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Towards a new kind of experimental psycho-aesthetics? Reflections on the *Parallellepipeda* project

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Abstract. Experimental psycho-aesthetics—the science aimed at understanding the factors that determine aesthetic experience—is reviewed briefly as background to describe the *Parallellepipeda* project, a cross-over project between artists and scientists in Leuven. In particular, I sketch how it started and developed further, with close interactions between the participating artists and scientists. A few examples of specific research projects are mentioned to illustrate the kind of research questions we address and the methodological approach we have taken. We often found an effect of providing participants with additional information, a difference between novice and expert participants, and a shift with increasing experience with an artwork, in the direction of tolerating more complexity and acquiring more order from it. By establishing more connections between parts of an artwork and more associations to the artwork, it becomes a stronger Gestalt, which is more easily mastered by the viewer and leads to increased appreciation. In the final part of the paper, I extract some general lessons from the project regarding a possible new way of doing psycho-aesthetics research, which is able to solve some of the problems of traditional experimental psycho-aesthetics (eg, trade-off between experimental control and ecological validity).

Keywords: art, perception, eye movements, aesthetics, ecological validity, expertise, Gestalt, mid-level vision.

1 Introduction

In this paper, I will briefly describe *Parallellepipeda*,[1] a cross-over project between arts and sciences, and I will reflect upon some aspects of this collaboration. In particular, I will indicate what I believe to be special about this project and what it can tell us about the relations between arts and sciences. I will also discuss some implications regarding the possibilities and limitations of experimental psycho-aesthetics. To be able to frame this innovative project properly, I have to start with my view on more standard forms of experimental psycho-aesthetics.

2 Experimental psycho-aesthetics: A personal overview

2.1 A brief historical and conceptual introduction

Whereas "aesthetics" originally referred to "the ability to receive stimulation from one or more of the five bodily senses," since Alexander Gottlieb Baumgarten (1714–1762) it refers more specifically to "the taste or sense of beauty based on feelings of pleasure or displeasure." This definition explicitly uses a sensory notion to introduce a distinction with some kind of judgment based on the intellect. Along the same lines, "experimental psycho-aesthetics" can be defined as the scientific discipline devoted to the understanding of the factors that determine aesthetic appreciation.

The origin of this discipline is usually taken to be *Vorschule der Aesthetik* (1876) by Gustav Theodor Fechner (1801–1887), who is also generally considered to be the founding father

[1] A parallelepiped ("parallellepipedum" in Latin and Dutch, "parallellepida" in plural) is a 3-D figure formed by six parallelograms. It relates to a parallelogram in very much the same way as a cube relates to a square. This name was chosen to refer to the multiple facets of the interactions between the parallel worlds of arts and sciences.

of psychophysics, with his *Elemente der Psychophysik* (1860). Psychophysics is not only one of the most extensively used methodological approaches in research of perception; it is also one of the important stepping stones for the development of psychology as a science (along with significant trends in 19th-century philosophy and sensory physiology). I do not think this is a coincidence. As will become clear below, in experimental psycho-aesthetics so many crucial aspects of psychology as a scientific discipline come together (eg, mind/brain relations; subjective and objective aspects of reality; interplay between perception, cognition, and emotion; tension between experimental control and ecological validity) that it could be argued that it actually constitutes a showcase of the characteristic possibilities and limitations of psychology as a whole. In this sense, the implications of the project I will describe could perhaps even be taken to extend beyond the confines of experimental psycho-aesthetics, in the direction of the wider disciplines of vision science and psychology.

Fechner must have thought that the famous adagio by S S Stevens (1951, p. 1), arguing for the importance of psychophysics—"When description gives way to measurement, calculation replaces debate"—also applied to research in psycho-aesthetics. After centuries of philosophical speculations about principles determining aesthetic appreciation, which led to the well-known dead-end captured by "De gustibus non est disputandum," Fechner proposed formal laws of beauty that could be tested experimentally. This proposal departed from the ancient idea about beauty as being caused by perfection, realized in right proportions, with a harmonious arrangement of parts, which was also present in Leibniz's notion of perfection as harmony and unity within variety. But it also allowed for elements of imperfection, which has led to various attempts to relate measures of aesthetics (M) to particular relations between order (O) and complexity (C), such as Birkhoff's (1932) ratio formula (M = O/C) and Eysenck's (1942) multiplication (M = O x C).

The most famous example in this tradition is undoubtedly the notion of the "golden section," defined as B/A = A/(A+B) ≈ 0.618 or A/B = (A+B)/A ≈ 1.618, with A and B being the longest and shortest segment, respectively, of a single line segment, divided in two parts by a single point between the two end points. The same ratio can also apply to a "golden rectangle," with A and B referring to the longest and shortest side of the rectangle. This ratio has been applied by architects and artists since ancient times to today, from the Parthenon by Phidias (480–430 BC) to Le Corbusier's (1887–1965) "Modulor," and it has sparked a lot of interest in art theory (eg, Bouleau 1980). Yet, research by Fechner (1865) showed only a small average preference for a rectangle of proper proportions (21 x 34 cm), with large interindividual differences, and Boselie (1992) found no special attractivity for the golden section in Mondrian paintings [see also Boselie (1984a, 1984b) and McManus (1980); and for a review of this extensive literature, see Green (1995)].

2.2 Sources of variation of psycho-aesthetic research

This is not the proper place and occasion to review the complete field of research in experimental psycho-aesthetics (for more background, see Allesch 2006; Jacobsen 2006), but it may be useful to sketch a few dimensions along which studies tend to differ (Crozier 1994).

First, studies in experimental psycho-aesthetics differ in their focus on the role of nature versus nurture as the basis of aesthetic preferences. Jay Appleton's (1975) "prospect-refuge theory" to explain preferences for landscapes is a nice example of the former because it is clearly rooted in Darwin's ideas of successful adaptation. In its most general form, the theory states that preference for an artwork is an acquired preference for particular methods of satisfying inborn desires such as opportunity ("prospect") and safety ("refuge"), so it is in fact already an attempt to balance nature and nurture. Daniel Berlyne's (1971) landmark book *Aesthetics and psychobiology* also starts from an emphasis on natural tendencies as sources of aesthetic responses. Specifically, the point of departure is every animal's curiosity, which

lies at the basis of exploratory behavior. However, a completely novel stimulus is always accompanied by a large degree of arousal—even stress—and this can be aversive too. So, for Berlyne, aesthetic preference ("hedonic value") is determined by the average arousal potential, usually somewhere midway between being arousing/exciting (novel) and dull (very familiar). This principle explains the general dominance of stimuli or artworks that are not too simple and not too complex. It also explains a preference for stimuli or artworks that are moderately familiar. This aspect is in contrast to the "mere exposure effect" (Zajonc 1980), which predicts that preference continues to increase with increasing familiarity. Berlyne's notion of optimal arousal level seems to give a foundation to the occurrence of cyclic trends in fashion (Crozier 1994) and to the MAYA (for "most advanced yet acceptable") principle in design (Hekkert 2006).

Gaver and Mandler (1987) have extended this theory to cognitive arousal, which reflects not the pure novelty as such but the discrepancy with schemata in memory, and have applied it to music preferences. Upon encountering a novel stimulus (eg, a piece of classical music), the listener's appreciation will depend on whether this fits her schema of classical music. When she has a broad schema, a rather original piece (eg, Stockhausen or Boulez) might be assimilated into it, and she might like it. When she has a narrow schema (eg, only Mozart or Beethoven), the discrepancy will be large, assimilation will fail, and accommodation of the schema itself will be needed instead. If this accommodation succeeds, the large discrepancy will result in a large positive emotion (strong liking); if it fails, the large discrepancy will remain unresolved, and a strong negative emotion (strong disliking) will follow. Purcell (1995) has applied similar ideas to preferences for houses. For novices, more prototypical houses were more attractive but less interesting, whereas less prototypical houses were more interesting but less attractive. For experts instead, less prototypical houses were both more interesting and more attractive. This pattern of results demonstrates that experience plays an important role in determining the scope and flexibility of someone's schemata, and hence also someone's preferences. In recent work, similar ideas have been derived from a "predictive coding" framework (eg, Van de Cruys and Wagemans 2011a, 2011b). More generally, these extensions have brought us far from the original focus on nature as the basis of aesthetic experience (for more discussion, see also Carbon 2011).

Second, research in experimental psycho-aesthetics can either focus on the object side (stimulus properties) or on the subject side (person properties) when studying the factors determining aesthetic preferences. As object characteristics, structural aspects such as composition and balance have been studied frequently (eg, Arnheim 1982; Gershoni and Hochstein 2011; Locher et al 1996, 1999a; McManus et al 2011), but also semantic and cognitive aspects have received some attention (eg, Martindale 1984; Martindale et al 1990). As subject characteristics, gender, age and expertise effects have been studied most intensely. In general, this kind of research has usually found substantial individual differences, especially as a function of expertise (eg, Nodine et al 1993; Vogt and Magnussen 2007), but also some consistent cross-cultural universals such as a preference for symmetry (eg, Washburn and Crowe 1988), and for curved versus angular shapes (eg, Bar and Neta 2006). More recent studies have focused on interactions between these factors. For instance, Carbon (2010) found that the overall preference for curved cars is modulated by long-term cyclic fashion trends. Vessel and Rubin (2010) found that there are indeed substantial individual differences in preferences for abstract (artificially created) images but that the differences decrease (consistency increases) for real-world images, probably because of their semantic associations. Shepherd and Bar (2011) showed that a preference for symmetric over asymmetric objects held for real-world objects as well as abstract objects, but somewhat surprisingly, this symmetry preference occurred in males only, not in females.

Third, and most important from this paper's perspective, is the trade-off between maximizing experimental control (using simple stimuli) and maximizing ecological validity (using real artworks). There is an overwhelming number of studies in experimental psycho-aesthetics that have actually not worked with real artworks (or reproductions thereof) but with very simple, artificial stimuli such as rectangles, geometric shapes, and polygons. This has, for instance, been the dominant approach to investigate how order and complexity contribute to aesthetic appreciation and in the experimental literature on the role of the golden section (see above). At the other extreme of the spectrum are studies that derive hypotheses from basic theories of perception and cognition and apply them to real artworks without carrying out actual experiments. A good example of this tradition is Leyton's (1987) analysis of some great works of art. Leyton starts from his theory of shape perception as the reconstruction of a shape's causal history, arguing that we always see dynamic processes underlying static shapes, spontaneously and automatically attempting a causal explanation of a shape by mentally undoing its asymmetries. For example, when we see a tilted parallelogram, we would first mentally undo its tilt (so that its basis is aligned horizontally)—then its skew (transforming the parallelogram into a rectangle) and finally its elongation (transforming the rectangle into a square). So, the final state (in the recovery of the shape's history) is the one with the maximal degree of symmetry. This theory has interesting aspects, for instance, with respect to the central role of geometry for shape perception (ie, the notion of invariances under transformations, see below) but it has problems too, both mathematically and empirically (see Hendrickx and Wagemans 1999). In Chapter 8 of his *Symmetry, Causality, Mind*, Leyton analyzes different works of art from the perspective of this theory. For him, an aesthetic response is an evaluation of causal explanations such as those above, as a solution to a problem (ie, trying to make sense of an artwork). For example, in Pablo Picasso's *Les Demoiselles d'Avignon* (1907), he sees ovals in particular areas of the paintings (based on form and color features, I suppose) and interprets them as reflecting a process of stretching; pointed ovals, as overcoming rigidity; pointed diamonds, as overcoming resistance; other more complicated geometric shapes and flow lines, as pulling open, branching out, tearing apart; and so on. Although these diagrams may be interesting to indicate particular aspects of the compositions that may otherwise go unnoticed, whether they actually determine someone's appreciation of the artwork, and whether that appreciation then depends on the perceiver's evaluation of the causal explanations of these compositional aspects remains unclear. The theory is pure speculation, and the chapter does not provide any empirical evidence for it.

