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Basic Interaction Design for Sonic Artefacts in Everyday Contexts

Keywords ↦ basic design ↦ methods ↦ sonic artefacts ↦ embodiment ↦ situated interaction

Basic interaction design can be defined as the analysis and creation of interactive experiences based on relational properties of an artefact. These properties describe how qualities of an interactive object, such as its behaviour, shape, sound or texture relate to human action in the broadest sense. This paper argues for the combination of basic design with contextualized methods, in order to ground the design process in everyday life while maintaining the experimental design approach.

The case study presented investigates the integration of basic interaction design methods within an interdisciplinary project dealing with interactive sound embedded in physical objects. A design process resulting in a number of abstract artefacts that are highly responsive to physical manipulation by the means of sound is described. Their creation is directed toward two aims: that of revealing new potential of interactive sonic artefacts, and that of creating prototypes which can be used in the psychological testing to investigate relationship between human movement and interactive sonic feedback.

1. Basic Interaction Design

1.1 Basic Design

"If the same methodology was used generally in all fields we would have the key to our age seeing everything in relationship."
[Moholy-Nagy, 1969. p.96]

Basic design is a predominantly visual design approach to research and education that investigates the foundations of the design disciplines. It originates in the kindergarten movement of the early last century and was firstly taught as design practice at Bauhaus School of Art and Architecture and at the Vhutemas School in Moscow. The basic investigations were grounded in the analysis of visual experience in terms of simple, abstract properties, such as forms, patterns, or colours. The aim was to uncover a universal visual language, independent from such cultural limitations as are present in alphabetical writing.

In order to achieve this goal, various members of the Bauhaus School explored formal abstraction in relation to human perception. In these experiments, researchers were not interested in individual preferences, but in intuitive, biological responses and in the most frequently occurring perceptual relations between abstract properties: graphics, colour, texture and so on. For example, in Kandinsky's "psychological test" in 1923 [Fig. 1 ↦**105**], he asked participants to fill in elementary shapes with the basic colours, in order to identify a perceptual link between the two [Droste, 1998].

In addition to analyzing human perception, Bauhaus members worked on manipulation of basic elements to create new design ideas. Although originally their focus had been on visual and formal aspects of artefacts, it was transposed to the sculptural domain, to include tactile properties and movement. Even in the study of visual elements, importance was given to dynamic temporal properties of creation: "line is a the track made by the moving point: that is, its product. It is created by movement..." [Kandinsky, 1979. p.71].

Moving away from visual elements, Moholy-Nagy regarded phenomenological experience as a result of the interplay between various senses in which light, time or texture become as important as the visual stimuli. Figure 2 shows the results of an exercise in his basic course at the Bauhaus school. Moholy-Nagy's tactile charts and structures explored sensations of pressure, temperature and vibration and brought multisensory complexity into basic design [Moholy-Nagy, 1969] [Fig. 2 ↦**105**].

Such use of dynamic and complex design elements provide motivation for applying the method to the design of interactive objects. In addition, methods such as reduction and abstraction, translation and morphological analysis make basic design particularly suitable for research of new topics such as that of digitally augmented interaction. However, relations between design elements are more complex where interactive artefacts are concerned than in the case of purely visual design.

1.2 Basic Interaction Design

Interaction design originates in human-computer interaction and encompasses a wide range of practices from screen-based interfaces to products and service design. Its research and methods are informed by disciplines of computer science and engineering, psychology, ethnography, social and cultural studies and theatre. However, basic design methods have been scarcely explored in this young field.

Dag Svanaes used basic design to inform his experiments using simple screen-mouse interactions with abstract graphical elements [Svanaes, 1999]. He showed that users focus on the behaviour of the objects rather than on their formal characteristics. For example, a square on the screen was interpreted as a switch due to its response to the user's input. He concluded that: "the interactive experience has gestalt properties[1], i. e. that its first-class objects are *interaction gestalts...* you perceive the interactive behaviour not as a collection of action/reaction pairs, but as a meaningful interactive whole."
[Svanaes, 1999, p.218]

However, such gestalts emerge from the interplay of the elements that compose an interactive experience. By analyzing the latter, one learns to understand the ways in which certain qualities of an object might affect others; for example, the case of the influence of colour on the perceived size or shape. As Kandinsky put it: "The artist must not forget ... that each one of his materials conceals within itself the way in which it should be used, and it is this application that the artist must discover." [Kandinsky, 1994, p. 154]

In this context, *Basic Interaction Design* can be described as a practice and theory focused on analyzing and designing the relationships between sonic, formal, haptic and behavioural qualities of interactive artefacts. It studies the interplay of these qualities, rather than an understanding of these as separate elements. Such understanding may facilitate the creation of new design concepts by engaging designers in structured explorations of interactivity.

