Insights into the instable.

Dynamics in perception and appreciation of ambiguous and indeterminate art

Inaugural-Dissertation

in der Fakultät Humanwissenschaften

der Otto-Friedrich-Universität Bamberg

vorgelegt von

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aus

Grünstadt

Bamberg, den 09.04.2015

Tag der mündlichen Prüfung: 13. Juli 2015

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Zweitgutachter: Universitätsprofessor Dr. Jascha Rüsseler

Acknowledgements

I would like to thank my supervisor Claus-Christian Carbon for his great support, many *insight*ful conversations, and his open-mindedness encouraging me to integrate art and science.

I would also like to thank my colleagues at the Department of General Psychology and Methodology in Bamberg for constructive and inspiring discussions as well as a very good working atmosphere. I am thankful to the students who assisted me with the conductance of the research projects comprised within this thesis.

Also I am grateful to the organizers, members, and visitors of the *Griesbadgalerie Ulm* who not only permitted but also provided personal support for a research project on-site.

I would like to thank the reviewers of this dissertation and of the comprised manuscripts. For proofreading and constructive comments I thank Stephanie Dojani, Regina Muth, and Sabine Albrecht.

Finally, this work would not have been possible without the encouragement and support by my partner, my family, and my friends.

Contents

Abstract

This dissertation presents research projects which investigated dynamics in the perception and appreciation of ambiguous and indeterminate art. It examines how semantical instability in art can induce pleasure in the perceiver although defying an easy consumption. The idea pursued within this thesis is that insights gained during an elaboration of such objects lead to an increase in appreciation (*Aesthetic Aha* effect, Muth & Carbon, 2013)—the creation of meaning itself being rewarding. The comprised research projects examine such dynamics in perception and appreciation of visual artworks which are semantically instable. A crucial quality of these objects might be that they confront the perceiver with semantical instability as well as opportunity for insight: for instance, we like Cubist artworks more the better we are able to discern identifiable objects in them—still they never dissolve into an easy recognizable interpretation (Muth, Pepperell, & Carbon, 2013a). Also the solvability of ambiguity in another set of visual artworks did not have positive effects on liking, interest, and affect. Instead, the strength of insights gained during their elaboration predicted appreciation positively (Muth, Hesslinger, & Carbon, 2015). In line with the *Aesthetic Aha* effect (Muth & Carbon, 2013) also the sudden emergence of Gestalt within indeterminate artistic movies elicited an increase in liking. Interest—in contrast –already increased prior to these moments of insight (Muth, Raab, & Carbon, 2015). The presented findings highlight that art perception does not equal a kind of problem solving process in which semantical instability needs to be resolved for the artwork to appeal. Instead appreciation might benefit from rewarding insights into the instable.

"in confused things
the mind is aroused to new inventions"
Leonardo Da Vinci (translated by Gamboni, 2002, p. 32)

General motivation

This dissertation comprises research projects which investigate dynamics in perception and appreciation of ambiguous and indeterminate visual art. Analogous to Leonardo's claim that "confused things" arouse "new inventions" (translated by Gamboni, 2002, p. 32), it pursues the idea that semantical instability can enable us to gain rewarding insights. While this interest has its focus on art perception and appreciation it roots in art production: my interest in indeterminacy and ambiguity began in 2009 with a series of stop-motion movies manipulating the detectability of more or less vague forms and shapes within intuitive drawings (see Figure 1 and the original movies in Supplementary material 1). A fascination for the sudden appearance and disappearance of Gestalt within a seemingly random entanglement of lines, blots, and scratches made me explore the limits and the variety of pattern evocation as well as the rewarding play with the induction, manipulation, and deprivation of meaning. The qualities of semantical instability on one hand and insight on the other hand motivated the scientific endeavor which will be presented within this thesis.

Figure 1. Exemplary frames of the stop-motion movie *Konstrukte* by Claudia Muth from the year 2009.

