PRINCIPLES FOR DESIGNING FOR PERCEPTION

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Abstract

The paper presents an overview on the different design principles that influence the aesthetic experience of consumers regarding products. Three levels of design principles are presented: 1) general principles regarding how humans group elements together, 2) principles that when applied to products can generate a range of emotional responses and; 3) detailed principles relating aesthetics with perceptions (normally product or category specific). Results from the evaluation of the literature show that more research is necessary in areas where a large number of terms are not defined to a level that is detailed enough to show what the influence of modifying the aesthetic properties are in regards to the perception one wants to achieve. Future work could focus on building generative design tools (e.g. spatial grammars) or tools for the evaluation of designs (e.g. using fuzzy logics).

Keywords: Emotional design, Industrial design, Aesthetics, Shape, Form

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1 INTRODUCTION

The field of emotional design has attracted the attention of many during the past years as it provides ways of differentiating consumer products from one another in markets where many products share the same or very similar functionality. Emotional design investigates the relationship between people and products and looks into the various interactions that can take place. There are three approaches to product emotions that try to explain how products and emotions relate:

- The pleasantness approach (Jordan, 2000) is a psychological approach to product emotions. Jordan states people want products because they want to feel pleasure from owning or interacting with them, where pleasure is defined as the sensation induced by what is perceived as good or desirable. Pleasure from the products comes from the practical benefits (from performing a task), the emotional benefits (products that affect the mood) and the hedonic benefits (sensory and aesthetic pleasure).

- The appraisal approach (Desmet, 2010) is explained as a cognitive appraisal. It is through the evaluation of the event (which can be a product) that the potential benefit or harm of something can be assessed. The appraisal is considered a non-conscious sense-evaluation and it mediates between events and emotions (Desmet & Hekkert, 2002). Hence different people can appraise the same event in different ways and therefore experience different emotions. Desmet distinguishes between the usefulness appraisal (when the event supports or obstructs reaching a goal), the pleasantness appraisal (when the event provides pleasure or pain) and the rightfulness appraisal (when the event meets or exceeds expectations).

- The process-level approach (Norman, 2004) is a neurobiological emotion-framework with three different levels of information processing: visceral, behavioural and reflective. The visceral level is a reactive (or automatic) layer which is almost the same around the world where appearance, touch and feel create the first impression of the product. The behavioural level is where effectiveness of use is perceived, it is not conscious and it is sensitive to experience. The reflexive level is where rationalisation of products takes place, that is, where people reflect about the product. This last layer is conscious and sensitive to experiences. Here the highest level of emotion, self-image and cognition is found.

Each of the three approaches explain the relationship between products and consumers with a different perspective. However, they have equivalent categories with different names. That is, they all differentiate between the emotional aspects elicited by products, the functional aspects and the aesthetic aspects; and it is clear that the aesthetic perception obtained from the product is not limited to an emotional response. The focus of our research is on aesthetics of products and the influence the shape (or appearance) of products have on perceptions. This area of research falls, if benchmarked against the three previous approaches, within the hedonic benefits category (Jordan, 2000), the pleasantness appraisal category (Desmet, 2010) and the visceral level of information processing category (Norman, 2004).

This paper focuses upon perceptions and not emotions. An emotion, according to Myers (2004) is an individual's mental experience when it interacts with internal and external stimuli, i.e. physical and environmental stimuli respectively. Emotions (e.g. happiness or fear) are conscious experiences that evaluate external stimuli according to physical body responses (Myers, 2004). Emotions have a short duration, seconds or minutes (Johnson, 2009) and are known to influence thought and behaviour (Cherry, 2012). There is no agreement on the number of emotions that exist, but there is agreement that they are a limited number (Ortony and Turner, 1990). Each author considers the basic emotions differently to the rest. A list of the basic emotions can be seen in Table 1 and other emotions are considered a combination of them.