2. Abstract Sonic Artefacts: A Case Study

The case study presented here is an initial attempt to bring the issues of basic design into the field of interaction design. Its subject is the design process for creation of abstract interactive artefacts with embedded computing and sound [Fig. 3 ↦**106**]. These objects afford simple manual interactions, such as squeezing, pushing or twisting, coupled to continuous sonic feedback. The goal is to create abstract artefacts that can be used in psychological studies that have been designed to investigate the relationship between human action and interactive sonic feedback. These tests are being defined together with auditory psychology researchers as a part of an interdisciplinary research project called CLOSED [Susini et al, 2006–2009] that is aimed at creating new sound design tools based on the human evaluation of performance and aesthetics.

2.1 Field Research in the Kitchen

Although most of the traditional basic design exercises use predefined geometrical shapes and colours, the earlier works preceding Bauhaus show the analysis and reduction from real world objects to define an abstract element [Ramsauer, 1821]. Similarly, CLOSED project

began with a study into everyday interactions to define our design material grounded in real experiences, rather than designing with the predefined taxonomies of sounds [Gaver, 1993] and actions [Robertson, 1997].

The domestic kitchen was selected as a rich context, because it is filled with artefacts allowing for physical manipulation [Fig. 4 ↦**107**]. The tools that were included range from manual tools, such as knives or spoons, to mechanical tools with moving parts, such as garlic squeezers, and finally to the vast array of electromechanical kitchen appliances, such as toasters and blenders. In the first two groups the manual operation responsible for generating sound is more transparent, as the action and its effect are directly linked. Such activities were the focus of the field research, which excluded chemical and electromechanical processes, as they did not involve performative user engagement.

Fieldwork began with audiovisual documentation of a number of common kitchen activities. The recordings were acquired with a single video camera and microphone placed near the interaction locus, to capture sonic details. Forty-eight individual audiovisual sequences of kitchen processes were acquired, with recordings ranging in length from approximately twenty seconds to a few minutes.

2.2 Action-Sound Analysis: Abstracting from Everyday Experiences

The analysis of documented activities began with the decomposition of kitchen tasks, such as making coffee, into smaller actions combined with the formal description of sounds created. Sound descriptions were based on common methods from psychoacoustics, from music, and from ecological everyday sound categorization [Fig. 5 ↦**108**]. This approach is similar to traditional task analysis [Diapper, 2003] which tends to consider user experience as composed of steps in a process, and which is performed from the viewpoint of an idealized detached observer. However, in CLOSED project, designers themselves experienced the phenomena they were studying, in order to avoid the usual difficulties of ascribing significance to interactive phenomena purely through observation [Mulder, 1985].

Hypotheses were formulated as to the significance of specific sounds for performance in the relevant situation. Key points about the relevance of sonic feedback included the cases in which sound can affect performance, can help focus attention to the action, can affect intentionality and that its loudness is in relation to action energy (AE) and action duration (AD).

For example, in the analysis of making coffee with a stovetop espresso machine (cafetiera), the following actions necessary to accomplish pouring were identified: grasping, squeezing, elevating, displacing and tilting [Fig. 6 ↦**109**]. Several of these, and related sounds, happened concurrently. One had to maintain pressure on the pitcher's handle in order to perform any of the subsequent actions. While squeezing produced little to no sound, tilting the pitcher to fill the cafetiera generated a dominant sonic contribution, that of pouring liquid. The sound of the water impacting the vessel that is being filled and the resonant excitation of the metallic volume of cafetiera informed about the level of the liquid poured.