The relevance of research on the appeal of semantical instability goes far beyond this specific personal interest. The deliberate creation, reception, and appreciation of ambiguous phenomena can be traced all along the history of the production and reception of cultural artifacts: humans seem to have created ambiguity in images, objects, and language since prehistoric times (e.g., Gamboni, 2002). Modernity in art certainly is a peak within this development that brought forth artworks entailing various forms of—sometimes even unsolvable—contradictions. But also the existence and appreciation of riddles, games, and jokes support the assumption that we seek, deliberately create, and elaborate cognitive and perceptual challenge and semantical instability. Transfers to various fields of interest within psychology, cognitive science, sociology, and educational science are obvious: how much incongruity, surprise, and ambiguity are needed to induce interest, explorative behavior, and learning processes? Is a self-generated insight into challenging material more effective with regard to learning than the reproduction of knowledge? And why is it that popular to visit an exhibition of artworks that violate perceptual expectancies and habits?

1. Theoretical part

1.1 Problem statement

"The more fluently perceivers can process an object, the more positive their aesthetic response" (Reber, Schwarz, & Winkielman, 2004, p. 364). This main assumption of the *Hedonic Fluency Model* (Winkielman, Schwarz, Fazendeiro, & Reber, 2003) describes a potential determinant of the frequently reported preference for symmetric, prototypical, or familiar objects: the ease of their processing. My artistic experiments made use of a quality inherent to so called *hidden images* (as defined by Gamboni, 2002) which— in contrast—are *not* easy to process as they conceal hardly identifiable objects. And there are other ways in which artworks defy an easy processing. A chair-sculpture by Stefan Wewerka (Figure 2) for instance interrupts automatic processes of identification by disappointing perceptual habits and by destructing the chair's affordance character (the set of possible interactions; see Gibson, 1986).

Figure 2. Stefan Wewerka (1969). *Untitled; chair-sculpture, corner chair*. Munich: Pinakothek der Moderne. Photograph by Claudia Muth.

Artworks like these might be comprisable under the programmatic statement of the Russian formalist Viktor Shklovsky (1917/2002):

> The technique of art is to make objects 'unfamiliar' (...) to increase the difficulty and length of perception(...). Art removes objects from the automatism of perception in several ways (Shklovsky, 1917/2002, p. 280; referring to artistic language).

And also the art theorist Konrad Fiedler (1913/1971) pointed out that art is capable to defy an automatic conceptual identification while enriching experience. Berlyne (1971) described this effect of de- automatization as a "reviving of habituated reactions" (p. 149) leading to heightened arousal in the perceiver. In other terms: many artworks disappoint perceptual and cognitive expectations. In drastic terms: they make us experience a breakdown of fluency instead of providing an easy consumption. Are these artworks thus less appreciated than objects with determinate meaning which can be more easily processed? Do they appeal due to another mechanism or do they affect another facet of appreciation than objects which provide ease of processing? The main

question underlying this scientific endeavor is consequently how semantical instability in art can induce pleasure.

1.2 Structure and rationale

The here presented research projects aim to shed light on this question by introducing dynamics: instead of matching static responses of participants to static qualities of stimuli they investigate perceptual, cognitive, and affective processes involved in the elaboration of visual artworks. The idea developed and refined throughout the research program is that insights gained during this elaboration lead to an increase in appreciation—the creation of meaning being rewarding by itself. From this perspective the processing of art is a dynamic, insight-driven elaboration which does not have to result in a determinate resolution of semantical instability to induce pleasure in the perceiver.

The following text is structured along an extensive introduction to the phenomenon of semantical instability in art and five publications, three of them representing the cumulus of the dissertation (each named *Core publication* hereafter) and two of them complementing the cumulus by further publications (each named *Peripheral publication* hereafter). Peripheral publication I (The Aesthetic Aha: On the pleasure of having insights into Gestalt; Muth & Carbon, 2013) establishes a mechanism which is the basic empirical fundament of the argumentation: the detection of facial Gestalts within a two tone image induces an increase in liking. For this *Aesthetic Aha* effect (Muth & Carbon, 2013) to occur, it might be crucial that the object confronts the perceiver with a simultaneity of semantical instability and opportunity for insight. Accordingly, Core publication I (Give me Gestalt! Preference for Cubist artworks revealing high detectability of objects; Muth, Pepperell, & Carbon, 2013a) reveals that the ease of the detection of concealed objects within a Cubist artwork predicts its appreciation positively—even if the stimulus material is indeterminate and strictly speaking unsolvable. Is it thus rather the struggling with semantical instability during art perception which is rewarding (as proposed for instance by Ramachandran & Hirstein, 1999)? Core publication II (The appeal of challenge in the perception of art: how ambiguity, solvability of ambiguity, and the opportunity for insight affect