Table 1. Theorists and their list of basic emotions (Ortony and Turner, 1990)

Theorist	Basic emotions
Plutchnik	Acceptance, anger, anticipation, disgust, joy, fear, sadness, surprises
Arnold	Anger, aversion, courage, dejection, desire, despair, fear, hate, hope, love, sadness
Ekman, Friesen and Ellsworth	Anger, disgust, fear, joy, sadness, surprise
Frijda	Desire, happiness, interest, surprise, wonder, sorrow

Gray	Rage and terror; anxiety, joy
Izard	Anger, contempt, disgust, distress, fear, guilt, interest, joy, shame, surprise
James	Fear, grief, love, rage
McDougall	Anger, disgust, elation, fear, subjection, tender-emotion, wonder
Mowrer	Pain, pleasure
Oatley and Johnson-Laird	Anger, disgust, anxiety, happiness, sadness
Panksepp	Expectancy, fear, rage, panic
Tomkins	Anger, interest, contempt, disgust, distress, fear, joy, shame, surprise
Watson	Fear, love, rage: based on what infants feel
Weiner and Graham	Happiness, sadness

In contrast to emotions, perceptions (e.g. that something is elegant or beautiful) are what is perceived from products, and there is no finite number of them. However, attempts have been made to categorize them. Goldman (1995) proposed a list of categories of aesthetic evaluative terms (see Table 2). Some concerns about this grouping is that the categories don't have well defined boundaries, allowing the same term to belong to more than one category. It is also a non-closed list of terms, which makes it difficult to decide when to stop listing adjectives to describe something. Additionally, the experience of the subject influences some categories, like the historical category, as this compares to other products over time so is dynamic and not necessarily constant across people. Hence, the categories are useful when working with perceptions, to identify those categories which are constant and static or can change (historical) and rely on individual memory.

Table 2. Evaluative aesthetic terms (Goldman, 1995)

Category	Examples
Broadly evaluative	beautiful, ugly, sublime, dreary
Formal	balanced, graceful, concise
Emotional	sad, angry, joyful, serene
Evocative	powerful, stirring, amusing, hilarious, boring
Behavioural	sluggish, bouncy, jaunty
Representational	realistic, distorted, artificial
Perceptual	vivid, dull, flashy
Historical	derivative, original, conservative

2   AIM OF THE PAPER

Understanding how aesthetics influence consumer perception is important to designers as consumers perception can differ from the designers (Ahmed and Boelskifte, 2006). Hence designers are not always able to convey to consumers the message they intend their products to transmit. Finding the relationship between perceptions and product features could lead to the enhancement of product appeal which would assist designers to convey the intended perception.

The aim of the paper is to collect together design rules by reviewing literature. From the literature review, which is presented in section 4, it can be seen that there exist rules and principles from different domains but they have not been gathered to create an overview. Pham (1999) proposed a list of nine basic principles for analysing the interaction between aesthetic characteristics and product characteristics. The principles were divided in three categories that influence the aesthetics of products, namely, shape, composition and physical attributes. These nine principles include those that can generate an emotional response and they detail what aesthetic characteristics influence the principles but they fail to give advice as to in which way these properties should be changed to modify the perception. Wertheimer (1938), studied the way people perceive things and identified several general principles of visual perception but does not identify the influence of these principles on people when applied to design (i.e. perceptions). This research tries to put together all design principles that deal with design elements and influence how people perceive them. From the very general principles to the more specific ones, suggesting how to change the aesthetic elements to change the perception. This overview is needed both for a foundation to build research, for example evaluation of designs for

perceptions (Achiche and Ahmed-Kristensen, 2011) or for generative design tools (e.g. spatial grammars) and also to support designers both through the tools and design principles.

3 AESTHETICS

Aesthetics play a key role in the interaction of consumers with everyday products as is often through aesthetics that consumers first interact with a product. The term originally comes from the field of philosophy, where philosophers have long studied aesthetics for different disciplines like art, music and literature. In design research, aesthetics is understood as the appearance features of a product which have the ability to create immediate responses when the product is experienced through the sensory system (Lawson, 1983). Aesthetic responses are rapid, involuntary and can be biased in a positive or a negative way (Ulrich, 2006). In the emotional design literature, the aesthetic response is equivalent to the hedonic benefits obtained from products (Jordan, 2000), the pleasantness appraisal (Desmet, 2010) and the visceral response (Norman, 2004). Material, colour, ornamentation, shape, size and reflectivity are some of the appearance features of products (Brunel and Kumar, 2007) that combined in certain ways can lead to experiencing pleasure or delight from the sensory system regarding a product (Goldman, 1995; Hekkert, 2006). Another aspect is that attractive things don't just happen, it take time to make them appealing which is the reason why aesthetically pleasing products area associated with quality products (Ulrich, 2006).

