CAN SYNESTHETIC PERCEPTION HELP TO DEFINE ATTRACTIVE PRODUCT DESIGN?

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Abstract:

The configuration of products and living environments is a highly creative process within which perception plays a major role. Thus the question arises of how individual phenomena of perception can be included in concepts and processes of design. Individual types of synaesthesia cause unique phenomena. The designing of products, buildings and environments, however, requires approaches which are intuitively understood by a broad community. Usually, the designing of industrial products requires various steps, in which numerous designers and engineers are involved. Therefore, including idiosyncratic inputs like fixed forms or colours, as caused by synaesthetic perception, is a challenge. This needs broad acceptance by development teams.

Perception is a multi-sensory phenomenon. Thus the results of design processes focused on single senses are limited compared to a multi-sensory or a cross-sensory approach. A variety of applications illustrates the benefits of multi-sensory design. The appearance of materials is perceived by various senses. Even when a surface is viewed but not touched, its visual appearance evokes expectations of the material’s nature, the haptic experience, its touch sound and smell. Thus, by means of memorized data, the stimulation of a single sense causes a multi-sensory experience. In these cases, genuine synaesthesia is capable of enriching sensory experience. In the usual cases of multi-sensory stimulation, specific synaesthetic phenomena can also enrich perception but show a potential to disturb perceptual integration.

Meaningful sounds which include cross-sensory implications help to make technical functions plausible to the user. As an example, the behaviour of visual objects on a screen can be expressed auditorily.

Spatial perception is also an important topic in designing products and environments. Cross-sensory interactions take place between spatial configurations of landscape, touchscape, soundscape, and even emotionscape. Genuine synaesthesia provides additional sets of sensations. Although these phenomena cannot easily be included in design processes that are valid for a large population of customers, they are appropriate for use as an extended creativity pool. Artists, designers and engineers need to enhance their creativity and conceptual thinking permanently by means of individual perception. Daily-life experience generates an ever growing pool of sensory cross-linking. In the case of genuine synaesthesia, even more, and rather, extraordinary data add to this cluster. This promotes modification and new combinations of perceptual contents, thus forming the basis of creativity. Conceptual thinking can further sensitize perception, thus enhancing the creativity pool. Perceptual training and education are therefore essential parts of recent product development, to which synaesthesia contributes.

Keywords: Synaesthesia, Design, Auditory Perception, Haptics

1. INTRODUCTION

The interior of a vehicle is a truly multi-sensory environment (Fig. 1). Alongside looking at the exterior situation, the driver has to observe a variety of visual control elements and signal lamps to ensure correct (and safe) vehicle operation. Haptic feedback regarding operational elements like the steering wheel, gear stick and pedals is indispensable. Control operations carried out by the driver are also reflected by proprioceptive data. The seats provide continuous stimuli, too. In addition to
vision, the state of movement of the vehicle is perceived via body perception and the sense of balance. Furthermore, audibility plays an essential role in the interpretation of warning signals, engine control and numerous processes, like those of windscreen wipers, window openers, brakes and many more. The sound that is audible during haptic operations is an additional element contributing to the perception of touched surfaces. All these stimuli contribute to the continuous flow of emotions which accompanies driving. Furthermore, smell is important for wellbeing and comfort.

Within the development process, the attributes of the various senses are usually addressed by separate requirements. With a view to the current high expectations of drivability and quality, however, the question arises of how an optimum alignment of sensory inputs can be achieved. It has become clear that perception is always a multi-sensory process. In contrast, separation of the senses is a result of intentional focusing. Nevertheless, it has been widely used for the experimental setups of psychological investigations, which is in fact a very artificial condition.

During the last two decades, research on synaesthesia has provided important impulses for the search for cross-sensory relationships. The arising public interest in synaesthetic phenomena has led to increased interest in the connections between the senses as experienced during everyday life. It thus needs to be discussed to what extent specific phenomena of perception can stimulate the development of things which gain intuitive plausibility for a broad spectrum of users. Designing objects always means designing multi-sensory perceptual phenomena for the user/customer. Design thus has to take into account the cross-sensory integration of the perceptual system. Research dedicated to the application of cross-modal connections for design was first published in the field of communication design (Anceschi 2000, Rico 2008, 2009). A taxonomy of phenomena which point to various processes of cross-modal connections has been provided by the author (Haverkamp 2006, 2013). Alongside the specific phenomena of genuine synaesthesia, cross-sensory analogies, iconic references and symbolic/semantic connections play an important role.