From the analyses, elementary actions were identified as those that appeared repeatedly in the studied examples and to which no specific meaning could be assigned when isolated from each other and from the context. Together these comprised approximately thirty actions, grouped into two categories. Those that cannot be decomposed into smaller actions that would still be perceived by the performer as actions were referred to as *basic action primitives*. These included directional movement and pressure (push, hit, slide), embracing pressure (squeeze, grasp), displacing while holding (elevate, put down, remove) and rotation (tilt, turn, spin). *Composed actions primitives*, on the other hand, were taken to be those in which two or more basic action primitives occur together simultaneously. For example, pulling is composed of squeezing and moving in a certain direction, and picking something up is composed of embracing, maintaining constant pressure, so the object doesn't fall, while generating a displacement.

The development of taxonomy of such design elements, even constrained to the domestic kitchen contexts considered in this work,

would exceed the scope of this research. However, we believe that such taxonomy would be a valuable, if challenging and complex, contribution toward establishing an approach to the design of interactive artefacts along the lines described here. Within the scope of this study, the action and sound examples that were gathered proved useful as source material generating ideas for abstracted sound artefacts. The full documentation and studies can be found in a dedicated wiki website [Franinovic, Hug, 2007].

2.3 Conceptualizing Experimental Artefacts

A series of concepts was created, consisting of abstract objects that afford simple action to which continuous sonic feedback [Fig. 7 ↦**109**]. The aim of this series was to enable further study of the simple relations between sound and action, as they are experienced in manipulation of objects. A number of constraints related to the experimental measurement and interpretation of human action with the prototypes were taken into account.

The generation of concepts began with exercises focused on remixing sonic and interactive features extracted from context research. One method that can be readily applied in such situations is that of the design matrix [Paulos et al, 2005], [Wood, 2000], [Zwicky, 1967]. It allows the designer to decompose otherwise seemingly non-reducibly complex design problems by organizing the multi-dimensional qualities (sonic, formal, interactive) along several axes. The resulting space is then sampled at individual points, and the resulting set of properties is used to generate a design case.

A two-dimensional matrix was developed to create a space for new concepts defined by one axis corresponding to action primitives identified in the field study and another corresponding to everyday sound processes. The problems of sound and action descriptors arose, as sound can often be described in terms of action: the sound of walking, of cutting, typing, and so forth. However, having previously conducted the analytic exploration it was easier to associate names to actual experiences. The complete set of ideas for abstract objects that afford one simple action to which continuous everyday sonic feedback is available at a dedicated wiki website [Franinovic, Visell 2007].

2.4 Abstract Sonic Artefacts

Several of the concepts have been developed into working prototypes by combining elements of sound, form, human action, object behaviour and, in several cases, light. The physical shape was designed to provide a suggestion for type of action that could be performed. It was modelled using 3D design software (Rhinoceros3D) and produced through 3D printing. The relationships between sound, light and gesture that are enabled through the manipulation of the form were designed within a real time data processing environment (Cycling 74 Max/MSP). The artefacts interacted by means of everyday sounds generated through models of everyday physical events such as the pouring of liquid and the rolling of a ball.

An example is *Twister,* an object that affords a continuous twisting motion, tightening over the course of several turns [Fig. 8 ↦**110**]. The physical tightening of the top is measured through a mechanism within the artefact. The increase in tightness is expressed through sound as a resonant squeaking, whose pitch increases and density of squeak-events decreases as the tightness grows. Twister was inspired by the analysis of coffee making with a cafetiera, and combines the action primitive of twisting and the sound of friction that were abstracted from that everyday experience. Similarly, *Crushhh* [Fig. 8 ↦**110**] is based on the action and sound elements studied in the analysis of crushing the plastic water bottles. It represents an object that must be regularly compressed, via a force applied to its top surface while the object rests against a solid (table or similar). The accompanying sound is generated by a physical sound synthesis model of the crushing of a can or the compression of a granular medium, such as gravel [Fontana, 2005. Visell, 2007].

The production of the artefacts created in this study raise a number of issues that are somewhat beyond the scope of this paper, ranging from industrial design considerations (processes), to electronic sensing (sensor selection, integration, signal conditioning and acquisition), actuation (mechanical design, actuator selection, signal transmission), and real-time software integration (control and sound synthesis models, task implementation, hardware interfacing).

More importantly, because these abstract sonic artefacts were created for the experiments, their design depended upon the specifications needed for the latter. The designers associated each prototype to a task that could be used to evaluate the relationship between action and interactive sound and the ways in which it affects functionality and preference. For Twister the task was to tighten the object and for Crushhh to compress the object vertically without breaking it (sonically). In short, these objects enable certain kinds of actions, data collection and evaluations, and therefore shape the way in which experiments will be conducted.