Luckily, for the state of the art of experimental psycho-aesthetics, there is also quite a bit of research in-between these two extremes, which has tested particular ideas about appreciation of art with real artworks in real experiments. For instance, Paul Locher and his colleagues have performed several experiments to test the visual rightness theory of art appreciation, which states that the organizational structure of a "visually good" composition (ie, the one used by the artist if it is a good artist and a good piece of art) is visually salient and is appreciated more than any other possible composition. They have tested this theory in four different experiments with high-quality reproductions of the same 16 famous paintings, selected to be representative for different styles (abstract, semi-abstract, semi-representational, and representational; linearly and painterly). In one study (Locher et al 1999b), they compared the original with a slightly adjusted version in which one of the compositional elements was displaced and asked naïve and expert observers to make a forced choice between the two, and also to give goodness ratings for both versions. Amongst psychology students, there was a small preference for the original (55%) and a somewhat higher goodness rating (especially for the representational artworks); amongst art-teachers, the preference for the original

was higher (64%) and the difference in goodness ratings was also larger (especially for the abstract artworks). In a third experiment, design students who were given the possibility to position one compositional elements freely within the painting generally positioned it into the neighborhood of the original location, although there was also quite a bit of scatter in the settings. In a fourth experiment (Locher 2003), naive participants (psychology students) were given the choice between the original, a slightly perturbed version, and a strongly perturbed version. Overall, they had a small preference for the original version, but for many paintings the difference with the slightly perturbed version was not significant. In sum, this line of research has demonstrated that visual rightness theory can be tested with real artworks in real experiments, although the empirical support for the theory is not all that strong.

As a second example of this experimental tradition with real artworks, I want to discuss a study on the microgenesis of art perception by Dorothee Augustin and colleagues (Augustin et al 2008). Their background was a model of aesthetic appreciation, which distinguishes several stages of information-processing and two types of outputs, aesthetic emotions and judgments (Leder et al 2004). In this experiment they wanted to investigate how the processing of style and content develops in real time and how these two sub-processes are interrelated. They used high-quality reproductions of 48 paintings, selected to represent a systematic variation of styles (ie, painters: Cézanne, Chagall, Kirchner, and Van Gogh) and content (ie, themes: trees, houses, flowers, and male portraits). Because they were interested in the processing of paintings irrespective of expertise and art-related vocabulary, they tested naive participants with no special background in art or art history, and they asked them to give similarity ratings for pairs of paintings presented side-by-side on the screen. Because they were interested in the microgenesis of style- and content-related processing, the paintings were presented for variable durations from 10 ms to 3 s. Pairs in which the content was the same were rated consistently more similar than pairs in which the content was different (already at 10 ms). Such a difference was also present for same versus different style, but it was generally smaller, and it arose later in time (from 50 ms for pairs with same content and from 200 ms for pairs with different content). These results demonstrate that non-experts process style aspects of paintings on the basis of very early visual information, which is a nice way to connect art perception to other kinds of visual perception.

2.3 Psycho-aesthetics as a prime example of psychology as a whole

Samples of studies in psycho-aesthetics such as those above illustrate the problems that have to be faced and the solutions that have been tried. To me, these are very typical for many kinds of psychological research. When we try to understand aesthetic appreciation, its components and underlying mechanisms, as well as all the factors determining it (objective and subjective, those rooted in universal natural tendencies and culture-specific ones passed on by education, etc), we are dealing with one of these internal, private experiences that are difficult to access by scientific research. An aesthetic experience typically results from an intricate interplay between perception, cognition, and emotion. It is a multifaceted psychological phenomenon, determined by a large number of different factors, mostly not under experimental control. Such phenomena provide huge challenges to be investigated properly, not the least of which is the tension between experimental control and ecological validity, and the selection of the most appropriate "response" as indicative of a genuine aesthetic experience.

As we saw above, studies in psycho-aesthetics range from purely experimental (rather psychophysical experiments with simple, artificial stimuli that are only remotely related to some reduced aspects of real artworks) to non-experimental (almost hermeneutical interpretations of rich artworks). Even when high-quality reproductions of paintings are used as experimental stimuli, research implies a serious reduction of the full experience

of real artworks in a museum, gallery, or exhibition, not only because the latter entails the presence of the real work compared to the reproduction on a computer screen but also because of the whole setting (space, lighting, atmosphere, attitude, etc). Locher et al (2001b) have found significant differences between viewers' hedonic responses to slide-projected and computer-generated images of famous paintings and those obtained from museum visitors experiencing the originals. They explained their findings in terms of a facsimile-accommodation hypothesis, which they also discussed more generally with respect to the issue of ecological validity of psycho-aesthetic research. Regarding the selection of the proper aesthetic response, the challenges are no less than with respect to the "stimulus" side. Questionnaires are often limited to a small number of scales (eg, beautiful, interesting, pleasing), although the vocabulary to describe aesthetic attributes is much richer (eg, Augustin et al 2011). Experimental measures such as reaction times, similarity ratings, goodness ratings, and the like are usually only a proxy of the variable of interest, or they tap mainly into a single aspect of processing. Indirect measures such as those provided by pupil dilatation and eye movements (fixation time, gaze duration, saccade length, scan paths, etc) provide interesting additional information about perceptual and cognitive processing, but they are not easily related to the aesthetic nature of the experience. Psychophysiological measures such as heart rate and skin conductance, and neural responses measured by EEG and fMRI (Chatterjee 2011), are becoming increasingly popular, but they, too, capture only one type of aspect, namely the bodily, material aspects—and we all know how difficult it is to establish a correspondence with the subjective characteristics of experience (ie, the qualia problem). Leaving all these problems aside with the measurement of "ordinary" aesthetic responses, some studies have attempted to capture thrills or chills but, honestly, who has ever moved a participant to tears by presenting a work of art in a psycho-aesthetic experiment? How close do we generally get to the experiences that really matter for the art lover? How big is the gap between the joy we experience while being engaged in art and the responses we record from our participants in our psycho-aesthetic research?

I will not argue that we cannot learn anything meaningful from studies in mainstream psycho-aesthetics; on the contrary, this is quite useful research, and we should continue to do this. I will also not argue here that our approach is able to solve all of the above problems; far from it, it has its own difficulties and challenges. I do defend, however, the value of the alternative route I have taken: By engaging in personal collaborations with living contemporary artists, we can complement the more traditional ways of doing psycho-aesthetics, and we can learn a lot from it, too. I cannot do justice to the full richness of these collaborations here, but I do want to sketch some fundamental characteristics of this approach, in an attempt to convince other scientists and artists to try something similar.

3 The *Parallellepipeda* project

Parallellepipeda is an interdisciplinary project on the boundary between arts and sciences (for some other projects of this kind, see Jacobsen 2006). It was a joint initiative by a number of partners in Leuven, such as the Department of Cultural Affairs of the City, the City Museum M, the University of Leuven (K.U. Leuven), the Institute for Research in the Arts (IvOK, a research institute which allows artists to obtain a PhD in Arts, not art science or art history but really practice-based art). The goal of this cross-over project was to stimulate intense interactions between art and science, allowing each to follow its own route, from start to finish, in a rich and full-fledged manner, both artistically and scientifically. It has been running from 2008 till 2010 with minimal funding. It officially ended with a joint exhibition in the City Museum M, from January 28 till April 25, 2010, although some collaborations have continued afterwards until today.

Parallellepipeda had several different sub-projects, basically consisting of smaller groups of artists and scientists—in many cases just duos or trios—working together. For instance, Ronny Delrue collaborated with Koen Van Laere from nuclear medicine; Nick Ervinck (www.nickervinck.com) collaborated with Pierre Delaere from experimental otorhinolaryngology; and Koen Vanmechelen (www.koenvanmechelen.be) collaborated with Jean-Jacques Cassiman from human genetics and Luc Vrielinck from stomatology. For some examples of their work, see Figure 1, which shows three photographs taken from the exhibition at M.

Figure 1. Three photographs from artworks on display at the *Parallellepipeda* exhibition at the Leuven City Museum M (January to April 2010, photographs taken by Kristien Daem). From left to right, work by Ronny Delrue, Nick Ervinck, and Koen Vanmechelen.

Within the Laboratory of Experimental Psychology, Géry d'Ydewalle collaborated with Carl Van Eyndhoven and Wendy Morris, both working on a PhD in the Arts. They started from one of Wendy's movies, *Off the Record*, and compared the effect of three different soundtracks on the audience's overall experience of the movie: the original one, by Philippe Ryckman, which is rather Hollywood-like and dramatic in style (eg, emphasizing what happens in the movie or making some emotional effect explicit), a newly created one by Carl Van Eyndhoven, with sounds recorded from the carillon of the old university library in Leuven, which forms more of a "soundscape," and another newly created one by Yannick Franck, which is the most experimental and hermetic of the three. They collected questionnaire data from two audiences, auditory experts (student-composers and student-musicians from the Lemmens Institute in Leuven, a high-school for music) and visual experts (students from the MAD faculty in Genk, a high-school for media, arts, and design). The original goal was also to collect individual responses from visitors of the exhibition at M, where the movie was on display and visitors could sit down to watch the movie three times and listen to the three different sound tracks if they wished, but this turned out to be difficult to organize in a scientifically justified way. This is just one complication of this kind of project (more below).

The largest and most intense subproject was between myself and three visual artists: Ruth Loos (www.ruthloos.be) and Wendy Morris, both preparing a PhD in the Arts, and Anne-Mie Van Kerckhoven (also known as "AMVK"), who had some experience in collaborating with scientists before. Before describing some of our collaborative projects, I will first sketch how the overall collaboration started and developed. I consider this relevant to be able to characterize its nature and achievements in a sufficiently specific and personal way.

3.1 How the collaboration started and developed

In the spring of 2007, the first contacts occurred to explore the possibilities of a collaboration. I remember vividly that I was rather hesitant to engage in this project. I consider myself primarily as a vision scientist, an experimental psychologist with a professional interest in visual perception (mainly perceptual organization and shape perception, with some extensions into low-level vision as well as high-level vision) and with an amateur interest in visual art. At that point, I had only occasionally worked on issues related to art and perception,

in small-scale projects with students (one of which was published, see Locher et al 2001a); I had occasionally lectured on art and perception, and on experimental psycho-aesthetics (eg, at a workshop on "Art meets Science" in the Rubenianum in Antwerp in 2004); and I knew enough about the world of art and science, I thought, to be sceptical about the possibility of a real collaboration between artists and scientists. And yet the fact that the university officials apparently supported this initiative, that they wanted to spend some seed money, that the artists involved were all genuinely interested in the science of vision, and that there was going to a be a joint exhibition at the end, sparked enough of my curiosity to step into the project.