appreciation; Muth, Hesslinger, & Carbon, 2015) allows us to differentiate accordingly between the solvability of ambiguity and the strength of insights. It reveals that—indeed—the strength of our own insights during elaboration but not the solvability of ambiguity predicts changes in appreciation positively: the activity of sense-making might be rewarding by itself without necessarily resolving semantical instability. It also highlights that a multidimensional account of appreciation is crucial, the variable of interest being a promising candidate for representing the appeal of challenge in art. Peripheral publication II (M50X: Methoden zur multidimensionalen und dynamischen Erfassung des Nutzererlebens; Raab, Muth, & Carbon, 2013) builds the grounds for a finer grained picture of the involved dynamics via the so called *CEP* (*Continuous Evaluation Procedure*) which is applied in Core publication III (The stream of experience when watching artistic movies. Dynamic aesthetic effects revealed by the Continuous Evaluation Procedure; Muth, Raab, & Carbon, 2015). This final research project investigates dynamics in perception and appreciation by making use of the film material introduced in the first chapter of this thesis (see Figure 1 and the original movies in Supplementary material 1). It extends the previous finding of the *Aesthetic Aha* effect (Muth & Carbon, 2013) by including much higher temporal resolution and a multidimensional account of appreciation. Its combination of dynamics and multidimensionality allows for the establishment of a preliminary model of the relationships between complexity, interest, and liking during the perception of indeterminate artistic material—a set of mechanisms which are highly relevant to the appeal of semantical instability in art. Each publication is introduced by a short description of the according motivation. After providing the original article in its original form a critical reflection puts its findings into the thematic context and builds connections to the precedent and subsequent publications. A general discussion summarizes all findings of the assembled articles, reflects on their relevance for the main question of this dissertation, and sketches important limitations of the applied approaches and issues to be debated and investigated in the future.

Before the articles are presented, the next chapters are dedicated to a detailed introduction of the phenomena of semantical instability and ambiguity from art theoretical, art historical, and psychological viewpoints. This extensiveness proved

necessary due to the fuzziness of the involved concepts, their distinctive role in visual art, and the variety of according theoretical accounts in psycho-aesthetics.

1.3 Introduction to semantical instability in art

1.3.1 Labels and definitions

Many artworks defy determinacy of meaning by inducing a variety of potential meanings. This thesis refers to this general quality via two concepts: *semantical instability* because it comprises a large set of according phenomena and because it is evocative of a dynamic quality as well as *ambiguity* because it is often used in the literature as a collective term. This chapter introduces these concepts as well as more specific phenomena in detail to arrive at concise definitions referred to throughout this thesis. Part of the conceptual challenge hereby lies within the interdisciplinarity of the topic. In the art theoretical domain for instance Krieger (2010) subsumed phenomena like *ambivalence*, *openness*, *multistability*, *mysteriousness*, and *indeterminacy* as well as *polysemy*, *homonymy*, and *vagueness* under the concept of *ambiguity* and provided a differentiated analysis of different varieties of *ambiguity*. A psychological account of *ambiguity* by Zeki (2004) differentiates it fundamentally from phenomena like *openness* and *indeterminacy*: here, *ambiguity* describes an instability between determinate solutions, several certainties with the same probability (other psychological accounts use a wider definition of *ambiguity* though, see, e.g., Jakesch & Leder, 2009; Mamassian, 2008). In Figure 3 for instance you can detect either a vase or two faces; both are equally likely but never present at once. While here, the term *instability* refers to *several stabilities*, *potential* (Gamboni, 2002) or *indeterminate* (Pepperell, 2006) images promise to contain identifiable patterns but never provide entire *determinacy*. This is for instance the case in Cubist artworks being evocative of recognizable patterns but hindering Gestalt recognition: “each hypothesis we assume will be knocked out by a contradiction elsewhere” (Gombrich, 1960/2002, p. 240). The differentiation between *indeterminacy* and *ambiguity* gets difficult to draw if we imagine a continuum between *determinacy* as full stability, *bistability* as a switch between two stabilities (e.g., Zeki, 2004), *multistability* as a switch between several stabilities (e.g., Berlyne, 1971; Kubovy, 1994), and *indeterminacy* as an infinite number of potential stabilities.