Multi-sensory design provides benefits not only for the products themselves but also for marketing activities. If senses other than vision are additionally involved, the emotional involvement of the potential customer is intensified. Audio branding adds sound logos and jingles to the visual symbols of companies and products (Bronner 2009). Furthermore, haptics, smell and taste play an important role (Kilian 2015).

An important aspect of multi-sensory design is the spatial distribution of stimuli and the corresponding spatial perception. A complex environment like a vehicle interior is perceived as equivalent to a landscape, with some elements (the landmarks) protruding from a more diffuse sum of merged elements (the background). With a view to the multi-sensory appearance of products, the visual landscape needs to be aligned with the distribution of sound sources, the soundscape. Furthermore, the spatial distribution of elements which are frequently touched forms a haptic landscape which can be described as a three-dimensional touchscape. It is essential to configure these contributions of the various senses with a view to cross-sensory integration of the perceptual system.

It must be clear that optimum design cannot be achieved by separation of the sensory inputs and pure optimization of elements related to single modalities. In the field of industrial design and the engineering of useful objects, however, the high level of division of work leads to a splitting of tasks into various departments. Thus, traditionally, visual, auditory, tactile and olfactory optimization is done by different organizations. Multi-sensory optimization of industrial products is thus also an organizational challenge.

2. SYNÆSTHESIA OR MULTI-SENSORY PERCEPTION?

It is understood that artists can help to illustrate synaesthetic experience to a broad public. “Where scientists ‘tell’ what synesthesia is, artists ‘show’ what synesthesia is” (van Campen, 2013, P.644). The artistic process, however, includes inevitable transformations of the perceptual content towards the media used for communication. Limitations are set by the material, colorants and tools. As an example, a drawing on canvas cannot easily show objects developing in time. This can only be done by clues which guide the eyes – like those used by painters of synchrony (see e.g. Stanton Macdonald-Wright’s Conception Synchrony, 1914; Brougher 2015). Sculptures are three-dimensional configurations but most often in a static manner. Interestingly, sculpture is quite seldom used by synaesthetes to express their specific experiences. Contrarily, animated videos can show development in time but face other restrictions, like a limited
Alongside these technical limitations, it is always a challenge to precisely reproduce subjective images. Anyone can prove this thesis by trying to exactly transfer a clear dream image to a medium of one's own choosing. Furthermore, it is not always easy to consequently exclude associative elements and semantic content from an artistic work. Synaesthetic art is never a pure copy but a complex transformation of mental imagination and perception. Synaesthetic phenomena can be quite complex. They are not always characterized by secondary sensations of single modalities like visual or auditory or olfactory content.

Synaesthesia often refers to real multi-sensory perception and design. As an example, visual-synaesthetic images with forms and colours can additionally show a texture which points to haptic features (Steen 2013, p.689).

Numerous recent publications outline the variety of genuine synaesthetic phenomena (see e.g. Cytowic 2002, Day 2005, Simner 2013). However, similar phenomena were described during the early days of synaesthesia research. This fact is consistent with the assumption that a characteristic feature of synaesthesia is its clear independency on exterior (e.g. environmental) factors. Examples are herein taken from descriptions collected during the 1930s, when coloured depictions of visual phenomena were published for the first time. An early typography of visual-synaesthetic phenomena is reprinted within Figure 2. Between 1925 and 1936, the psychologist Georg Anschütz initiated various activities in synaesthetic research at Hamburg University. These efforts resulted in four congresses in Farbe-Ton-Forschung (Colour-Tone Research) in the years 1927, 1930, 1933 and 1936. Numerous documents in this regard may be found in three volumes with the title Farbe-Ton-Forschungen 1-3 and in numerous additional publications (Anschütz 1927, 1931, 1936).

For the first time, these publications served as a comprehensive compilation of colour visualizations of synaesthetic phenomena. Furthermore, exhibitions accompanying the first congress encompassed approximately 2,000 images and documents – this scope was even exceeded by the second congress (Anschütz 1931, p.407). The congresses showed a close connection between multi-media arts and design. Concepts of dynamic visualization of music were presented, including colour light music (Farblichtmusik) by Alexander László and Ludwig Hirschfeld-Mack, kinetism by Zdeněk Pešánek and abstract film by Oskar Fischinger. These artistic contributions have been discussed with a view to their relevance for individual perception.