In the first couple of weeks/months, we exchanged some texts, and we had some informal meetings to explore common interests and to consider possibilities for collaboration. The goal in that stage was to be able to write a joint grant application. We acquired the grant, and the project officially started on April 1, 2008.

The key factor which has changed the general attitude towards this project, both from the artists' point of view and mine, was the fact that we spent a whole lot of time getting to know each other's work; each other's way of working and thinking; and each other as artists, scientists, and persons, each with our own background, interests, expertise, preferences, drive, and so on. I have been involved in many large interdisciplinary projects, but this *Parallellepipeda* project is clearly the one with the largest number of bilateral and group meetings of all kinds (at least 50 in the first two years). We had seminars, where the scientists explained some of their research projects to the artists and why the study of visual perception could be relevant to visual art. I presented a more or less chronological overview of my own research projects, the motivating questions behind them, and some elementary introduction to vision science. I also pointed out how I saw the work by the artists and how I thought their work could be linked to mine. (I will summarize some of this discussion below.) We invited the artists whenever we had visitors that gave lectures that could be relevant to them (eg, Irving Biederman on "Aesthetics and the brain," Chris McManus on "To please and entertain the eye: Explorations in visual aesthetics," Steve Palmer on "Aesthetic science of color: WAVEs of color, culture, music, and emotion"). The artists told me they liked these meetings a lot because they learned a lot in this way, and they felt they were taken seriously by famous scientists.

The artists invited us to their studio so that we saw how they worked. I have been to each of the artists' studios several times, and to me this has been the most valuable part of the collaboration because they provide an insider's perspective and a much more personal insight into an artist's work. By seeing how an artist works, what she has around her while working, by looking together at a work in progress (its origins, its stages), by verbalizing one's emotional reactions to it and thoughts on it, and so on one gets much closer to an artist and her work than through any other way, I think. Together, as a group, we visited several exhibitions by one of the artists: "Off the Record" by Wendy Morris at In Flanders Fields Museum in Ieper (May 2008); "Nothing More Natural" by AMVK at Wiels in Brussels (October 2008); "Het Boek Verbeeld(t)" by Ruth Loos in Sint-Niklaas (March 2009); "On Mars the Rising Moon is Blue" by AMVK at Zeno X in Antwerp (November 2009); and "Tussen boeken en schrifturen" by Ruth Loos at Passa Porta in Brussels (December 2009). These, too, were always quite illuminating. We learned a great deal from one another in this way. More than developing a common language to describe perceptions, feelings, and thoughts about an artwork to one another, this stage has taught us to try to listen to one's different voices and languages, to try to pick up a message, to translate it in one's own vocabulary, bouncing it back and finding out whether it resonates, let it sink in and digest it. It is probably even more of a feeling and thinking together than a talking together.

The interpersonal relationships and the collaboration were strongly intensified on the occasion of our participation as a group at the Art & Science symposium on "Exploring the limits of human perception" in Benasque, in the Spanish Pyrenees, in July 2009, where we had a separate session devoted to the *Parallellepipeda* project. The weeks before the conference had been rather hectic, finishing some of the research and art projects and preparing six talks, with a lot of cross-referencing to each other's work. We also had a panel discussion in which we turned out to have nicely complementary ideas about the process and products of our collaboration. Apparently our enthusiasm had carried over to the audience who reacted quite positively, full of admiration of our approach and sometimes even with some jealousy from people who had tried to set up similar projects but with no comparable outcomes. Not only did we all present some of our work and experience in the context of the *Parallellepipeda* project there; we also spent quite a bit of time doing things together, discussing other people's work (science and art) presented there, brainstorming about our own work, and so on. Again, this quality time together has had a long-lasting impact on the collaborations.

3.2 The present situation

Thanks to all these joint activities, the collaborations took specific and concrete form, and they almost automatically became richer and deeper. I will sketch that development with specific examples of research projects in the next section. At this point in time, we are involved in several stages of each other's work, from ideas to design to end-result, be it an artwork, an exhibition, a scientific experiment, poster or paper. We give each other feedback about each other's work and we comment on each other's texts. It is quite striking to see that we can say much more with fewer words now; we seem to feel now what the other person needs, and we can provide the right type of input at the right time for the other person to take advantage of it. Additional connections between each other's work now seem to come automatically (eg, the experience of time in relation to animation speed in both Wendy's and Anne-Mie's movies; the use of eye movement data as input to new artistic work by Ruth).

4 *Parallellepipeda*: From parallel worlds to interacting people

Parallellepipeda was meant to bring the parallel worlds of artists and scientists closer together and to stimulate intense interactions between them. I think this has largely succeeded, mainly because we have taken our time to get to know each other quite well and thanks to the genuine interest in each other's worlds, and everyone's open attitude and sincere engagement in the collaboration. An important aspect has been the common ground which was already there before we started but the project blossomed more fully when the interactions become more intense and personal.

4.1 Parallel worlds between artists and scientists

When I was studying the work created by the artists in the project, during the initial, exploratory stage of the project, I discovered that they had been working on a great number of similar issues as I had done in my research. Of course, the specific cases and approaches had been different, but there were striking parallels as well. In particular, the artists also appear to develop a deep understanding of visual form and visual form processing in their work, not just by experimenting in the studio but also by the observation of the effect of their art on the viewer. I will briefly indicate some of these parallelisms, mostly by presenting some visual examples. A thorough discussion of the specific issues that are investigated, the different methods used by scientists and artists, and the similarities and differences in approach and results are beyond the scope of this overview. It is the range of topics covered in the parallel worlds of my lab and their studios which is the most salient feature of this discussion.

4.1.1 *Repetition and symmetry.* My PhD was on the detection of different types of symmetry (eg, Locher and Wagemans 1993; Wagemans 1993; Wagemans et al 1991, 1992, 1993), and I have continued to work on symmetry ever since (eg, Kayaert and Wagemans 2009; Koning and Wagemans 2009; Machilsen et al 2009; Nucci and Wagemans 2007). I was very pleased to see, therefore, that Ruth Loos has also played a lot with repetition and symmetry in her compositions (see Figure 2). Only in one study I have investigated the perceptual effects of mirror reflections and planar rotations of a rich photographic picture of a 3-D object (Cornelis et al 2009). All of my other research on symmetry has used dot patterns or other simple stimuli (mostly black-and-white, sometimes with variable gray levels). Instead, Ruth has usually started from dense, colored patterns, sometimes with recognizable motifs, and she has then created rich, varied compositions with them, employing different combinations of repetitions and reflections.

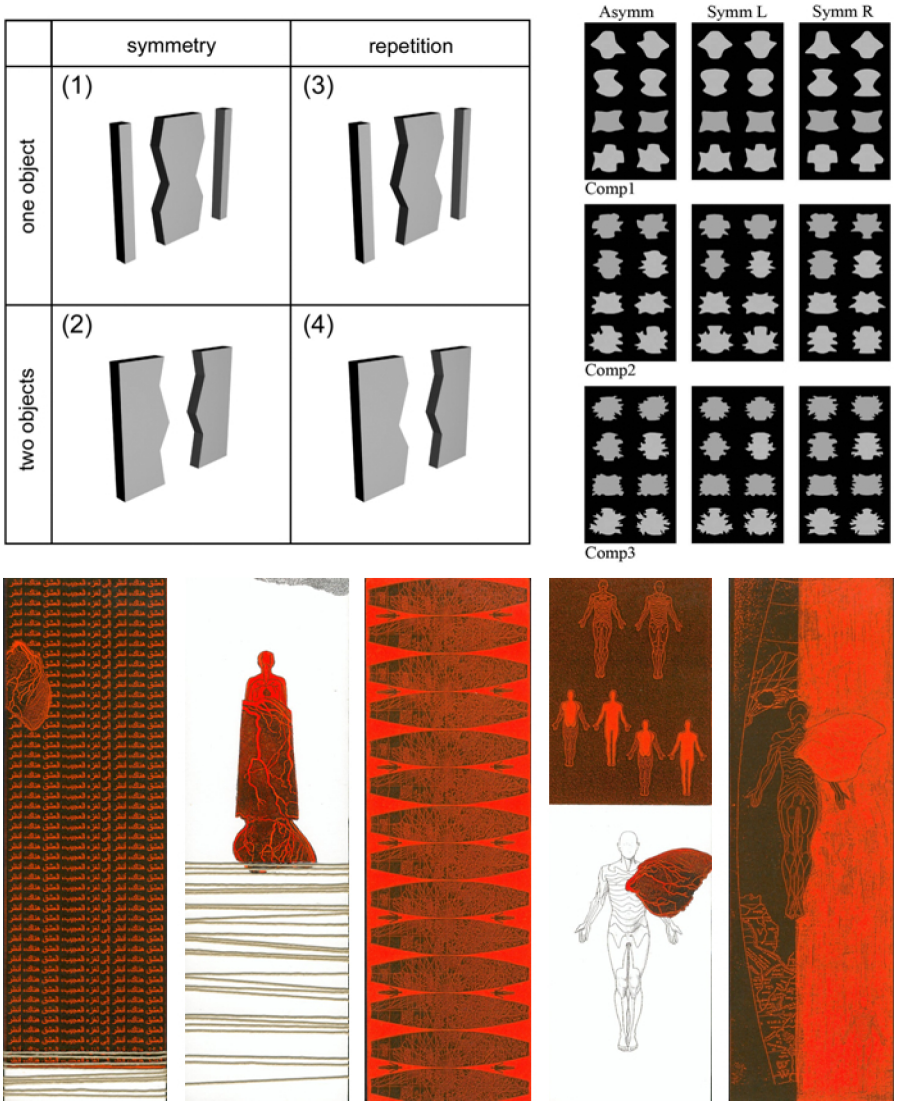

Figure 2. Repetition and symmetry in vision science and visual art. Stimuli from Koning and Wagemans (2009) and Kayaert and Wagemans (2009); artwork from 2004 by Ruth Loos.

Three examples will suffice to give a representative impression of our recent symmetry research. Together with Arno Koning, I have studied to what extent the detection of symmetry and repetition between contours is influenced by their being embedded in one or two

objects (Koning and Wagemans 2009). With Massimo Nucci, I examined to what extent the "goodness" of different global dot patterns is influenced by different interactions between several local symmetries (Nucci and Wagemans 2007), and with Greet Kayaert to what extent visual short term memory is influenced by the interaction between symmetry and complexity (Kayaert and Wagemans 2009). My impression is that Ruth Loos has also examined similar issues in her work but rather than systematically comparing and quantifying the effects of these manipulations, she has probably just picked the one for her final composition that seemed to "work"—as per the notion of "visual rightness" (see Figure 2 again).

4.1.2 *Textures and slant in depth.* Ruth Loos has often used repetitive patterns in her work (see Figure 3), starting from a simple motif (eg, an alphabet) or even a digital photograph (eg, a picture of an open book on a clay underground), and then repeating this. Depending on the presentation of the overall resulting pattern, the slant of the ground plane also becomes a salient aspect of the visual pattern. I have often studied the perception of repeated patterns such as dot lattices (eg, Claessens and Wagemans 2005, 2008; Kubovy et al 1998; Kubovy and Wagemans 1995), usually focusing on the way in which the spatial distribution of the elements affects the overall organization (eg, the role of proximity and alignment). And in research with Pedro Rosas (eg, Rosas et al 2004, 2007), I have examined slant perception as a function of the type and distribution of different texture elements (eg, simple dots, Polka dots, leopard skin, Perlin noise). So, here too, similar interests seem to be at stake but the approaches used to get a grip on the issues appear to differ between the artist and the scientist (see Figure 3 again).