2.5 Next Steps: Experimental and Contextual Evaluation

The subsequent steps of this research are aimed at the evaluation of the designed objects with respect to their performative, aesthetic and social qualities. In addition to the experiments that have guided the creation of these artefacts, the reintroduction of the sonic objects to the domestic contexts of users is planned in order to further explore the phenomenological and social interactions. The results will be fed back into the design process, resulting in further iterations of abstract sonic artefacts and the case study showing the application of the generated knowledge in an everyday product.

3. Conclusion

Recently, various authors have stressed the importance of basic design as central to the discipline of design [Findeli, 2001] [Anceschi, 2006]. Since its origins, basic design has been an analytic and a creative process as well as an educational discipline. Combining of the educational practice with the theoretical and methodological foundations of design enables the pursuit of research though design. These foundations are particularly important when a new design discipline emerges, as is the case of interaction design today.

In the case study presented in this paper, basic design methods were adapted to interaction design research, allowing the study and experimentation with elements that contribute to an interactive experience with an artefact. However, the pitfall of the basic design is that it fails to account for interactions of the designed object within

different contexts of use and might direct designers towards formal explorations rather than products based on the human needs. To investigate this issue, the next step of CLOSED project is to apply the basic methodology to design for an everyday setting rather than a laboratory.

Context research is needed in the development of real products, because experience is shaped both by perception of formal elements as well as by meanings emerging from users' cultural background and the context of use. For example, some centuries ago, it would not have been possible to associate Svanaes's square behaviour described above to the notion of a switch, as electricity did not exist. Such interpretations of perceived elements provide motivation for introducing contextual design methods in basic design practices.

On the other hand, interaction designers often rely on ethnographic data as an objective input to design. In this approach, contexts of application and potential users are seen as the source of design problem. If as Paul Dourish argues, the goal of the context research is to explain real world experiences rather than provide implications for design [Dourish, 2006], additional creative methods are required to complement the design process. How, then, as designers can we integrate the creative components of our practice with embedded, reflective, analytic, and context-immersed research practices? Can basic design methods enhance ethnographic approaches with a more formal, structured and exploratory practice?

In real experiences with everyday objects, complex relations between the artefact, action and sound coexist, and link with myriad issues of context of use. The aim of this paper has been to provide a method for working from these complex interconnections through basic design approach while grounding them in the context. However, this is an initial step and there is a need for more knowledge about how to integrate basic design with contextual issues, such as those linked to users, environments, or activities that are seen as key elements of contextualized design practices.

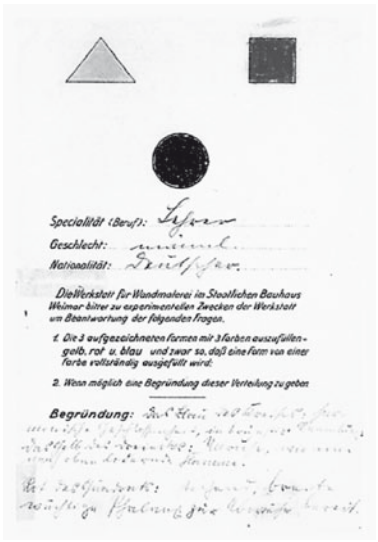

Fig. 1: Kandinsky's test. (Droste 1998)↦**96**

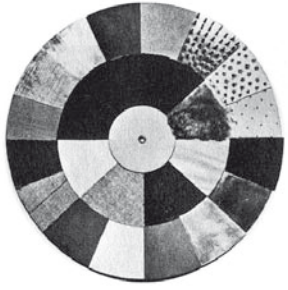

Fig. 2: Revolving tactile chart. Walter Kaminsky for Moholy-Nagy's Basic design course. 1927. [Moholy-Nagy, 1969]↦**97**