Figure 3. Smithson, J. (2007). *Rubin-Vase*. Retrieved from http://en.wikipedia.org/wiki/File:Rubin2.jpg

To furthermore highlight the difficulty of a differentiated conceptualization, we can note that the phenomena of *indeterminacy* and *determinacy* have a dynamic character and both can qualify the perception of a *hidden image*. Take the movies introduced at the beginning of this thesis: out of an *indeterminate* pattern a *determinate* Gestalt emerges (see Figure 1 and Supplementary material 1). Peripheral publication I made use of such *hidden images* like the one in Figure 4A allowing you to find a face within a pattern of black dots. In contrast, Figure 4B shows an *indeterminate* painting which motivates you to search for identifiable bodies without providing *determinacy*. This difference is crucial with regard to the idea pursued within this thesis: an insight into the hidden face in Figure 4A is a rewarding *Aha* experience (see Peripheral publication I; Muth & Carbon, 2013). But what if the detected Gestalt is at most a fragment as in Figure 4B and for instance in Cubist artworks (see Core publication I; Muth, et al., 2013a)? It can be shown that expectation plays a major role here: the name of the *indeterminate* painting *Paradox 1* for instance underlines that there is incongruity between our expectations to find bodies within the images and the actual lack of *determinacy*. Paradoxes are also present in rather conceptual works; think of the famous representation of a pipe by René Magritte in *The Treachery of Images* which he added by the sentence “Ceci n’est pas une pipe” (“this is not a pipe”). Both

examples play with incongruence between anticipation and actual stimulus. The variable of *incongruence* was discussed among other so called *collative variables* by Berlyne (1971). These variables describe a *collation* between object-internal elements or a divergence between perceptual cues and expectations. The variable *novelty* for instance describes a collation between elements of here-and-now with elements experienced in the past. Still, it is not always an effect of a violated expectation as we can expect *novelty* (Berlyne, 1971). The collative variable of *complexity* defines the number of collating (in)dependent elements. Berlyne (1971) related it to arousal and uncertainty due to the growing opportunity for conflict with an increasing number of elements. *Conflict* exists between incompatible simultaneous processes; it applies to novelty, surprise, uncertainty, and complexity. Finally, in Berlyne's (1971) conception *ambiguity* describes a collation of multiple meanings, and *instability* exists in elements which do not conform to a referenced pattern. *Collative variables* are clearly linked to the phenomena described above. *Hidden images* might induce surprise by a *conflict* between expectation of *indeterminacy* (random pattern) and sudden perception of determinacy (face); even more so as *hidden images* can be *accidental images* (Gamboni, 2002) if they unintentionally form Gestalt like when we see a lamb in clouds. Also, *indeterminacy* might be linked to the *collative variable* of *complexity* due to the high number of potential elements and to *instability* as it does never entirely fit to one interpretation or Gestalt alone. Furthermore, Berlyne's (1971) analysis underlines that instability of meaning is about relationships—between elements, between hypotheses, as well as between expectations and perceived elements. For our understanding of the concept of *semantical instability* as well as for empirical approaches examining its effect on appreciation it is thus crucial to specify the kind of collation of the according material and to include the role of expectation.

Figures 4. A) *Hidden image*: We are able to reduce *indeterminacy* as soon as we detect a face in the left display (highlighted in red in the right display). B) *Indeterminate* or *potential image*: Robert Pepperell's (2005) *Paradox 1* provides cues for potential detection but never reveals a determinate Gestalt.

Several open questions regarding the definition of *ambiguous* phenomena become obvious if we look at a concrete example: the neurobiologist Semir Zeki (2004) applied his definition of *ambiguity* as switch between equally probable interpretations not only to *bistable* figures but also to artworks, e.g., to the facial expression of the girl depicted in Vermeer's *The Pearl Earring* from the year 1665. The rationale is that—analogous to the detection of vase versus face in Figure 3—her facial expression offers different interpretations: "at once inviting, yet distant, erotically charged but chaste, resentful and yet pleased" (Zeki, 2004, p. 189). But *semantical instabilities* like these might not actually be reducible to a switch between determinate interpretations. They eventually build up new categories integrating the inconsistencies within one object. Think for instance of the androgynous fashion style of Berlin women in the 1920s. Despite once having been *ambiguous* with regard to perceptual habits and semantic connotation of stylistic elements, it is a rather determinate pattern of style from today's perspective. Again, a differentiation of *semantical instability* with regard to the actual relationships between elements is useful here. We might describe our experience of the facial expression in Vermeer's painting with reference to Berlyne's (1971) *collative variables* as *novel* due to a mismatch with patterns of familiar facial expressions and as *incongruent* due to conflicts between elements associated with different partially mutually exclusive meanings. Instead of an *incongruity*—implying simultaneity of