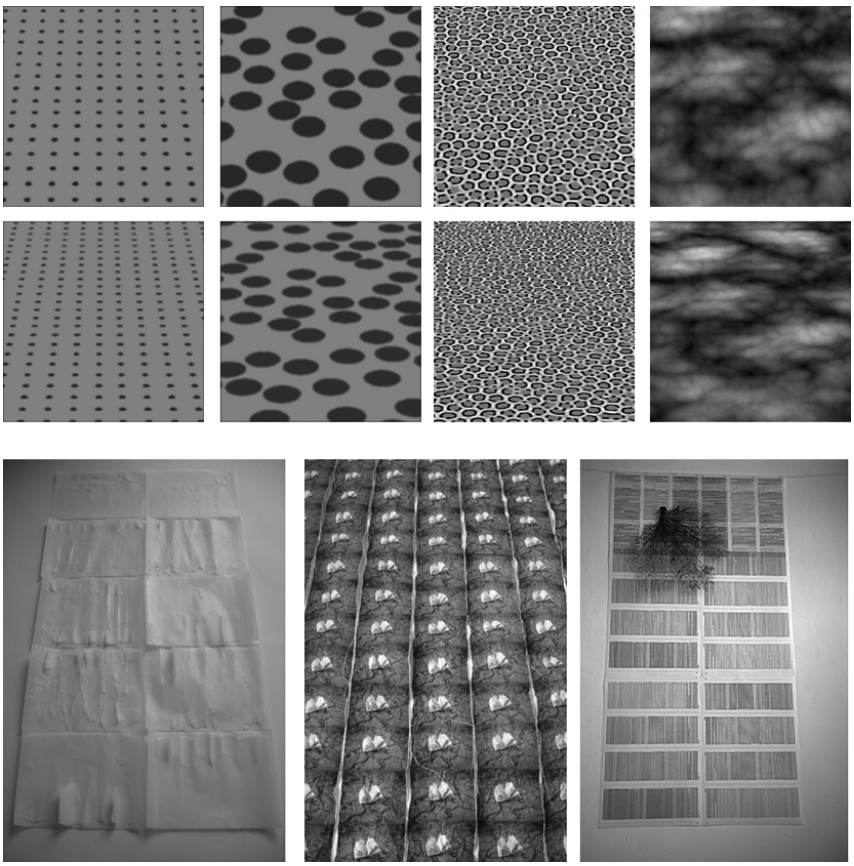

Figure 3. Textures and slant in depth in vision science and visual art. Stimuli from Rosas et al (2004); preliminary study and artwork from 2006–2007 by Ruth Loos.

4.1.3 *Transformations and invariances.* The role of transformations and invariances has been a central theme in my research program, ever since I started to work on the detection of symmetry (for reviews, see Wagemans 1995, 1997), considered as invariance under Euclidean transformations (for an intuitive geometrical background, see Van Gool et al 1994). After my PhD, I extended my earlier use of skewing, an affine transformation inducing changes in bilateral symmetry which correspond to changing from an orthogonal to an oblique viewpoint (eg, Wagemans 1992, 1993) to other types of affine transformations (eg, Wagemans et al 2000) and to systematic comparisons between different families of transformations, in line with the hierarchy of geometries as defined in Klein's Erlangen Program, from Euclidean to affine and projective (eg, Wagemans et al 1997). Hence, I was highly fascinated by the way in which Wendy Morris induces transformations to objects in her movies, playing with a delicate balance between identity and change, changing certain features of the drawing while the overall shape retains its key properties (eg, elongation, aspect ratio, degree of curvature, structural skeleton). Two nice examples are shown in Figure 4, changing between different weapons and changing from a corncob to a hand grenade. To me, these sequences are often the most attractive ones to look at, specifically because they tap into the visual system's sensitivity to transformations and invariances.

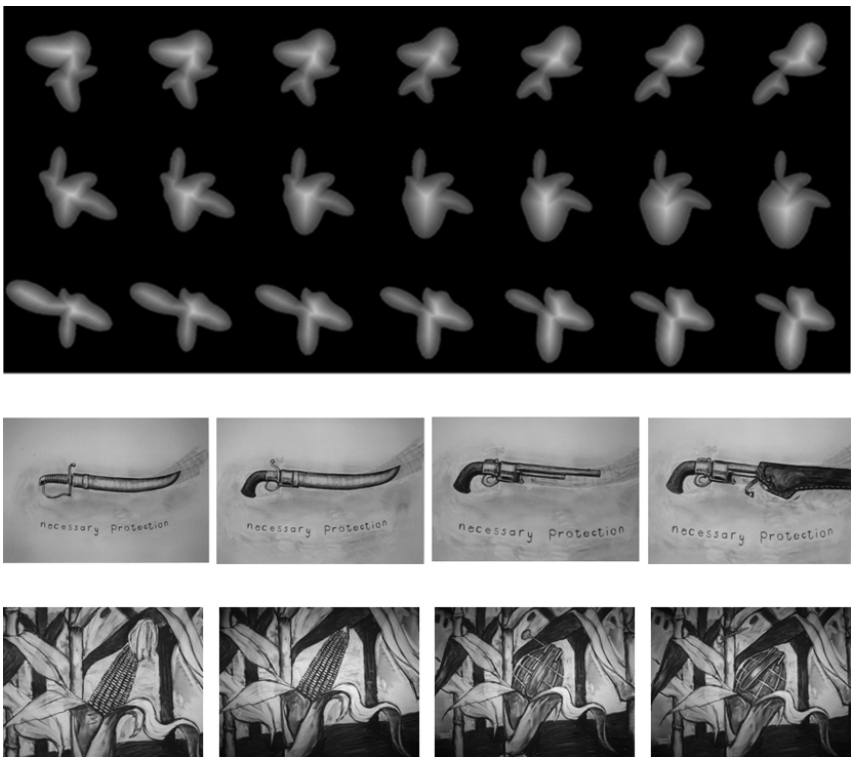

Figure 4. Transformations and invariances in vision science and visual art. Stimuli from Kayaert et al (2011); artwork by Wendy Morris (snapshots from *Off the Record*).

In more recent work, I went beyond easily parameterized changes of simple dot patterns and polygon shapes to less easy to parameterize changes of smoothly curved outlines (eg, Op de Beeck et al 2001), to comparing the role of different shape changes for within- and between-class membership (eg, Kayaert and Wagemans 2010; Ons and Wagemans 2011), to making similar pairwise shape changes more or less salient by experimentally inducing differences between prototypes and extremes along a single shape dimension (eg, Kayaert et al 2011; Panis et al 2011), and to investigating perceived shape similarity and its neural correlates in 2-D spaces of shapes created by morphing outlines of different exemplars of the

same basic-level object (eg, Gillebert et al 2009; Panis et al 2008b, 2008c). And, yet, despite these additional complexities, these studies lack the visual imagination and sheer beauty of a simple structural deformation accompanied by a semantic category change and all of its associated meanings and intentions in the context of an animated movie such as Wendy's (see Figure 4 again).

4.1.4 *Perceptual grouping and figure-ground organization.* Anne-Mie Van Kerckhoven has a life-long interest in science, and from the early days of cybernetics and artificial intelligence she has been following developments in these areas with more than a casual curiosity. She has developed a close relationship with Luc Steels, a professor of artificial intelligence at the Free University of Brussels (V.U.B.), which has inspired quite a bit of her work in the 1980s. I suspect that she has also been introduced to early computer vision approaches like the one by David Marr (1982), as several of her digital artworks of that period make extensive use of image-processing techniques that appear to create what I would call a "full primal sketch" of the original image (see Figure 5). In any event, these artworks seem to have enough of the surface and contour elements available for us to spontaneously organize them as regions bounded by contours, although there are also some interesting problems of perceptual grouping and figure-ground organization left to keep the visual system puzzled and intrigued when processing these images.

Figure 5. Perceptual grouping and figure-ground organization in vision science and visual art. Stimuli from Torfs et al (2010); artwork by AMVK.

I also have a longstanding interest in perceptual grouping and figure-ground organization since my research on grouping in the context of symmetry detection (eg, Locher and Wagemans 1993) and on perceptual grouping by proximity (eg, Kubovy et al 1998; Kubovy and Wagemans 1995). Only very rarely did I include additional variations in the stimulus elements such as luminance modulations in Gabor patches instead of dots (Claessens and Wagemans 2005), to study the interaction between grouping by proximity and grouping by orientation alignment ("good continuation"), and color variations of the contours of unfilled dots (Van Lier and Wagemans 1997), to study the interaction between grouping by proximity and grouping by regularity.

It is also relatively recent that I started to examine the role of perceptual grouping in the context of line-drawings of everyday objects, in collaboration with several members of my laboratory. We first made silhouette and outline versions (Wagemans et al 2008) of

a famous set of line-drawings of everyday objects (Snodgrass and Vanderwart 1980) and then created fragmented versions, with the fragments being located at different points along the contour (eg, around extrema or inflections) and with variable degrees of fragmentation (Panis et al 2008a). In addition to testing norms of identification with all these stimuli (see De Winter and Wagemans 2004 for an overview), we also investigated the interplay between different processing stages occurring in object recognition by distinguishing difficulties at the level of perceptual grouping of elements along the contour from those at the level of matching on-line perceptual representations with those stored in visual memory (eg, Panis and Wagemans 2009; Torfs et al 2010).

However, the type of stimuli that my collaborators and I have used come nowhere near the complexities which are brought to bear in Anne-Mie's images, which appear to represent in an artistically pleasing way the possible output from some low-level image processing stage, as further input to mid-level organization processes and high-level interpretation processes (see Figure 5 again). We, of course, have more control over the geometric stimulus attributes that vary in our stimuli, and this enables a better understanding of the mechanisms producing their perceptual effects. But the effects are usually less striking and puzzling, at least for non-scientists.

4.1.5 *Contours versus surfaces.* In a related, more recent line of research, my collaborators and I have tried to further tighten the connection between mid-level and high-level processes by presenting observers with Gabor displays, with orientation alignment along the contour and grouping based on orientation similarity within the surface enclosed by the contour (see Figure 6). In one of these studies, we have tested detection of shapes as a function of contour and surface grouping (Machilsen and Wagemans 2011), whereas most of the others have added shape identity as well by implementing these grouping cues in recognizable outlines, creating so-called Gaborized outlines (Nygård et al 2009, 2011; Sassi et al 2010).

The interplay between surfaces and contours is a nice feature of series of digital works by Anne-Mie Van Kerckhoven (see Figure 6 again). Of course, these are much richer again, with quite irregular 2-D shapes—some recognizable, others not—showing interesting variations, such as somewhat shiny surfaces with holes and open contours that appear to have escaped from the surface, all against a 3-D background scene (colored pictures of recognizable indoor scenes). Note that the range of possible stimuli, from an experimental point of view, which is made available in a single artwork such as these, is quite impressive, from contours to surfaces to pictures of scenes, with variable saliency of 1-D, 2-D, and 3-D features (eg, somewhat rounded edges around the surface, 3-D corners in the surroundings).