There are different ways of understanding aesthetics that are not mutually exclusive but instead provide different perspective and give insight on different aspects. The evolutionary aesthetics approach defends that preference for specific aesthetic elements or objects comes from evolution. We as humans developed a way to judge our environment in a much faster way by developing a preference for those things that are good for us (like food, shelter and a safe environment). Implicit in this concept is the idea that many aesthetic evaluations will be shared across cultures, that is, they would be universal. However, this does not exclude the other approach of cultural aesthetics, which defends that our preferences are influenced by the social environment that we are raised in. In this second approach, different cultures would have different aesthetic preferences (Ulrich, 2006). This research looks at aesthetics objectively, meaning that the aesthetic pleasure is seen as independent of the subject that is perceiving. Previous work (Perez Mata et al., 2014) found that the background information of the subject can be transcended, that is, aesthetic appreciation is shared independently of the viewer's demographic information.

4 METHODOLOGY

A total of 46 papers were initially reviewed to identify existing studies that relate aesthetics (i.e. geometry or product features) to perceptions. Only those papers that included design principles connecting those elements were taken further into consideration and are presented in Table 3. Three varying levels of detailed principles were identified and are presented: 1) general principles regarding how humans group elements together, 2) principles that when applied to products can generate a range of emotional responses and; 3) detailed principles relating aesthetics with perceptions (normally product or category specific). Before presenting the principles found, a brief summary of the three principles is introduced.

Gestalt theory was originally studied in the domain of psychology and Wertheimer (1938) was one of the first to work with defining general principles based on how people perceive. He was interested in understanding why when we are presented with a number of stimuli, we don't usually experience a number of things, but instead we identify groups of elements as belonging together. For example, we don't see different and independent colour dots, we see a house or we see trees. He studied the way humans perceive and organize individual elements into groups (Wertheimer, 1938). He developed a number of principles to explain this pattern recognition. Those principles (or factors, as he called them) compose the Gestalt principles (Wertheimer, 1938). Gestalt theory states that the individual perceives things as a whole or gestalt, and not as independent parts (Fisher and Smith-Gratto, 1999). That is the same as saying that the perception of the whole cannot be explained by the sum of the independent part. But the independent parts, if modified, can change the whole perception. Other authors after him from the field of emotional design have investigated and proposed some principles to analyse the interaction between aesthetic characteristics and product characteristics (Pham, 1999), while others have looked into perception terms associated to the aesthetics of products (Schütte and

Eklund, 2005; Hsiao and Chen, 2006; Achiche and Ahmed, 2009; Achiche and Ahmed-Kristensen, 2011; Perez Mata et al., 2013). The variety of products used as case study to link perceptions with product features or geometry is very wide, from cars to kettles or rocker switches to vases (Hsiao and Chen, 2006; Perez Mata et al., 2013; Schütte and Eklund, 2005).

The literature is organized in the table as follows: First, the Gestalt rules or principles explaining how humans detect patterns and recognize shapes are presented. They are considered very general principles of design. Next, principles that can have an emotional influence on consumers are presented. They include what elements of the shape have an influence on the overall evaluation of a product. Lastly, the more specific and lower level instructions are presented. They are normally product related and offer not only what elements of the shape have an influence on the perception, but also include rules on how to change those parameters to increase or decrease the achievement of that perception. Definitions were identified from the authors and are included in Table 3. Under each definition, the design factors that have an influence on those principles / perceptions are stated (column one). Then, more detailed design rules (if found) specifying how to change a shape to have a specific effect are presented (column two).

