color

Discussion of form syntactic analysis

Form syntactic analysis is a qualitative method, which has the purpose of clarifying the visual effects of the content and structure of a form design. For evaluative purposes, it can contribute to the knowledge about the visual effects of an existing product, or for comparing a number of competing form concepts. The result of the analysis procedure is dependent on the skill and experience of the analyst team to assess visual effects of the form syntax. The method reduces the influence of subjective bias in form evaluation activities by establishing a causal relationship between specific features of the product appearance and the experienced visual impact created by those form features.


Form syntactic evaluation

Form syntactic evaluation is a questionnaire-based, empirical method for evaluation of respondents' formal-aesthetic preferences of a studied visual product form. The method uses the results of the form syntactic analysis described previously to achieve an objective assessment of the visual syntactic effects of a product form, employing users as evaluative subjects. The results of the evaluation can be compared to the analysis to acquire a basis for comparison of results and validation of the design intent of the product form syntax. Thus, the evaluation necessarily must be preceded by form syntactic analysis, to define the areas to be evaluated.

In the evaluation procedure, a paper-based questionnaire (Figure 4) was handed out to the respondent, who evaluated each indicated design element. The respondent was aided by an assistant, answering any questions that arose during the study. The time required for each respondent to complete the questionnaire averaged 30 minutes. The result of the evaluation is an indication as to whether the visual form is syntactically legible, i.e., whether the form carries the intended syntactic functionality clearly enough to be perceived. The data collected during the inquiry was analyzed using elementary descriptive statistics.

Form evaluation

Focus area: **The whole form**



Harmonious

Not at all Definitely

Dynamic

Not at all Definitely

Complex

Not at all Definitely

Balanced

Not at all Definitely

Consistent

Not at all Definitely

Figure 4. Example of form syntactic evaluation questionnaire used in the study. Adapted from [10].

The questionnaire employed in the study included a number of instruments for data acquisition:

- a visual focusing tool,
- a semantic word scale, and
- an ordinal estimation scale.

The semantic word scale and the ordinal estimation scale were developed as a special type of semantic differential scale. The instruments of the questionnaire are described in the following.

1. Visual focusing tool

The purpose of the focusing tool is to direct the respondent's attention to the visual "target area", i.e. to focus the respondent on the syntactic effect to be assessed. The focusing tool consists of a verbal description of the visual focus area to be evaluated, and a thumbnail image depicting the area graphically. If necessary, the focus area can be highlighted, e.g., by encircling a specific area or otherwise indicate specific design elements on the image. In the inquiry process, the assistant provided the respondent with additional, high resolution pictures from various perspectives of the product to enable the respondent to acquire a complete understanding of the visual area to be evaluated. Ideally, the inquiry is made using real products or scale models as evaluation objects. In this case, this was not practically possible, however.

2. Semantic word scale

Through the form syntactic analysis, a number of visually significant areas, i.e. design elements carrying syntactic functionality, were identified. In the evaluation phase, it is thus of interest to validate if these areas are perceived as significant by the responding user group, and how they value the visual effect of these areas. In order to enable the respondents to perform the evaluation, they were provided with a semantic word scale, consisting of property words (adjectives) describing selected syntactic effects of the form. The vocabulary used was selected based on the result of the previously performed syntactic analysis procedure.

For the evaluation to be effective, the vocabulary used must be understandable by the respondent. This requires careful planning of the terms used in the evaluation. Words aimed for should correspond to normal language. They should also be as specific as possible and characteristic enough not to be interchangeable. Furthermore, the number of words used should be limited in quantity, in order to avoid confusion by using too similar terms. If necessary, respondents should have access to a list of synonyms for each term in order to ensure that respondents associate correct meaning to each property word. The terms used should only describe objective syntactic characteristics of the product form. Careful attention should be devoted towards avoiding words denoting expressive properties of the design, since such terms are subject to personal interpretation and will measure semantic qualities [19]. Terms used in the study included, e.g., dynamic, complex, balanced, and consistent (see Figure 4).