4.1.6 *Perceptual ambiguity of figure-ground organization.* While she was an artist in residence in Shangai in May to June 2007, Anne-Mie Van Kerckhoven has created some nice variations on the vase-face illusion (see Figure 7). Starting from an edge of a tree trunk, which looked a bit like a face profile, she enhanced the facial features by coloring a region (thereby defining and bordering it). She then duplicated it to create two profiles looking at each other, as in the standard vase-face illusion, leaving the region in-between the faces empty, however, which creates a pleasing type of figure-ground ambiguity with part of the background now visible where the vase region is in the standard vase-face illusion. Together with a student, Naoki Kogo and I have manipulated the degree of seeing vase versus face by varying the areas of the two regions (a classic figure-ground cue; see Rubin 1915), and tested whether our neurocomputational model of figure-ground multistability (Kogo et al 2011), which was derived from our earlier neurocomputational model of surface completion and illusory contours (Kogo et al 2010), could also produce such variations in figure-ground percepts. In an earlier line of work, Ilse Verstijnen and I had studied other cases of perceptual multistability, establishing transition points between two figural percepts, such as a duck

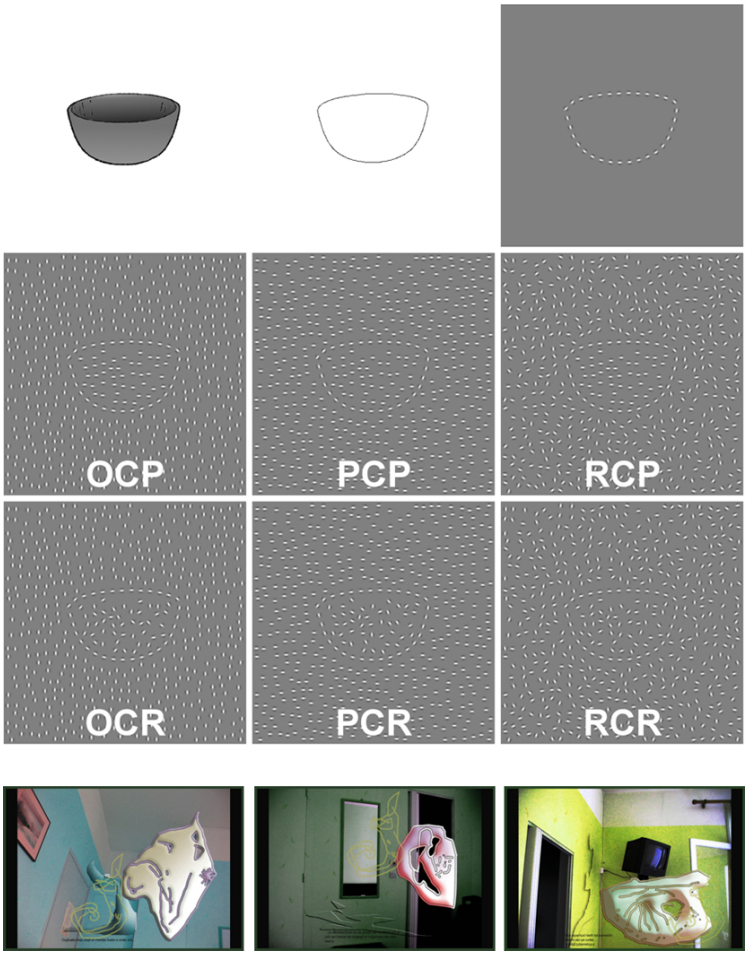

Figure 6. Contours versus surfaces in vision science and visual art. Stimuli from Sassi et al (2010); artwork by AMVK.

and a rabbit, in several series of well-known ambiguous figures (Verstijnen and Wagemans 2004), but these multistabilities do not arise from figure-ground switches. We are currently exploring whether our model can be extended to apply to such cases too.

4.1.7 *Viewpoint changes of 3-D objects.* The role of viewpoint changes in 3-D object recognition has long been a hot topic of debate in the scientific literature on human visual perception. Much of the work originates to test contradictory predictions from theories arguing that particular characteristics that are crucial to distinguish between basic-level object categories can be derived from a large range of viewpoints (eg, Biederman 1987) and theories arguing that only certain views are stored and that recognition from other viewpoints requires a time-consuming normalization process akin to mental rotation (eg, Tarr 1995). Although I had a great deal of sympathy for the focus on invariance, the general idea of part-based object descriptions, and the specific use of non-accidental properties as an interesting bridge between perceptual organization and object recognition in Biederman's theory (Wagemans 2009), I have always maintained an intermediate position in this debate. With several collaborators, I have shown that object recognition can be either viewpoint-dependent or independent, depending on the nature of the 3-D objects, the viewpoint changes, and the task requirements (Demeyer et al 2007; Vanrie et al 2001, 2002; Willems and Wagemans 2000, 2001). In some of these studies we have also demonstrated that viewpoint effects need not always indicate the use of mental rotation as a viewpoint normalization

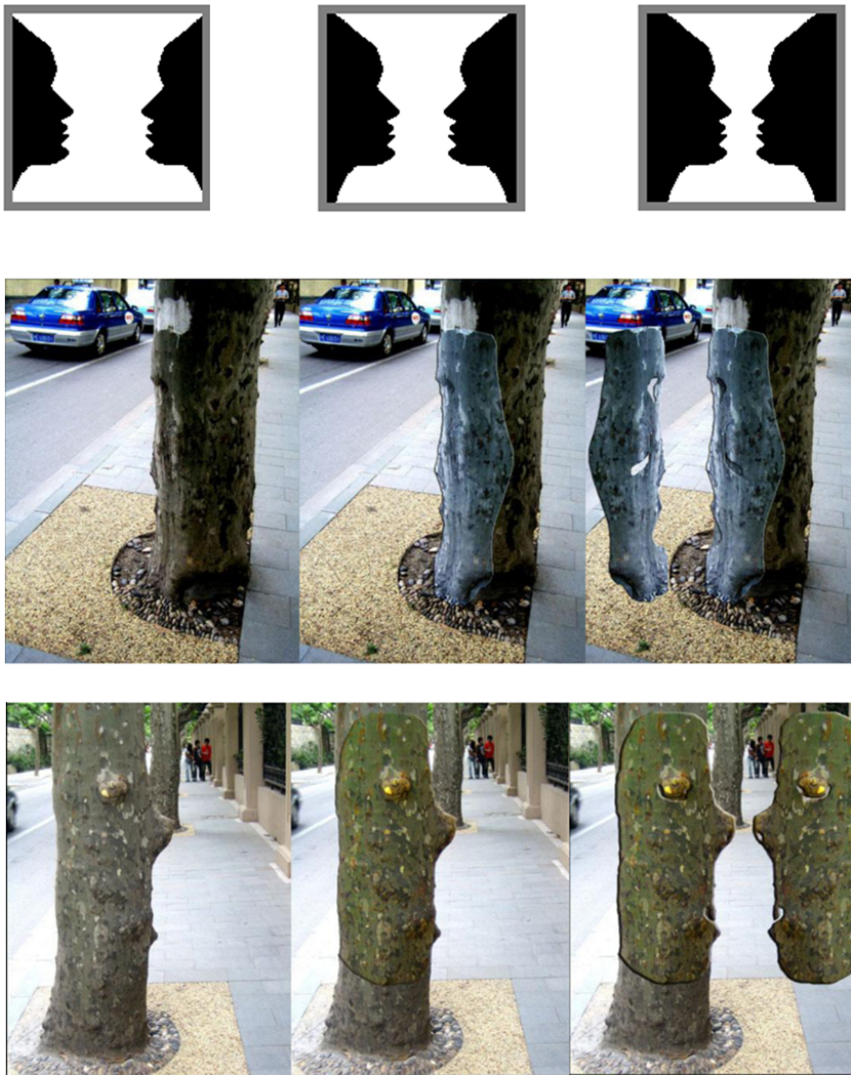

Figure 7. Perceptual ambiguity of figure-ground organization in vision science and visual art. Stimuli from Kogo et al (2011); artwork by AMVK.

strategy (Demeyer et al 2007; Willems and Wagemans 2001), a point which we had already made earlier in the context of affine transformations, emphasizing the distinction between the mathematical notion of invariance and the way the visual system must derive this from input images (Wagemans et al 1996).

In some of her work on "the book object," Ruth Loos has also focused on the interesting visual effects arising from presenting objects from somewhat odd views (see Figure 8). As usual, visual artists go a bit further in their manipulations than vision scientists. Not only has she taken snapshots from very degenerate angles, yielding views with a lot of self-occlusion (see also Van Lier and Wagemans 1999). In addition, she has deconstructed the 3-D object by tearing the pages from the book, and then made a new 3-D object from it by rolling the pages to create a fundamentally different shape with novel 2-D image features when viewed from the side.

4.1.8 *Conclusion.* Visual artists and vision scientists are often struggling with the same issues, but their approach to tackling them differ. Visual artists and vision scientists alike are interested in the perceptual effects of particular image manipulations. Vision scientists usually attempt to get an analytic understanding of the stimulus-percept relationship (and—

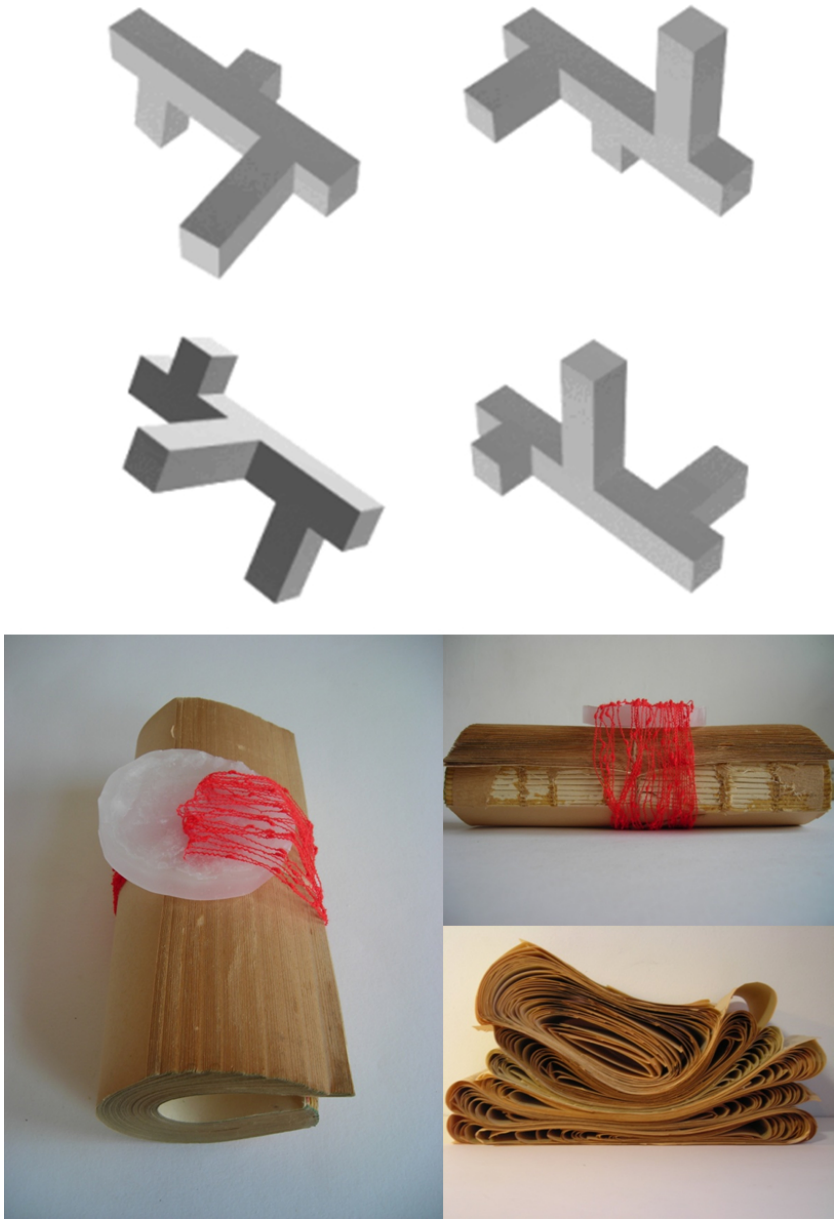

Figure 8. Viewpoint changes of 3-D objects in vision science and visual art. Stimuli from Vanrie et al (2001); preliminary studies from 2006 for artwork by Ruth Loos.