conflicting interpretations—Zeki (2004) proposes an oscillation between interpretations. The expression of the face might even be *instable* in Berlyne's (1971) sense as it does not resemble a typical pattern (it does not provide *Prägnanz*; see Berlyne, 1971). Another insightful account of how conflicting elements and interpretations can relate to each other in *ambiguity* is provided by Kaplan and Kris (1948; with regard to linguistic *ambiguity*). They speak of *projective ambiguity* when meaning differs across perceivers, *disjunctive ambiguity* when mutually exclusive interpretations are induced, *additive ambiguity* when there is overlap between interpretations, *conjunctive ambiguity* when several meanings contribute jointly to an interpretation for instance in irony and humor, and *integrative ambiguity* when several meanings are divergent but build one complex meaning together—like it might be the case with the girl's facial expression. Besides these theoretical suggestions, empirical approaches to a categorization of *ambiguity* in art are rare (see, e.g., Muth & Carbon, 2012) but seem highly important with regard to the fuzziness of the applied concepts as well as to the overlap of according phenomena.

Another challenge for a clear definition of *ambiguous* phenomena concerns the sensitivity to context: Gaver, Beaver, and Benford (2003) gave a theoretical account on three types of *ambiguity* in design. They stated that not only object-based information can be *ambiguous*—also determinate information can become *ambiguous* in certain contexts. So called *Ready Mades* are industrially produced objects exhibited in an art context which make use of this technique by being everyday objects and potentially meaningful artworks alike. And as a third option *ambiguity* "arises from the viewer's personal relationship with the piece" (Gaver et al., 2003, p. 237). Especially the latter type of *ambiguity* seems highly relevant for product design but as well if you think about contemporary *Relational art* (Bourriaud, 1998) which includes participation of the audience, for instance by organized Swarm-Happenings evoking discussions on the usability of public space. Here, people's interactions make up the artwork in the first place. Pretend play is even another example for the relevance of the relationship between object and perceiver as a source of *ambiguity*. Here, an object changes its meaning due to a new way of interaction, a *re-enaction* of meaning (Di Paolo, Rohde, & De Jaegher, 2007)—using a hairbrush as a microphone for instance. As will be described

in the next chapter—not unlike play—art makes us of and violates general perceptual habits; *semantical instability* might even be a cultivated feature of art. The perception scientist Pascal Mamassian (2008) accordingly described ambiguities in art along with conventions how they are perceived, applied, and rooted in general perceptual constraints (for instance the way Egyptian art presents human contortions). He analyzed conventions with regard to composition, spatial scale, illumination and color, three-dimensional layout, shape, and movement.

To conclude: within this thesis *semantical instability* and *ambiguity* will be used as comprising terms for various characteristics of objects defying a determinate interpretation. More specifically it will be referred to *hidden images* if objects conceal identifiable patterns, *multistability* if several meaningful patterns can be established and *indeterminacy* or *potentiality* if objects are evocative of an identifiable pattern but never provide determinate identification. The review of the various kinds of *semantical instability* from art historical, art theoretical, and psychological perspectives revealed that they differ in the way perceived elements and expectations relate to each other. The characteristics of some of these relationships are of great use for the empirical investigation of effects of *semantical instability* in art: a *hidden image* as the one in Figure 4A for instance allows for comparing effects of *indeterminacy* (random elements) on appreciation with those of determinacy (face). Peripheral publication I accordingly examined the effect of the sudden detection of a facial Gestalt on liking (Muth & Carbon, 2013). *Potential* pictures—in contrast—provide the opportunity to see how an ongoing disappointment of expectations affects the perceiver. This was highly relevant to Core publication I which shed light on the appeal of Cubist artworks and to Core publication II examining if we can appreciate art even if *indeterminacy* cannot be resolved with elaboration. Core publication III furthermore dealt with the role of expectation which—as the current chapter highlighted—is a crucial factor for the induction of *ambiguity* and—as will be shown—plays a great role for the arousal of interest as well.