As early as the beginning of the 1930s, colour-tone research had already achieved a scientific level which was not exceeded until new methods of brain research were employed towards the end of the 20th century. The publications authored by Anschütz contain very detailed descriptions and analyses of visual synaesthetic phenomena, including precise information pertaining to the acoustic recording used in the experiments and an exact reference to the number of musical measures. Whereas research on synaesthesia has claimed new
One of the main characteristics of synaesthesia is that related phenomena do not depend on cultural and/or historical circumstances. Nevertheless, the figure must be understood as an historical document. This typology by Anschütz predominantly includes visual phenomena triggered by sound, music and pain. Abstract forms are depicted but representational drawings based on iconic references are presented as well: a bell sound seen as bells of different colours, and a landscape. Esoteric observations of the “aura” are included with a view to discussions around esoteric phenomena as types of visual-to-visual synaesthesia.

From a scientific point of view, the discussion of esoteric perceptual phenomena still appears to be tolerable if phenomenology is separated from transcendent interpretations of any kind. Colour-graphemic phenomena were not shown within Figure 2 but had already been discussed within other papers of that time. This includes coloured perceptions of Braille letters as reported by blind persons (Voss 1936).

The frequent occurrence of non-representational simple forms points to the fact that perception is fundamentally based on the neuronal assembly of elementary forms building up holistic models of the human environment. These phenomena are thus of huge importance for configuring basic product components towards complex but somehow plausible products (see below).

Although the types of genuine synaesthesia depicted are strictly individual, some results regarding multi-sensory design can be taken out of the typology:

- Simple, basic forms play a major role. Therefore, a multi-sensory design should be based on simple elements in all modalities and on combinations of these “atoms” of perception.
- In the visual modality, combinations of colours and forms are of specific interest. This fact is underlined by the high occurrence of colour-graphemic phenomena (Day 2005).
- Visual phenomena as induced by auditory stimuli often show movement, as even early reports show (Anschütz 1927). Thus, movement is an important parameter with multi-sensory relevance.

3. MULTI-SENSORY VERSUS CROSS-SENSORY DESIGN

The driving of vehicles is a truly multi-sensory experience. Design and engineering thus need to take the various senses into consideration. A plausible design is based on optimization of sensory qualities within and across the modalities. The classical approach to fulfilling this task is to address all the senses individually. Such a multi-sensory approach is illustrated by the upper part of Figure 3.

Visual, auditory, tactile/haptic and olfactory features are increasingly understood to be essential.
for the perceived quality and marketing/branding of still addressed by different departments: designers focus on visual appearance and aesthetics, NVH engineers (Noise, Vibration & Harshness) work on optimization of sound quality, the haptic element is a topic of ergonomics and usability engineering, and smell is tested by means of dedicated material labs. Therefore a typical question for customer studies will focus on the optimum design and material quality within the visual or auditory or tactile or olfactory modality. There is no doubt that this approach can lead to optimized product appearance for the different senses. However, it does not deliver any information about how the senses will interact, and whether or not the sensory features of the product will match. As an example, based on assumptions of driver comfort a soft layer on a steering wheel may be considered preferable. In parallel, however, the designers could define an interior concept that requires clear lines with rigid-looking surfaces.

Additionally, the demands of long-term durability may require a surface treatment which leads to a specific wish to include touch sound, which might be nice but might also remind one of sand paper. Smell, finally, can foil a high class leather appearance with inappropriate ingredients. Overall, it becomes clear that isolated optimization of the features of each modality bears the risk of cross-sensory misalignment and perceptual conflicts which highly degrade perceived product quality.

Therefore, maximum refinement of perceived attributes can only be achieved by means of cross-sensory harmonization, as indicated in the lower part of Figure 3. In addition to multi-sensory products. Usually, however, different senses are optimization, this approach addresses relationships between the senses. Correlating parameters are taken into account as well as congruence with intended brand features. The cross-modal perception of product quality can thus be addressed systematically.

Multi-sensory studies and customer clinics shall be based on various steps to intentionally include and/or exclude specific senses. All relevant modalities must be active during a true multi-sensory assessment. Eye masks, masking sounds, video streams and sound recordings are some of the tools used for intentional exclusion of specific senses. Within surveys, even questions which point to specific senses will include cross-sensory references. As an example, a specific instruction can be: do not assess the quality of the stimulus (sound, touch, feel) but assess the quality of the material (that can be heard, felt etc.) which is communicated via the stimulus.

In general, cross-sensory optimization must be based on all types of intuitive features which enable connections between the senses, like cross-sensory analogies/correspondences, iconic features and symbolism (Haverkamp 2013). Recently, iconic references have become a fundamental part of design, advertisements and brand images. They are thus also reflected by fine arts and music. Figure 4 provides some examples of remarkable iconic references to the urban environment as elements of visual appearance. These references are likewise important for the other senses: a musical theme or characteristic sound heard before, a smell that reminds one of a nice taste or an atmosphere rich in memories.