ultimately—the intermediate mechanisms) by quantitatively assessing a well-controlled range of systematic experimental variations on a well-defined measure of task performance. Visual artists experiment in their studio, and they then expose the unique work, which they judge to be working best, in the sense of yielding the strongest visual impression and richest aesthetic response, as one synthetic whole—an ideal Gestalt. In looking at the parallels between our work and talking about the converging and diverging views on some of the issues, I am convinced that vision scientists can learn a lot from collaborating closely with visual artists.

4.2 Interacting artists and scientists: Some examples of our research projects within *Parallellepipeda*

I will briefly discuss some examples of studies we performed in collaboration with the artists participating in *Parallellepipeda*. Some of these were done early in the project and are more

standard experimental psycho-aesthetics studies. Others were done later in the project and are somewhat more innovative.

4.2.1 *Example 1: Early stage experiment with a composition by Ruth Loos.* Artists usually create compositions with a certain degree of balance which they find appropriate (see above). Researchers in experimental psycho-aesthetics can create different versions of the same artwork and examine whether naïve observers who do not know the original work, would prefer the one made by the artist. That is what we did with one of the works by Ruth Loos (see Figure 9). We took the original composition, decomposed it again in the 21 smaller units it was composed of, and created seven other versions by rearranging the units in different ways, some more symmetrical than the original, others quasi-randomly. Observers received all eight of these compositions printed on cardboard with plastic cover as a stack in front of them, in random order. They were asked, first, which one they liked the most, and second, which one they liked the least. Then, they were asked to rank order the remaining ones in-between these extremes (in decreasing order of preference from most to least). Finally, they were also asked whether they could guess which one was the original. We did several of these experiments with compositions by Ruth Loos. The results, suggesting a small preference for the original composition, will be published in a separate paper.

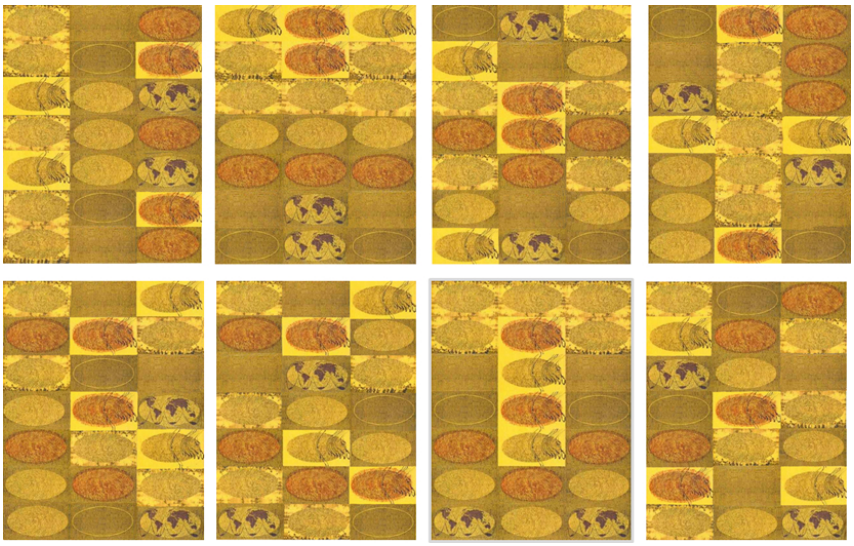

Figure 9. Eight different versions of the same artwork from 2003 by Ruth Loos. One of them is the original, seven others are derived from the original (marked by a subtle grey frame).

4.2.2 *Example 2: Early stage experiment with a series of drawings by AMVK.* In 2005 Anne-Mie Van Kerckhoven had made *I'll Rob You*, a series of 36 drawings on colored paper, while she was working in the Lakenhalle, a very traditional building in the old-town center of Bruges. They were produced as a sequence, one per day, and when you see them in sequence, you can clearly see the connections: certain themes are followed up in consecutive drawings, some shapes return later, the background color of the paper sometimes affect the changes within the series, and so on (see Figure 10). We wondered whether naïve observers would be able to see the connections between the drawings when they were no longer presented in a series. We also asked which of the commonalities and differences between the different drawings would be detected spontaneously by naïve observers. To study these questions, we removed all 36 drawings from the booklet and put them (with plastic cover) in random order in front of our observers. They were given a free sorting task, with as many stacks as they wanted and with as little or many drawings on each stack as they wanted. In the analysis, we checked

which of a great many sources of variation were used as spontaneous sorting criteria: the color of the paper, the color of the central blob, one or more blobs present, female present or not, body and head integrated or not, furniture present or not, and so on. The results, indicating a large role for colour, will be published in a separate paper.

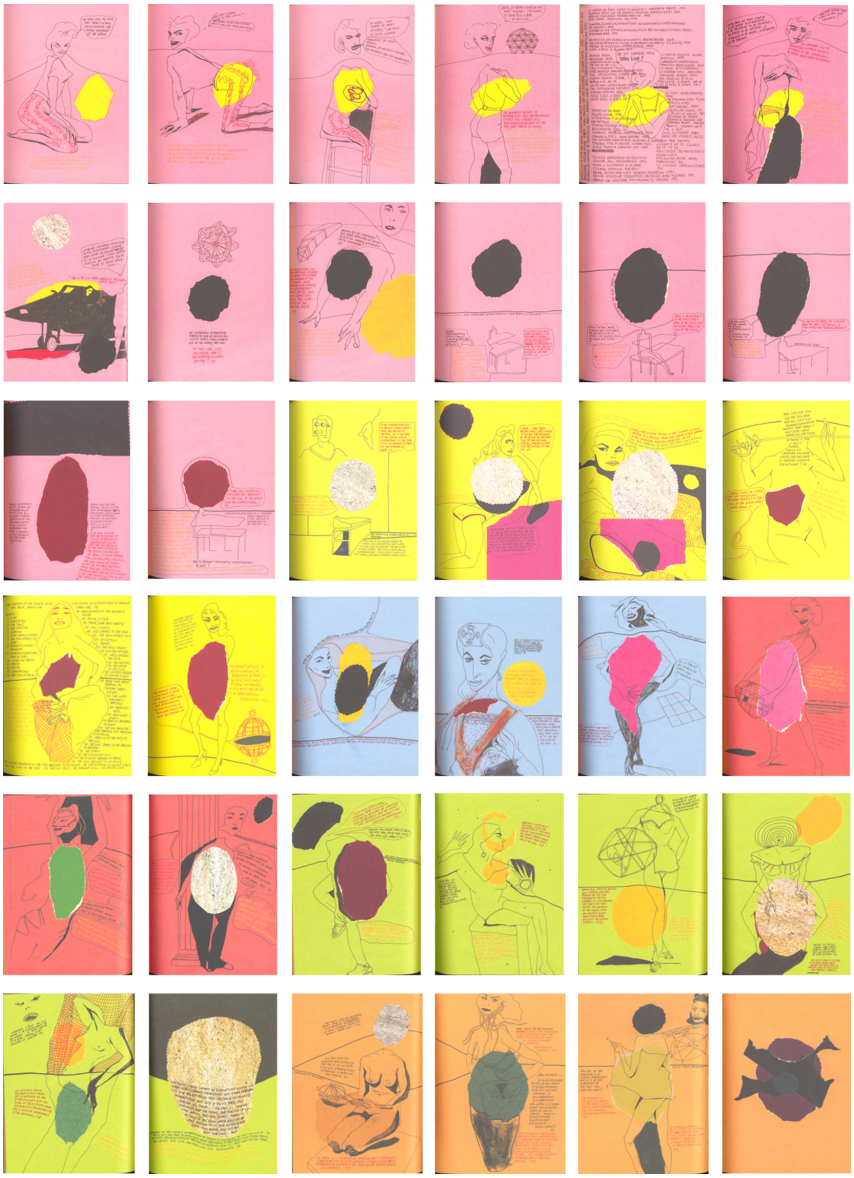

Figure 10. *I'll Rob You*, 36 drawings by AMVK, produced as a series, one per day, each time on a colored paper in a booklet consisting of 36 pages.

4.2.3 *Example 3: Eye movement study with* Kalligrafie *by Anne-Mie Van Kerckhoven.* Anne-Mie Van Kerckhoven is a highly experienced visual artist, who has made a long career with artworks of various forms (including installations, digital movies). All along, she has also been drawing for herself, usually one drawing per day, which is a habit she likes to maintain, although she did not consider this part of her "official art collection" until curator Dirk Snauwaert wanted to make an exhibition with all of her drawings, from her very early days until then ("Nothing More Natural" at Wiels, Brussels, in October 2008). It was quite interesting to see drawings from a period of more than 30 years, with a striking consistency, in spite of some minimal changes regarding style and content, which one could clearly

recognize as characteristic AMVK work. Around the same time, she made *Kalligrafie*, a series of 15 drawings for an exhibition at Manifesta 7 (Trentino–South Tyrol Region, from July 19 to November 2, 2008). The set is rather typical for her general style of drawing, containing a mixture of complex shapes with all kinds of borderlines and surface features (some open, some filled in with texture or color), some human bodies (almost exclusively female), some geometric and natural objects—sometimes numbered as if items of a collection, some furniture or room elements (eg, a corner, floor or wall), some text—apparently remotely connected to the content of the drawing (see Figure 11 for four examples).