Table 3. General design principles and perceptions, factors and detailed design rules

GENERAL PRINCIPLES OF HOW PEOPLE PERCEIVE		
Principles/ perceptions	**Factors**	**Design Rule**
PROXIMITY: Elements with the smallest interval (or spacing) between them will be group together (Wertheimer, 1938; Fisher and Smith-Gratto, 1999).	• Physical distance between elements	Not found
SIMILARITY: Similar elements tend to band together if perceived as related: being it through similar shape, constant direction or continual changes of colour (Wertheimer, 1938; Goldstein, 1999; Moore, 2003).	• Constant direction • Continual changes or similar lightness, hue, size, orientation and shape	Not found
UNIFORM DESTINY / COMMON FATE: When groups of elements move or shift at the same time they will be grouped together (Wertheimer, 1938; Goldstein, 1999).	• Same direction, same speed	Not found
OBJECTIVE SET: The sequence in which something is seen affects how elements are arranged (Wertheimer, 1938).	• Previous shapes	Not found
DIRECTION / CONTINUITY: Elements will be grouped together if there is a smooth or gradual transition from one to another (colours, shapes, arrangement of features or objects) (Wertheimer, 1938); Pham, 1999) or if a continuous pattern is detected and expected to continue although hidden (Moore and Fitz, 1993).	• Constant direction, continual changes Shape: • Size, convexity, curvature and orientation Composition: • Size, convexity, curvature and orientation Physical properties colour / intensity: • Value, hue and saturation	Not found
CLOSURE: Elements forming a closed figure tend to be grouped together (Wertheimer, 1938). There is also a tendency to complete unfinished forms by filling in the missing information (Fisher and Smith-Gratto, 1999).	• Closed shapes	Not found
PRINCIPLES THAT GENERATE EMOTIONAL RESPONSES		
BALANCE: Visual equilibrium between the elements (Pham, 1999).	Shape: • Degree of asymmetry about center of mass, major axes and planes of reference.	Not found

	• Comparative size and spacing of features <u>Composition:</u> • Degree of symmetry of arrangement of objects about center of mass, major axes and planes of reference of the whole product <u>Physical properties colour / intensity:</u> • Relative location, area coverage and variations of 1) complementary and opponent colours, 2) different luminance intensity, hue or saturation	
PROPORTION: Spatial balance, which can be linear, areal and volumetric (Pham, 1999).	<u>Shape:</u> • Ratio of major linear dimensions of object features, ratio of areas and ratio of volumes <u>Composition:</u> • Relative spacing of objects • Relative size, area and volume of objects	Golden ratio
DOMINANCE / PRINCIPALITY / FOCAL POINT: When one feature dominates the rest and attracts attention because the properties differ from the ones around them. Distinct by shape, colour, material or arrangement (Lauer, 1979; Pham, 1999).	<u>Shape:</u> • Major orientation, smoothness of curvature, convexity of shape, global shape characteristics of smallest convex polygonal enclosing object and surface types: plane, single curved, double curved, warped <u>Composition:</u> Presence of distinct patterns of arrangements: • Orientation, path and grouping pattern (number of objects, positions within a group), e.g. triangular, pyramid, radiation, circular <u>Physical properties colour / intensity:</u> Presence of: • Prevalent colour, distinct colour and highlight (can work with hue, saturation and value separately or with their combination in terms of colour) <u>Visual:</u> • Use colour, relative position or shape.	Not found
ALTERNATION / INTERCHANGE / CONTRAST: When impact is created by combining things with different characteristics (Pham, 1999).	<u>Shape:</u> • Size, convexity, curvature and orientation <u>Composition:</u> • Size, convexity, curvature and orientation <u>Physical properties colour / intensity:</u> • Opponent colours, light / dark intensity	Not found
SOLIDITY / STRUCTURAL COHERENCE: Visual power, stability and strength (Pham, 1999). Related to the perception of light / massive (Achiche and Ahmed, 2009).	<u>Shape:</u> • Convexity, surface types: double vs. single-curved, roundness and squareness <u>Composition:</u>	