3. Ordinal estimation scale

In the evaluation process, respondents were asked to assess their opinion about the form area with regard to the syntactically descriptive terminology. For each property word, the respondent marked his or her opinion on a seven-step ordinal scale, ranging from “not at all” to “definitely”, signifying the total absence to the very obvious presence of the described syntactic effect, respectively (Figure 5). This type of scale was considered easier to construct than a traditional semantic differential scale [21], containing a property word on one end of the scale and its antonym on the other end. The reason for this is that certain words do not have a natural antonym, and that some words may have several antonyms since they may have several meanings [22].

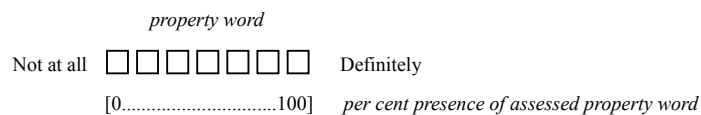


Figure 5. Principal content of the type of semantic differential scale developed and employed in the study. The scale consists of a property word (adjective) describing the syntactic effect to be assessed, and a seven-step ordinal estimation scale ranging from ‘not at all’ (denoting ‘zero’ presence of the syntactic effect) to ‘definitely’ (denoting a 100% presence of the syntactic effect).

Discussion of form syntactic evaluation

Descriptive statistics was used to obtain a very basic analysis of the collected data. For each assessed term, the mean value was calculated and compared to the results obtained from the evaluation of the competing truck model to provide an indication of the differences in perceived syntactic effect in each truck model. Thus, it was possible to determine the visual syntactic quality of each truck design. In this explorative study, the number of respondents was very limited (n = 6) and not sufficient for any kind of statistical validation. Due to reasons of confidentiality,

it is not possible to present the results in this paper.

The objective was not to obtain a statistically valid evaluation of respondents' opinions of the syntactic qualities of the visual form. Rather, the aim was to put the evaluation method to a primary test of the method as such. As an empirical evaluation method for visual form syntactics, it has the potential to become a working tool in the process of validating a proposed or final form design, in an area where such methods are largely lacking. By providing a quantitative measure indicating the perceived syntactic property of a number of specified design elements in a product form, it is possible to relate a specific syntactic visual effect to a specific set of design elements. Thus, it is possible to attain a causal relationship between product form characteristics and visual experience, based on syntactic effect. In a design situation, the tool can hence be used for optimizing visual properties of a product, such as expression, identity, and coherence. In the future, the aim should be to validate the method as a tool producing valid results. The correspondence between the conclusions made by professional designers and respondents from a user group should also be studied in order to validate the method as a predictive tool for design evaluation purposes.

4. Conclusions

The aim with studies of methodology for analysis and evaluation of design syntactics is to increase the knowledge of our appreciation and understanding of visual form appreciation. Even though the need for further validation studies with more respondents in order to obtain larger quantities of numerical data is acknowledged, the standpoint taken here is that it is possible to achieve a substantial amount of knowledge about the appreciation of a visual product form through rather simple methods. Compared to other methods, with the ambition of solving the causality problem relying heavily on statistic analysis, the proposed method presents a theory-based approach for achieving the goal in a much less complex, but more reliable way, which is validated in terms of visual appreciation.

The study shows that methods for analyzing and evaluating form design based on qualitative approaches are very plausible. The purpose with such methods is to utilize the designer's ability to perform such analyses, provided with tools that are easy to use and in line with established working procedures in the design process.

The intention with the methodology developed and implemented in this study has been to take a step towards primary theoretical understanding of the design phenomenon. The most important issue is to understand that elaborate evaluation methods cannot mend an infirm theoretical basis. Evaluation of design syntactics intrinsically requires designerly knowledge, since it is a designerly phenomenon. Therefore, we must understand the basic principles behind designing, and especially form design development and form perception, to be able to analyze and evaluate this phenomenon.

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