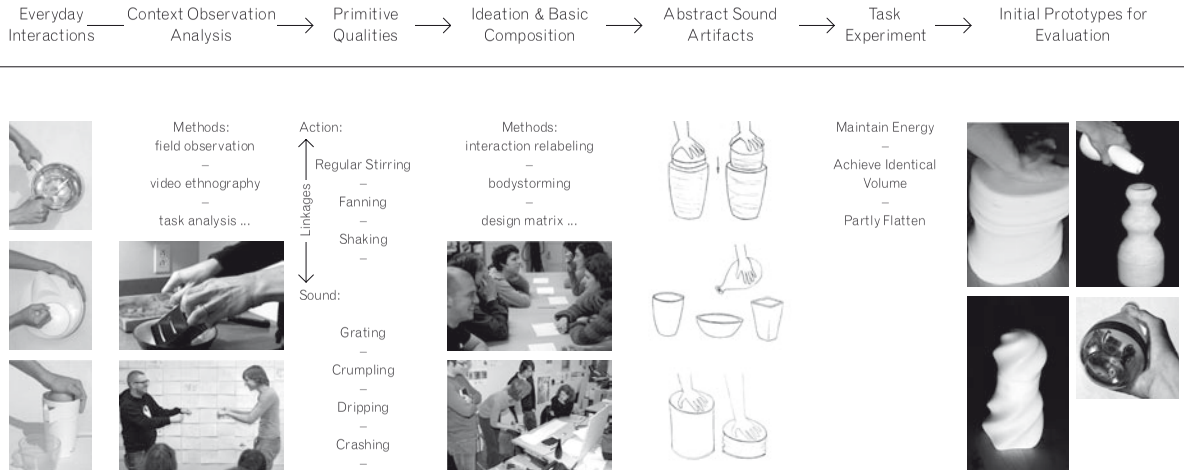

Fig. 3: The CLOSED design process. Although it is represented as a logical sequence, various activities were conducted iteratively. [Credit: Visell, Franinovic, 2007] ↦ **98**

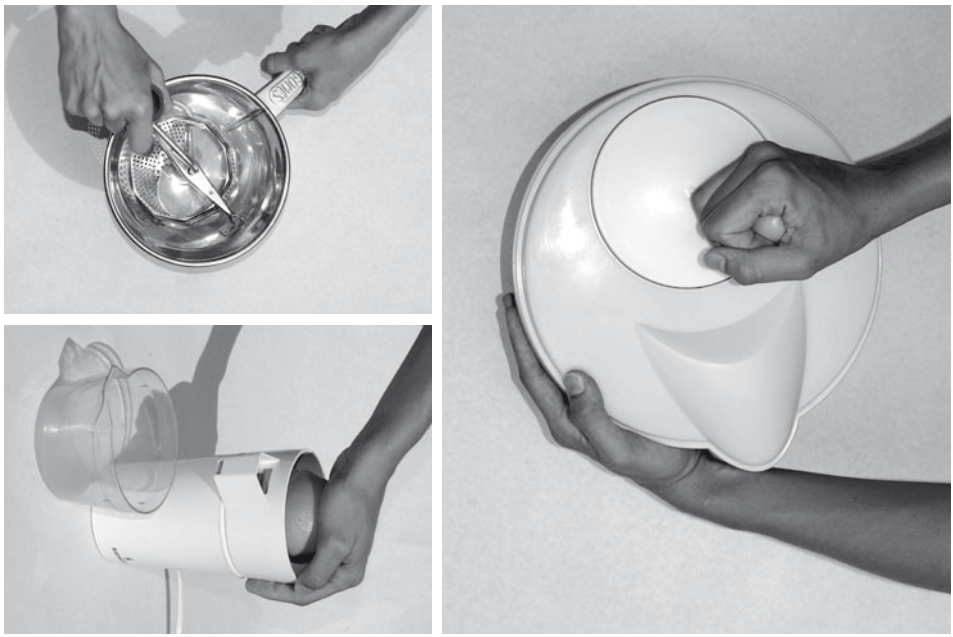

Fig. 4: Existing interactions with kitchen tools. [Credit: Visell, Franinovic, 2007] ↦ **99**

Action – General Parameters	
AD	Duration of action in seconds
AE	Energy exerted during manipulation

Action Descriptors (Examples)	
Elementary	Push, hit, slide, squeeze, grasp, elevate, put down, remove, tilt, turn, spin
Composite	Pulling, moving in circular motion, smoothing, uncoiling, turning, picking up, pouring, ...