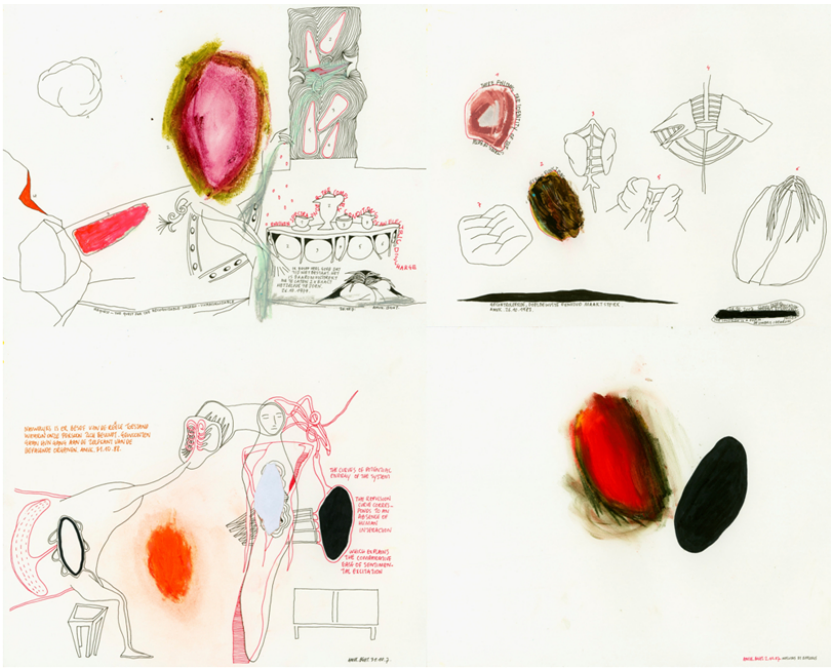

Figure 11. Four drawings of *Kalligrafie* by AMVK.

Usually viewers show strong emotional reactions to these works, very outspokenly positive or negative, being attracted to them or repelled by them, which is a rather typical response for innovative, characteristic, unusual (if not odd), and difficult (if not hermetic) work, which does not belong to any mainstream that people recognize (cf above, Berlyne's arousal potential theory describing what novel work does to people). To examine what attracts people's eyes in these works, how their spontaneous exploratory eye movements are influenced by what they know about the work, and how the eye movements relate to the art appreciation, we set-up an eye movement recording study. We showed all 15 drawings for 20 s each, one after the other, in the sequence intended by the artist (because that matters a lot to her), to two groups of participants (those who knew Anne-Mie's work quite well and those who did not). All participants saw all drawings twice, interrupted by a video recording of an interview in which she talked about *Kalligrafie* (the period in which she made them, what was on her mind then, the material they were made of, the importance of the text quotes, etc). After each series, they were asked to fill out a number of rating scales (Osgood's semantic differentials as well as appreciation scales).

In the analyses we were interested in differences between groups of viewers, first and second viewing, and before and after seeing the interview, with respect to their eye movements, appreciation data, and the interrelations between them. The results will be discussed fully in another paper which is in preparation, but here I would like to point out a number of characteristics which distinguish this study from related eye movement work.

First, the artwork itself was brand new and thus not seen before by any of the participants. Second, we could ask real artists as participants, often friends of her, who know her work quite well, some even intimately, except this series. Third, we could also record the artist's own eye movements. Oddly enough, she first refused to participate as a subject in this experiment because she thought that this would be completely ridiculous because she would not make any eye movements. As a matter of fact, she showed the most frequent saccades and shortest fixations of all participants, and her scan patterns revealed a striking regularity, exploring the complete composition, jumping to all crucial components but relating them into particular, ordered sequences (capturing the visual and semantic relations between them), and anchoring all of these short fixations from all parts of the drawings, also the peripheral ones, to the center of the composition, thereby determining the structural skeleton of the complete work. In this respect, the artist herself constitutes the super-expert, a caricature of what is normally found in the ambient viewing style of normal experts contrasted with the more focal viewing style of novices. Fourth, we could determine the content of the interview, and therefore the specific elements we wanted to provide as background information, which allows for an ideal combination of ecological validity and experimental rigor. Fifth, we can ask the artist who made the works and other real artists to help us establish the structural skeleton of the overall composition, as well as its key elements and their key relationships, which we can then use to relate with the scan paths, if we wished. This kind of semi-professional examination by really experienced art viewers, if not the artist herself, is rare in standard psycho-aesthetics studies. Sixth, and probably most importantly, because the different ways in which the eye movement data were processed and visualized (eg, heat maps and scan paths) were found aesthetically pleasing by the artist, adding another layer to her work, we actually showed them during the exhibition (see Figure 12) on four flat screens (in a 2 x 2 configuration, reflecting the central aspects of the experimental design: experts vs. novices, 1s vs. 2nd viewing) on a wall next to the actual drawings (in a loop of 15 recordings, one for each drawing, in two data view modes). To all of us, scientists and artists alike, this was one of the nicest elements of the joint exhibition because it was a way to actually visualize what we had been doing together, in a context and a format that was doing justice to both worlds. We have received a great deal of enthusiastic responses to this joined work, from all kinds of audiences.

4.2.4 *Example 4: Eye movement study with* Off the Record *by Wendy Morris.* Wendy Morris makes animated movies on the basis of charcoal drawings [for more background, see Morris (2011) elsewhere in this special issue]. Her movies are relatively short (a couple of minutes), but the amount of work that is put into it is huge (several months of work, often a year or more, including the research into the topic, the studying of background material, the drawing, the filming, the editing, etc). The movies are played at a relatively fast speed, and there is a lot to see, much more than can be processed and digested in a single viewing. The films are visually attractive in themselves, but there is also much to be learned from them, and most viewers understand and appreciate the films much better if they know more about the topic, the background, the sources of the images, the associations between them, and so on.

It is against this background that we have to position the artist's and our common interest in the interrelationships between attention, perception, memory, understanding, and appreciation pertaining to such a piece of art. Specifically, we had viewers watch the movie *Off the Record* three times, with some additional information after the first viewing. Three different groups were created with different kinds of additional information: one more biographical and historical by an external expert (a curator), a second more personal and anecdotal by an internal expert (the artist herself), and a third (control) condition with an

Figure 12. Four photographs from AMVK's *Kalligrafie* on display at the *Parallellepipeda* exhibition at the Leuven City Museum M (January to April 2010, photographs taken by AMVK).

unrelated scientific text. While they watched the movie, participants' eye movements were recorded; in-between the different viewings, some aesthetic appreciation scales were filled out by the participants; and afterwards we performed an unexpected recognition memory experiment with 40 static images from *Off the Record* and 40 other static images similar in style and theme (from other movies by Wendy).

The details of this study will be presented elsewhere, but one of the important conclusions is that the additional information does enhance the richness of the experience a great deal. In contrast to a frequently heard remark in circles of some artists, art critics, and art theorists that knowledge prevents a pure aesthetic experience, at least for this kind of work, the pleasure is strengthened significantly by knowing more, seeing more, remembering more, and making more associations while engaged in these processes. The artist is now more confident in presenting her work not just at film festivals but as a complete artwork, along with drawings, source material, notebooks, sketches, and so on in art galleries and museums—as a modern "Gesamtkunstwerk." At the *Parallellepipeda* exhibition, she exposed all this material in the same room as where the movie was played, along with the eye movement recordings we had made in our study on two large flat screens on a parallel wall just next to this room (see Figure 13). This way of exposing her work does much more justice to the full richness of it and strongly facilitates rather than hindering a deep appreciation.

4.2.5 *Example 5: Field study at an exhibition by Ruth Loos.* The least conventional study we have done so far is a field study we carried out at the exhibition *Het boek verbeeld(t)* by Ruth Loos in Sint-Niklaas (March 2009). All of the work by Ruth Loos at this exhibition pertained to the book object, the book as an object, in addition to the book as a content-holder of a text with meaning, in addition to text as scripture, symbols, texture, and so. (for more background, see Loos 2011 elsewhere in this special issue). Ruth exploits the multidimensionality of books in her artworks and strengthens it further by exposing her artworks in particular ways,

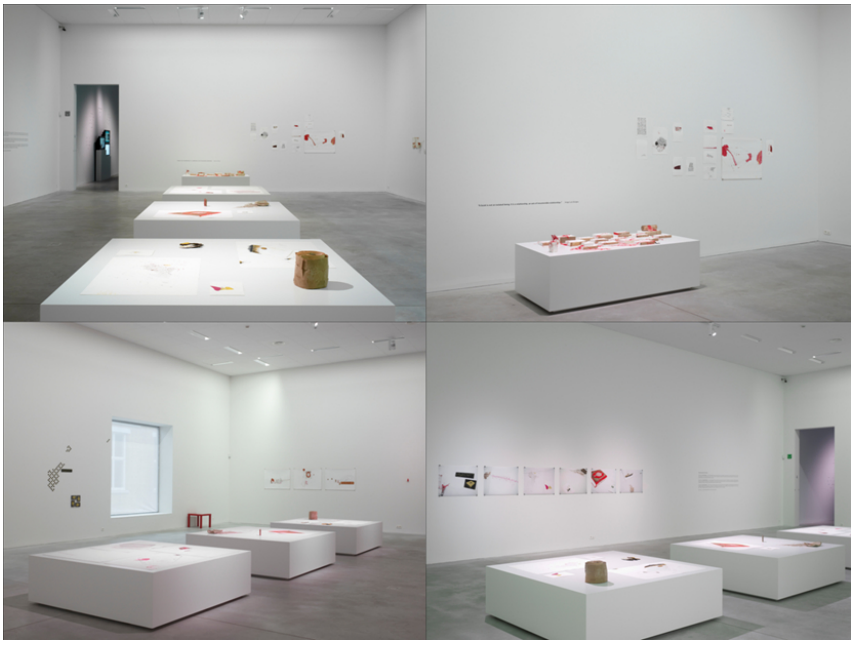

Figure 13. A photograph from Wendy Morris's artworks on display at the Parallellepipeda exhibition at the Leuven City Museum M (January to April 2010, photograph taken by Kristien Daem).

with plenty of cross-references between the different works (eg, the original book, digital photographs of the book from different angles, paintings inspired by those photographs, compositions with pieces of those photographs, threads which could be seen as letter strings that have run away from the text printed in the book). Such an exhibition usually forms a true Gestalt, which is clearly much more than the sum of the artworks brought together, but we wondered whether the casual visitor normally extracts those interrelationships between the works, and whether the extent to which they do so affects their appreciation of the exhibition.

To examine this, we divided the exhibition in two halves, each consisting of an equal number of works, with a comparable level of cross-referencing and cohesion. All visitors who volunteered to participate in the study were given some explanation about the artist's work, the different materials used, the different dimensions of the work, some relations between the works, and so on, while they were looking at the work together with their personal guide in one half of the exhibition (eg, A+); they were also given the freedom to explore the other half of the exhibition on their own (eg, B–). All participating visitors were assigned to one of four conditions with different orders between the part with (+) and without (–) the explanation: A+/B–, A–/B+, B+/A–, and B–/A+. After each half, they were asked to fill out a number of standard questionnaires about their appreciation of the artwork (eg, interesting, pleasing, attractive, original), and a semi-structured interview was taken to assess their perception and understanding of the work. In the analyses, we could then relate their perception and understanding to their appreciation, determine effects of the intervention, and so on.

The specific results will not be presented here, but it is clear that there is a lot to be learned from this approach. The kind of manipulation we carried out here seems to do justice to the full-fledged delicacy of the individual artworks and the overall exhibition, the personal interviews provide complementary information to the standard questionnaires, and the interaction between researcher/guide and visitor/participant was usually quite pleasant to both parties. More generally, the artist-investigator-visitor relationships constitute significant added value to this kind of research. When one is interested in complex and rich processes such as those involved here, it appears more appropriate not to squeeze them into a

randomized list of trials with fixed stimulus-response sequences. We wanted to repeat the study with a different collection of works in a different exhibition (*Parallellepipeda* at M, see Figure 14), but organizational obstacles and some communication problems between scientists and museum officials prevented this. It is clear that this kind of research requires full support and enthusiasm from everyone involved. It is easier to turn such an adventure into a failure than into a success.