![Figure 4. Iconic elements of design: urban environments.](image)
4. THE MULTI-SENSORY APPEARANCE OF SURFACES

For each person, the overall perception of a surface is determined by different senses (Fig. 5). The primary sensations include the visual, auditory and tactile modalities. Haptic activity also leads to perceptions of subjective surface temperatures. Smell is also an important comfort factor and helps to identify the original nature of the material. Taste is not only important for foodstuffs but has to be taken into account with a view to the perceptual interaction of materials used for packaging and storage, alongside foodstuffs. As an example, a cup holder must be equipped with an appealing material which supports enjoyment and does not spoil the appetite. Even when certain sensory stimuli are absent during observation of a surface, the available information is involuntarily completed from the memory. When a surface is not touched with the hands, the possible touch feel is predicted from data which are compiled during past experiences.

In addition to the sensations which are generally prevalent, phenomena of genuine synaesthesia add on to or overlay these phenomena. Thus, secondary sensations specifically enrich perception in a highly individual manner.

A holistic problem persists due to the fact that cross-sensory ratings are not a simple sum of single-sensory ratings. Multi-sensory perception cannot be estimated from single sense sensations. With contradictory data transferred via different sensory channels, perceptual conflicts can occur. These phenomena may lead to confusion, displeasing feelings and negative product assessment by the customer. On one hand, studies on the perceived quality of products need evaluations within the visual, auditory, tactile and olfactory modalities. These single-sense evaluations, however, need to be supported by an additional cross-sensory assessment. In this case, the fit between the sensations of the two modalities is investigated. As an example, if a surface is touched, a question could be: “does it sound what it feels like?” Usually, haptic exploration of objects is a spatial activity. A three-dimensional structure is scanned with dedicated movements of limbs and hands. Additionally, touch sounds form a soundscape which correlates with visual and tactile perceptions. The spatial arrangement of multi-sensory stimuli is the quintessence of design.

5. MULTI-SENSORY SOUND DESIGN

When product surfaces are touched the perceived quality is also influenced by the noise which is thereby generated. In general, there is also an interaction between visual, auditory and tactile perceptions (Altinsoy 2006). Touch sounds are very important for all surfaces that are frequently touched. Sliding a steering wheel through the hands can be quite loud. High loudness degrades the perceived quality of materials. Furthermore, optimization of touch sounds must take into consideration the associations which thereby arise with regard to possible iconic connections. Thus, a smacking sound can increase the tactile sensation of stickiness. As another example, the surface of a switch can sound something like paper, cork or polystyrene. Material-related sounds thus also include perceptions of quality which are intuitively associated with these materials. The process of optimizing perceived quality therefore logically proceeds by defining a reference material which is assessed as being of correspondingly high quality. The material which is really used for production must reproduce the properties of the reference material via its touch sounds.
perception of shapes of sound is not limited to people who experience genuine synaesthetic phenomena. Alongside colours, audio-visual synaesthesia is often characterized by two- or three-dimensional forms. However, most people are able to intuitively map auditory structures to other modalities. Thus, the shape of sound appears to be more than an intelligent metaphor. It is experienced by synaesthetes (Layden 2010). Moreover, there are common ways to establish plausible connections by means of analogies (correspondences). Thus both perceptual experiments and reports of synesthetic phenomena show that elementary forms play an important role in the configuration of cross-modal connections.

6. SYNESTHESIA, CREATIVITY AND PRODUCT VALIDATION

Synaesthetic design means systematic configuration of objects. This includes all methods of achieving cross-sensory connections within the perceptual system, including individual phenomena found in genuine synaesthesia. In all fields, synaesthetic design requires interactive stimulation of concept thinking, creativity and sensitized perception. This fundamental context is demonstrated by Figure 7.

![Figure 7. Essential elements for refining multi-sensory optimization and design.](image)

Perception is the initial driver of all human activities. Perceptual data are integrated and thus form models of the objects perceived. The content of perception is herein described as perceptual objects, which are essentially models of the presumed reality. Perception drives creativity, while the brain tends to find new combinations of data and modifications of content. Creativity itself delivers elements of new physical objects which can be configured. First approaches are then mentally reflected by concept thinking in order to integrate the newly created things into a broader context. This again triggers perception, while the interaction between perception and concept thinking is fed back into the next iteration of the creative process. In the early development of industrial design, the combination of perception and systematic approaches was outlined by Johannes Itten (see Düchting 1996 p.34). He based his Bauhaus lectures on the connection between “intuition and method”, as well as on the “competence of subjective experience and objective recognition” (Düchting 1996). With a view to the fact that perception drives creativity, and with respect to the interaction of instantaneous and memorized flows of data, synaesthetic experience plays a specific role in design and the arts. Additional perceptual content is generated via secondary perception phenomena. Thus, the data flow approaching from sense organs and the memory is specifically enriched. This leads to an interference between individual perception content and common data, which are presumed to be experienced in a (somewhat) similar way by a broad community. While engineering mainly orients itself towards the technical requirements of a user/customer of products, creativity is still seen to carry more individual content. The specific phenomena of synaesthesia provide an excellent pool of material which can be used to provide practical solutions for design tasks. If analysed systematically, this enhanced pool also drives the establishment of advanced concepts with new, exciting content. Synesthetic experience, however, needs to be seen as an additional option for creative approaches. In the design process, it cannot be directly applied as the final outcome of development. At the least, the product’s appearance has to be tested with non-synaesthetes in order to be sure that product features are plausible and sensible for a broad community.