1.3.2 Specifics of semantical instability in art

The question how *semantical instability* in art can induce pleasure might as well refer to the perception of non-easy objects in general: finding Wally in a crowd of similar people (a kind of *hidden image*), or finding out what your child intended to draw (might get close to *indeterminacy*), seeing a new car design for the first time, or being overtaxed by a map of New York—why focusing on art perception? *Ambiguity* is claimed to be a characteristic of especially modern art from the perspective of art theory (e.g., Gamboni, 2002; Krieger, 2010; Shklovsky, 1917/2002) as well as from the perspective of perception science (e.g., Jakesch & Leder, 2009; Mamassian, 2008; Van de Cruys & Wagemans, 2011; Zeki, 2004). But is there something specific about the *semantical instability* in artworks? As these questions seem highly relevant to the whole endeavor of this thesis an overview on three main arguments shall be given within this chapter before the text turns to psycho-aesthetic accounts of the appeal of *semantical instability* in art.

One answer to the question of the specificity of *semantical instability* in art is that *semantical instability* is a cultivated, historical feature of art. The paradigmatic character of *ambiguity* as a quality characteristic is applicable to art at least since the epoch of modernity starting around the beginning of the 19th century (see, e.g., Krieger, 2010). But "several ways" to a de-automatization of perception—as intended by Shklovsky (1917/2002)—were already undertaken before. For instance it is suspected that Albrecht Dürer concealed faces in drawings of pillows in 1493 (see Gamboni, 2002). And deliberate *ambiguous* manipulations of picture elements occurred frequently from the 16th century on. Back then, art went beyond the religious context which had demanded the generation of symbolic motives offering a determinate interpretation (a specific saint had to be identifiable as such; see Krieger, 2010). Popular examples from this era are Arcimboldo's visual compositions of vegetables, fruits, and other objects which together resemble a human head. It might be useful to look at an analysis of the beginning of modernity in art, especially in painting, to understand why modernity and *semantical instability* are often explicitly linked to each other. According to Meinhardt (1997) the invention of photography and other techniques of reproduction in the mid-19th century induced a crisis for painting—a photograph being the 'better' depiction.

Threatened by its replaceability painting had to explore its possibilities asides the mimetic function. Subsequent artistic approaches can be understood as a response to that threat; they focused less on the represented *sujet* but reflected for instance on the process of perception itself (e.g., in impressionism) or on the activity of painting (e.g., in expressionism; Meinhardt, 1997). According to Meinhardt (1997) painting was shaken by another crisis in the beginning of the 20th century induced by Marcel Duchamps' first *Ready Mades*. The aesthetic experience of an artwork, its status *as* an artwork as well as the supposition of meaningfulness of an artwork were exposed as social conventions bound to the context of a gallery or a museum. The subsequent route of self-reflection in art and its reflection of its own conventional context can again be understood as a response to that second crisis (Meinhardt, 1997). For instance, monochrome paintings deprived the image of a representation (the illusory layer) and thus pointed to the *ambiguity* of material and illusory layer of pictures in the first place. Another way to make such an *ambiguity* explicit was taken by Lucio Fontana in the 1950s and 1960s who pointed to the materiality of a painting by cutting the canvas. Among the different manners of self-reflection art movements like *Art Informel* aimed at a total deprivation of objects from associations and intentionality (Krieger, 2010). Here, *semantical instability* refers to an intentional openness during the production of artworks. According to Eco (1989) an *open artwork* is thus "characterized by the invitation to make the work together with the author" and "is effectively open to a virtually unlimited range of possible readings" (p. 21). If a total lack of associations is possible though is highly questionable from a psychological view promoting strong effects of knowledge on perception. Other modern as well as postmodern means to induce *semantical instability*—besides, e.g., the context shift inherent to *Ready Mades* and intentional openness in *Art Informel*—are for instance contradictions among style and content, contradictions by multiple perspectives and techniques like collage, or recourses on other artworks (Krieger, 2010).