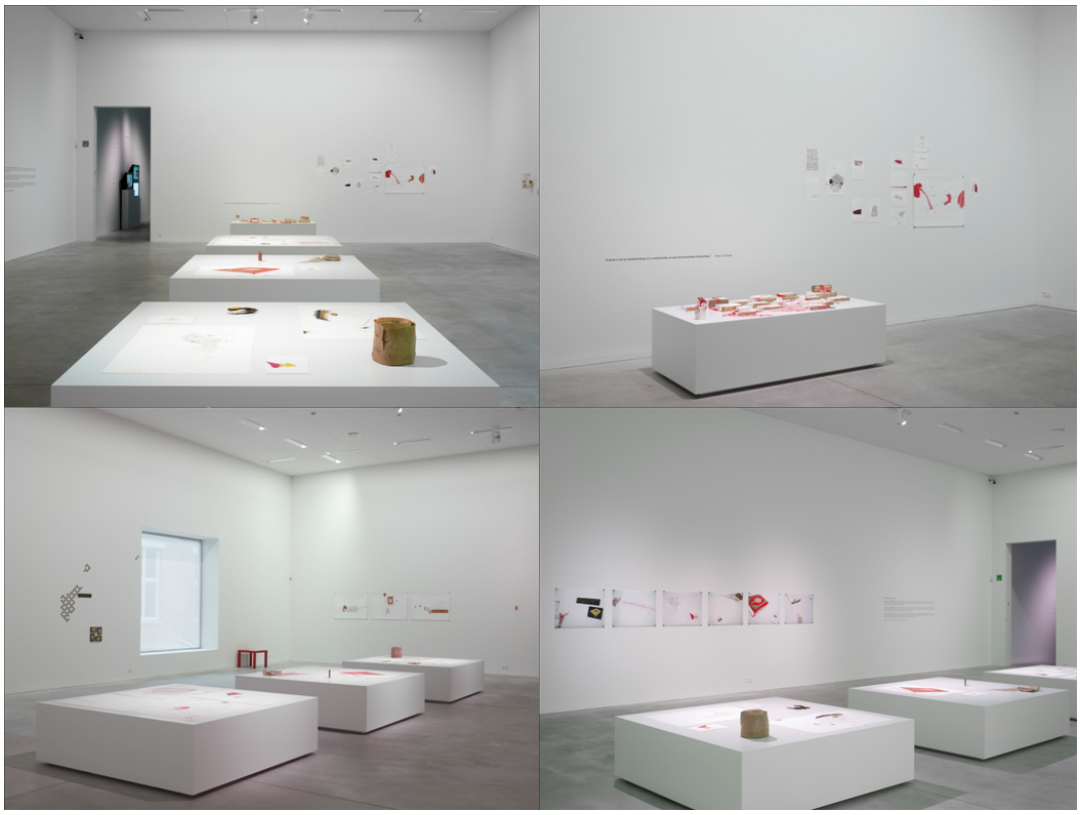

Figure 14. Four photographs from Ruth Loos's artworks on display at the *Parallellepipeda* exhibition at the Leuven City Museum M (January to April 2010, photographs taken by Kristien Daem).

4.2.6 *Conclusion.* Whereas the two first examples above could be considered relatively standard psycho-aesthetic experiments, the last three examples are somewhat less typical because the artists' involvement was larger than usual. These three projects all belong together in the sense that they all investigate the influence of additional knowledge on the way of looking at a work and how that affects the total aesthetic appreciation. The way this issue is addressed here does full justice to the artwork and the artist's interests, while at the same time yielding reliable and valid scientific information. In spite of considerable differences between the methods of these studies, the results seemed to converge to some common conclusions, at least on a general level. We often found an effect of additional information, a difference between novices and experts, and a shift with increasing experience (eg, multiple viewings of the same work), which could be described as a shifting balance between order and complexity, in the direction of tolerating more complexity, and acquiring more order by establishing more connections between parts of an artwork and more associations to the artwork. In some sense, this comes down to creating a stronger Gestalt, discovering additional relations within and towards the artwork as a whole, and thereby mastering the work so that it "sticks" better. Moreover, these results go well with the findings that people

with a background in the arts show more detailed and differentiated categorizations of art (Augustin and Leder 2006) and evaluate abstract art more positively than people without art background (eg, Furnham and Walker 2001). Finally, in sometimes surprising ways, these studies have also inspired new ways of exposing artwork and perhaps even future artwork. All this is more than we could have expected from this project in the beginning.

5 Reflections on the *Parallellepipeda* project

Looking back on the project, I can distinguish three stages we went through. After describing these stages briefly, I will try to distil some general implications from this project, at least from my personal point of view.

5.1 A personal reflection in retrospect

5.1.1 *Looking and art — Artworks as stimuli.* In the first stage, my research on visual perception and the work done by the artists were parallel, separated worlds. Even when I did research on visual perception of art, I continued to work according to the standard model of experimental psychology of visual perception: The researcher selects and manipulates a visual stimulus (eg, an original artwork and versions derived from it), assigns a task to the participants (eg, sorting), and registers responses (eg, numbers on a rating scale). Looking and art are then quite separate ontological entities. Artworks are merely used as stimuli and this type of research seldomly penetrates to the core of aesthetic experiences. It is not hard to imagine that artists do not value this type of research highly.

5.1.2 *Looking at art — Artists as a source of stimulation and inspiration.* By receiving an internal look in the environment in which the artist works and her world of experience, and by looking at art together with the artists, I have gained much additional insight into art, into what drives the artists, how they work, how they look, what they try to express and try to induce, how they think and feel, how they influence the thoughts and feelings of the spectator looking at their art and experiencing their art, and so on. By the intense interactions with artists within this project, I now look differently at art and also my view on visual perception has changed. I see better now that visual perception cannot be separated from knowledge, expectations, context, feelings, bodily sensations, and so on. In fact, I knew this all along, but because I could not do much with this as a scientist, it was easier to put it between brackets. I find it somewhat easier now to handle this additional complexity, also in my own way of looking and doing research on perception. Artworks are no longer mere stimuli. Artists are now sources of stimulation and inspiration.

5.1.3 *The art of looking — Artists and scientists in a truly mutual collaboration.* By looking at art together with the artists and by talking together about their intuitions about looking, I no longer look with the reduced, analytical vision of a scientist. My view is broader and more dimensional now. I can make more associations while looking, and I can switch more flexibly between multiple registers of perceiving. As a result of this unique experience of a truly mutual collaboration with artists, my way of perceiving and experiencing art will be forever more intense, less abstract-rational, and more bodily-emotional—less scientific and more artistic in a sense. Perhaps that is the best way of describing the development I made during this project: Perhaps I have become somewhat less of a scientist and somewhat more of an artist, beyond the limits of the two prototypes. And by this, I have probably become also a broader, fuller and deeper scientist. I am intrigued, more than ever, by the art of looking. Through this collaboration, I have come to realize that some artists and some scientists share parallel interests, struggle with the same questions, and are searching for answers in similar or at least equally valuable and complementary ways.

5.2 Towards a new kind of psycho-aesthetics research?

The new kind of psycho-aesthetics research that I see emerging here is defined by a close collaboration with active artists who are scientifically interested and motivated to tackle research questions of joint interest in ways that are found acceptable by both, and yielding results that are both scientifically and artistically valuable and useful. This contrasts with more traditional forms of psycho-aesthetics research in which science and arts remain more separate worlds, usually because the research methods preferred by the scientists imply a reduction from artworks to stimuli and from aesthetic experiences to responses that are no longer of interest to the artists.

This new kind of psycho-aesthetics research uses a multi-method approach, combining more controlled laboratory studies using carefully manipulated but relevant characteristics of artworks and rigorous measurements, with less rigid work in richer contexts and tapping into more private, subjective aspects of aesthetic experiences. The added value of such an approach is obvious, leading to new insights in visual perception, aesthetics, and arts. In addition to immediate scientific results, this approach can also yield long-term enrichment of both the arts and the sciences involved. Bringing art into the lab and research into the museum in this alternative way can lead to innovative kinds of research and art, for instance, when experimental results or ways of visualizing scientific data inspire artists in their future artwork, when new artworks are being considered as "experiments" (eg, trying out different stages or versions of an artwork, discussing on-going artwork with interested colleagues from arts and sciences), and so on. Presenting results of experiments in a museum context, in artistically justified ways, preferably by the artists themselves, can be very rewarding to both artists and scientists. Measuring appreciation in a museum context, preferably in a personal relationship between the researcher/guide and the visitor/participant, can add to the ecological validity of psycho-aesthetics research (for a similar point, see Locher 2011). It might even lead to new ways of exhibiting, by having close encounters between artists, scientists, and visitors who are genuinely interested in such cross-over projects between arts and sciences.

5.3 Possible concerns and limitations

As will be clear from the above, I have enjoyed this collaboration a lot. It is clearly my most precious collaboration and truly enriching experience so far, so I would strongly recommend trying this alternative approach to everyone interested in psycho-aesthetics. However, one should be aware that it takes a lot of effort and time to develop such a collaboration. I also think that its chances of being successful depend a lot on the people involved and on the "chemistry" between them in this kind of personally committing transdisciplinary project probably more than in other types of professional collaborations. Even if the artists and scientists themselves are enthusiastic, the other players involved in the larger context must be able to follow (museum directors, staff, curators, public, media). In the *Parallellepipeda* project, this has not always been the case, and we might even have been more successful with support from all wider circles around the core project being further optimized. The exhibition at M, for instance, did not succeed fully in communicating clearly about the science part of it and the nature of the collaborations between the artists and scientists involved. We have organized some debates in which we could clarify some of this to an audience that was interested in knowing more, but we heard from many visitors that their hunger to learn more about science-and-art from the exhibition was generally not satisfied. We have also missed some opportunities to perform additional research in the context of the *Parallellepipeda* exhibition, which had a great potential for it.

In addition, of course, there are some rather fundamental problems to this new approach towards psycho-aesthetics. For example, working with particular artists almost necessarily has the characteristics of a case study, with all the benefits and problems involved. Extracting reliable and generalizable results from interviews with visitors of exhibitions and museums is far from trivial. The scientific and artistic goals of the projects may lead to conflicting choices. And so forth.

Other limitations concern the ins and outs of such a project. At the input side, it may not be easy to obtain funding for these collaborative projects because the traditional funding bodies usually operate in rather dogmatic and monolithic ways. At the output side, it may not be easy to publish this type of research in traditional outlets (scientific journals, artistic catalogues). Also for artists it is not easy to expose their work together with the science part of it (or even justify the value of the involvement of science in it). Although we feel that there is a potential audience for this kind of cross-over projects, reaching them and serving them is not straightforward.

In sum, a long-term effort by many people will be needed to help in removing the barriers between disciplines to try to develop more of these collaborative projects between artists and scientists as the one I sketched in this paper. I am convinced it is worth the effort.

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