Sound – General Labels	
MS	Manipulative sound
AS	Automatic sound
NSf	Incidental or weak feedback for action
RSf	Relevant for action

Sound – Dynamics	
pp, mp, mf, f, ff, ...	
Sound Descriptor Types (selection)	
Psychoacoustic	Loudness, brightness, ...
Physical source	Aerodynamic, liquid, solid, combustion, ...
Material	Elasticity, density, ...
Configuration	Shape, size, structure (resonant cavities, etc), support, weight
Surface contact	Smooth, rough, regular/grated, jagged ...
Spatial qualities	Delay, reverb, echo, damping, perspective, distance resonance, ...
Soundscape	Location/context, interpretation, semantic interactions, ...
Gestalt / pattern	Rhythm of vibration, iteration of sound event (e.g. bouncing), ...

Fig. 5: The annotation used in action-sound analysis. [Credit: Visell, 2007] ↦ **99**

2. *Action: Elevating the pitcher from the counter.* AE: depends on the size and material of the pitcher and quantity of liquid in it.

   (a) *Sound: the short impact and friction sounds.* Caused by the contact between the counter and pitcher. MS.

   — RSf: N/A However it provides information about the material of the pitcher and surface on which it has been positioned.

3. *Action: Displacing the pitcher towards the caffetiera.* AE: depends on the size and material of the pitcher and quantity of liquid in it. AD: 2s

   (a) *Sound: Moving liquid in the pitcher.* The liquid hits the walls of the pitcher. MS

   — RSf: It communicates the quantity of water in the pitcher. Can lead to the action of refilling of the pitcher.

4. *Action. Tilting the pitcher, while aiming at caffetiera.* AE: Larger than in the previous action, but still depends on the size and material of the pitcher and quantity of water in it.

   (a) *Sound: Water impacting the bottom of the metal caffetiera followed by the sound of splashing: water hitting the surface.* The sound changes continuously as the volume of the caffetiera is being filled. The sound is louder than that of other actions. If there is not sufficient liquid in the pitcher, the sound of filling will ends with the sound of dripping. MS

Fig. 6: An excerpt from coffee making analysis. [Credit: Franinovic, 2007] ↦ **100**

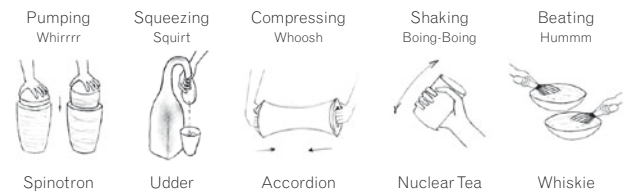

Fig. 7: Concepts for Abstract Sonic Artefacts. [Sketches credit: Franinovic, 2007] ↦ **101**

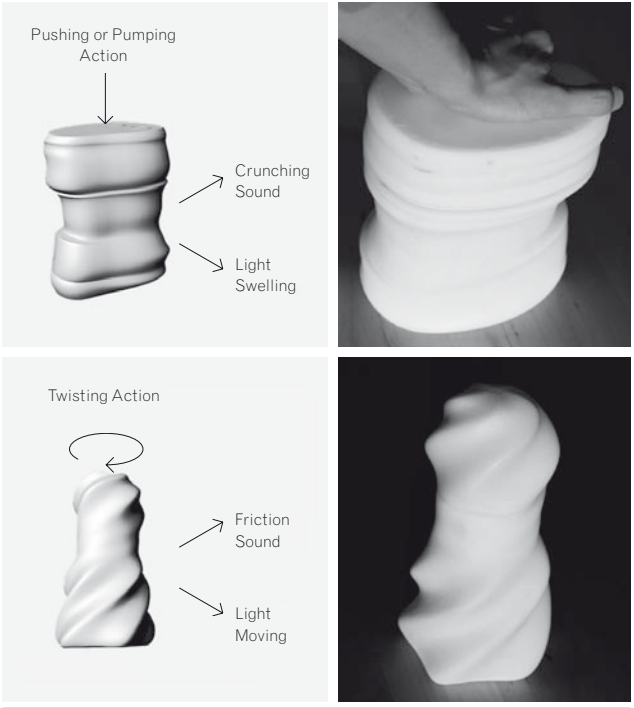

Fig. 8: Twister and Crushh prototypes. [Credit: Franinovic, 2007]↦**102**

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Endnote
1 "The word *Gestalt* is used in modern German to mean the way a thing has been *gestellt*; i.e., "placed," or "put together." There is no exact equivalent in English. "Form" and "shape" are the usual translations; in psychology the word is often rendered "pattern" or "configuration"." (Encyclopaedia Britannica Online).

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