Product validation with appropriate customer groups is an important step in design and development. It cannot be omitted in any case. Moreover, the multi-sensory configuration of products requires us to overcome the separation between engineering approaches, which are responsible for functionality, and design, as aspects of pure aesthetics. In the future, design departments should not be solely responsible for the sensual aspects of a product but instead all areas should cooperate closely.

The phenomenology of synaesthesia points to the fact that perception is a highly integrative process. Many synaesthetes are both artists and musicians. Thus, the separation of the arts and music must be rethought. Even the supposed discrepancy between the arts and natural sciences has been proven inadequate by numerous subjects. The holistic nature of brain processes demands reflection by equivalent structures in product development groups, engineering teams, companies, art projects, universities and, last but not least, the whole of society.

Indeed, designing should also be understood as a holistic task involving perception with all senses, in all areas of application. All functions participating in product development are to be equally responsible, regardless of whether it is the engineering area as the definition and implementation of the product properties, construction, visual contouring, materials, sound design, marketing or others. The cooperation of particularly different areas, however, is a challenge. Different occupational processes and thinking styles can lead to misunderstandings and uncertainties regarding the contents of the configuration task. Experience in film production can
be quite helpful, for this generally involves an extremely distinct division of labour. Dedicated design management is needed to ensure a common basis of communication for product development.

7. CONCLUSION

Synesthetic experience is not inevitable for creative approaches to design. Genuine synaesthesia, however, helps to enhance creativity and to find innovative, exciting solutions. With a view to the fact that an appealing design is configured on the basis of simple, clear elements, it is remarkable that simple forms are characteristic elements of synaesthetic phenomena. In the context of synesthetic perception and the arts, Klüverian form constants are often considered to provide a set of relevant visual elements (Steen 2013, referring to Klüver 1926). Basic forms of visual perception as redundant elements in hallucinations and visual imagery have also been discussed before (Horowitz 1970).

A study of basic forms of perception was done by Josef Eichmeier and Oskar Höfer (Eichmeier 1974). They examined the visual perception of numerous persons during electrical or magnetic stimulation of the optic nerve. Here, phosphene structures were stimulated which were then allocated to a catalogue of endogenous image patterns. As already indicated, the forms observed during acoustically stimulated visual synaesthesia provide information on the basic elements important to an elementary connection between auditory and visual perception. Generally speaking, every visual, auditory and tactual structure can be composed of elementary basic forms. For clarification, Figure 8 compares the design of a headlamp with a selection of endogenous image patterns – these are typical phosphene structures. It is advisable to base a consequently synaesthetic design on elementary basic forms. The success of such an approach is based on clear visibility, plausibility of function, ergonomics and aesthetic appearance (Fig. 9).

In addition to the already well-researched visual basic forms, the equivalent auditory and tactual basic forms need to be determined. Perceptual experiments need to accompany the design process. They are essential for clarifying the forms by virtue of which allocations of data between the senses can occur. Tracing the product gestalt back to simple basic forms, however, does not necessarily mean a dogmatic fixation with respect to modern concepts. Moreover, associative and symbolic aspects can be purposefully superimposed. Ultimately, every appealing configuration can be attributed to simple components (Fig. 9). Elementary forms, as the determining building blocks of multi-sensory configuration, must be constantly considered in order to optimally utilize fundamental connections between the sensory areas. It is still a challenge to base design approaches directly on specific phenomena of synaesthesia. A careful validation of these approaches is indispensable with respect to a broad community of customers. However, across-the-board, synaesthesia shows a high potential for enhancing creativity. Furthermore, the holism of connections between the senses can serve as a model of a dedicated, holistic and cross-sensory design process.
**Figure 9.** Product design as a sense-full combination of simple forms.
Fan by Dyson (top left), coffee machine (top mid), all other images by Ford Motor Company.
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