	• Tightness of arrangements, arrangement of similar objects and no hole, or a small number of holes Physical properties colour / intensity: • Saturation of colours and strength of intensity Light / Massive • Volume / Surface Ratio (VSR) • Height / Width Ratio (HWR)	<table><tr><td>Light / Massive</td><td>VSR</td><td>HWR</td></tr><tr><td>Very Light</td><td>Low</td><td>High</td></tr><tr><td>Light</td><td>Low</td><td>Medium</td></tr><tr><td>Light</td><td>Medium</td><td>High</td></tr><tr><td>Neutral</td><td>Medium</td><td>Low</td></tr><tr><td>Neutral</td><td>Low</td><td>Low</td></tr><tr><td>Neutral</td><td>High</td><td>Low</td></tr><tr><td>Massive</td><td>High</td><td>Medium</td></tr><tr><td>Very Massive</td><td>High</td><td>High</td></tr></table>
SIMPLICITY: The use of the fewer number of elements possible and in the right combination to achieve the desired result (Pham, 1999; Roussos and Dentsoras, 2013).	Shape: • Number of features, range of sizes, number of different line or curve, and orientations Composition: • Number of objects, number of different major line or curve, and orientations Physical properties colour / intensity: • Number of different colours or tones	Low number of features, lines, curves, orientations or colours.
DYNAMICS: Energy and tension created with lines and forces (radial directions, gravitational pulling forces and outwardly thrusting forces) and the sense of movement by an orientation or path (Pham, 1999).	Shape: • Change of curvature, orientation of lines • Planes towards (or away from) one point or along a specific orientation Composition: • Arrangement of objects towards one • Point (or away from) or along a specific path Physical properties colour / intensity: • Gradual change in hue, saturation or • Value of colours towards (or away from) one point or along a specific path • Arrangement of similar colours • Towards (or away from) one point or along a specific path	Not found
RHYTHM: Recognition of patterns by repeated form, colour, intensity or tone (Pham, 1999).	Shape: • Repetitions of orientation, line, curve types, volume size and global characteristics Composition: • Repetitions of similar objects Physical properties colour / intensity: • Repetitions of similar colours (in hue, saturation or value)	Not found
FIGURE-GROUND: It is possible to distinguish between figure and background because the background is perceived as being behind. The figure is always more visible (Arnheim, 1970; Fisher and Smith-Gratto, 1999).	• Figure always more visible. It stands out by colour, shape or texture	Not found

BELONGINGNESS: When an element can only belong to one source at a time (Moore, 2003). For example, different textures indicate different parts (Chang and Nesbitt, 2006).	• Surface texture or hardness • Colour	Not found

| **DETAILED PRINCIPLES RELATING AESTHETICS WITH PERCEPTIONS** |||

AGGRESSIVE / FRIENDLY (PASSIVE): are adjectives investigated for both general shapes and vases (Achiche and Ahmed-Kristensen, 2011; Perez Mata et al., 2013).	Aggressive / friendly • Line to Curve Ratio (LCR) • Acute angles to Obtuse angles ratio (AOR) • Regularity Level (RL) Aggressive / passive • Lines Curves Ratio (LCR) (for vases)	<table><tr><td>Aggressive</td><td>LCR</td><td>AOR</td><td>RL</td></tr><tr><td>Not</td><td>Low</td><td>Low</td><td>High</td></tr><tr><td>Slightly</td><td>Low</td><td>Low</td><td>Low</td></tr><tr><td>Quite</td><td>Low</td><td>High</td><td>High</td></tr><tr><td>Quite</td><td>Low</td><td>High</td><td>Low</td></tr><tr><td>Very</td><td>High</td><td>Low</td><td>High</td></tr><tr><td>Slightly</td><td>High</td><td>Low</td><td>Low</td></tr><tr><td>Quite</td><td>High</td><td>High</td><td>High</td></tr><tr><td>Very</td><td>High</td><td>High</td><td>Low</td></tr></table>Aggressive: High LCR (more straight lines than curves)
BEAUTIFUL / UGLY: perceptions studied for vases (Perez Mata et al., 2013).	• Lines Curves Ratio (LCR) • Complexity Level (CPL) • Vertical Horizontal Aspect Ratio (VHR)	Beautiful: Low LCR (more curves than straight lines), low CPL (simple or low number of independent modules) and high VHAR (tall)
EXPENSIVE / CHEAP: perceptions studied for vases (Perez Mata et al., 2013).	• Lines Curves Ratio (LCR) • Complexity Level (CPL) • Vertical Horizontal Aspect Ratio (VHR)	Expensive: Low LCR (more curves than straight lines), low CPL (simple) and high VHAR (tall)
EXCITING / BORING: perceptions studied for vases (Perez Mata et al., 2013).	• Complexity Level (CPL) • Vertical Horizontal Aspect Ratio (VHR)	Exciting: Low CPL (simple) and high VHAR (tall)
ELEGANT / DULL: perceptions studied for vases (Perez Mata et al., 2013).	• Complexity Level (CPL) • Vertical Horizontal Aspect Ratio (VHR) • Low High Chroma ratio (LHCR) • Acute Obtuse Angle Ratio (AOR) • High Low Gravity Point Ratio (HLGPR) • Vertical Horizontal Aspect Ratio (VHR) • Brilliance Dull Ratio (BDR)	Elegant: Low CPL (simple), high VHAR (tall) and low LHCR (high chroma). Or low AOR (more obtuse angles than acute angles), a low HLGRP (low gravity point), a high VHR (vertical) and high BDR (brilliant vase) would be perceived as an elegant vase if all elements were present at the same time.
MASCULINE/FEMININE: perceptions studied for vases (Perez Mata et al., 2013).	• Lines Curves Ratio (LCR)	Masculine: High LCR (more straight lines than curves)
MATURE / YOUTHFUL: perceptions studied for vases (Perez Mata et al., 2013).	• Brilliance Dull Ratio (BDR)	Mature: Low BDR (more dull colours than brilliant ones)
ARTIFICIAL / ORGANIC: perceptions studied for vases (Perez Mata et al., 2013).	• Lines Curves Ratio (LCR)	Artificial: High LCR (more straight lines than curves)

PRECISION FACTOR: a combination of precision, control, exact, feedback, distinct, secure, plain, quality, ergonomic and stable. Used to investigate perceptions for rocker switches (Schütte and Eklund, 2005).	• Form ration (wide / narrow) • Surface (smooth / grooves / indentures / other)	Not found
CHEAP / STIFF FACTOR: a combination of cheap, stiff, tenacious and plastics. Used to investigate perceptions for rocker switches (Schütte and Eklund, 2005).	• Form ration (wide / narrow) • Surface (smooth / grooves / indentures / other)	Not found
ROBUSTNESS FACTOR: a combination of robust, lasting, stable, strong, genuine, secure and hard. Used to investigate perceptions for rocker switches (Schütte and Eklund, 2005).	• Form ration (wide / narrow) • Surface (smooth / grooves / indentures / other)	Not found
EMOTION FACTOR (E): a combination of soft, feminine, emotional and cute versus hard, masculine, rational and not cute. Used to investigate shared perceptions for cars, sofas and kettles (Hsiao and Chen, 2006).	• Curve lines, curve surfaces, sharp corners, corner type, straight lines and flat surfaces	E+ (soft, feminine, emotional, cute): Curve line, curve surface, organic overall form E- (hard, masculine, rational, not cute): Sharp corner, large arc corner type, straight line, flat surface, geometric overall form
POTENCY FACTOR (P): a combination of heavy and strong versus light and weak. Used to investigate shared perceptions for cars, sofas and kettles (Hsiao and Chen, 2006).	• Volume, number of elements	P+ (heavy, strong): Heavy volume, more element amount P- (light, weak): -
COMPLEXITY FACTOR (C): complexity versus simplicity. Used to investigate shared perceptions for cars, sofas and kettles (Hsiao and Chen, 2006).	• Number of elements	C+ (complex): - C- (simple): Less element amount

Three different principles were identified with varying level of detail. But few rules from the list are specific enough for designers to use which provides with areas or gaps for future research. Many factors, e.g. the cheap factor (which is a combination of cheap, stiff, tenacious and plastics) or other factors, are only described in a general level but they are difficult to take further when so many different terms are included in the definition. However, they could be investigated further.

5 CONCLUSION

There is a lack of overview of the different principles for aesthetics. The literature is scattered in different fields and it is difficult to find guidelines for designing and evaluating the aesthetics of products. This paper has presented an overview on the three different levels of design principles in the literature (from 46 papers reviewed): 1) general principles of how humans detect groups of elements; 2) design principles that generate emotional responses when applied to products and; 3) detailed principles linking perceptions and geometric elements that contain information on the actions a designer should take in order to improve the perception of their product in one direction or another.

The main contribution of the article is to have provided an overview of the state of the art and offer a list of principles that can be used as rules or guidelines for designers showing which elements to consider when generating the aesthetics of products. Those principles can form the foundation for the

building blocks for researchers to expand towards building generative design tools (e.g. spatial grammars) or tools for the evaluation of designs (e.g. using fuzzy logics). The principles can be used as rules to: evaluate existing designs; as guidelines for the generation of new designs and; they can additionally be used as the foundation for shape grammar rules.

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