A second argument for the specificity of *semantical instability* in art might come from a sociologist perspective: the level of *ambiguity* might not stem from the artwork's features alone but might be bound to historical changes in reception. Krieger (2010) highlights that nowadays *ambiguity* is widely perceived as an aesthetic norm

influencing the judged quality of an artwork; great art has to be challenging and semantically instable. Also, beyond its aesthetic impact, *ambiguity* in art fulfills the function of social distinction. This point clarifies that a work of art is a historical artifact and an aesthetic object at the same time and thus its reception is different at different time points in history (Krieger, 2010).

Even another answer to the question is that at least mimetic paintings are *ambiguous* per se: they always entail simultaneity of a material layer—canvas and color—and an illusory layer—the depicted content (see, e.g., Gombrich, 1960/2002; Krieger, 2010). Gregory (1970) even claimed in this regard that "[p]ictures have a double reality"; they are paradoxical (p. 32). Importantly, from a psychological perspective, this co-existence might not necessarily pose a challenge to the observer who is trained in looking at representations—at least unless he or she is pointed to it. That we acknowledge the dual nature of a painting being material *and* image—even if we might not be aware of that—is reflected in the point that we do not take the depicted as real; illusion here is not delusion. In other words: "[i]f art actually has the power to convince us that appearances are reality, perhaps it ought to be outlawed along with hallucinogenic drugs" (Burwick, 1990, p. 122). This point furthermore questions the exclusivity between the experience of form versus the experience of content: if we focus on an artwork's content we never entirely exclude the fact that we are confronted with a representation—this seems also true when singing in a hairbrush. While the question if we can be conscious of various interpretations of an object at the same time is only peripheral to the here comprised empirical research projects it actually lies at the very core of the theoretical conception of *ambiguity* and *semantical instability* as well as of its appeal. A short excursus to this topic for the sake of completeness might thus be beneficial to this thesis:

From a classical psychological view the principle of exclusivity forbids a simultaneity of states or meanings and thus explains sudden switches between interpretations in *multistable* perception (Leopold & Logothetis, 1999). Similarly, in the domain of art history and philosophy, Gombrich (1960/2002) argued that we are not able to be simultaneously aware of conflicting interpretations of a *bistable* picture; instead "[i]t is through the act of 'switching' that we find out that different shapes can be

projected into the same outline" (p. 198). Accordingly, we would not be able to regard the surface *and* the represented scene of a painting simultaneously as "we cannot, strictly speaking, watch ourselves having an illusion" (p. 5). In contrast, Richard Wollheim (1982) developed the concept of *seeing-in* which would qualify each kind of representational perception: our capacity to perceive a depicted scene *in the way* it is represented. This would enable us in the first place to praise a good painting by the way it represents an object via brushstroke and color like we are able to fuse phoneme and meaning in lyric poetry. On the other hand, as described in Berlyne (1971), visitors of exhibitions might step forward and backward oscillating between a focus on the represented content versus a focus on the form—e.g., color and composition—of an artwork. With regard to pretend play—in which something is represented by something else as well—we might ask if we oscillate analogously between microphone and hairbrush or if we rather use the microphone as represented in form of the hairbrush (to roughly refer to Wollheim's idea of *seeing-in*). Furthermore, despite being mutually exclusive, we don't seem to experience a conflict between the two interpretations of the object. Berlyne (1971) contributes to the question of simultaneity of elements or hypotheses in *ambiguity* by taking yet another perspective:

> An expectation can be associated with more or less confidence or "subjective probability." It follows from this that expectations of several mutually exclusive events can occur in the same individual at once (Berlyne, 1971, p. 144).

In other words: uncertainty is induced by a deviation of actual perceptual cues from our expectations and this signifies that there might be a simultaneity or collation between perceptual hypotheses or between hypotheses and actual perceptual cues. *Semantical instability* might thus be marked by such an ongoing mismatch in the case of *potentiality* or *indeterminacy*. The question of simultaneity in *semantical instability* is quite relevant to our understanding of perception in general; think of the duality with which we are confronted every day when perceiving a coin as round while seeing it as elliptic from most perspectives (see an overview on an according philosophical discussion in Noë, 2012). In the case of art perception it might even be crucial for an aesthetic effect that we experience incongruity between the two layers of content and form: the psychologist Lew Wygotsky (1976) pointed to the fact that material and

content are never independent of each other; the same figure made either of paper or of bronze will have a completely different appearance and effect on the perceiver. This dependence gets obvious in the poetic induction of contradictions between the form of a verse and its content—for instance by utilizing a meter which differs from the natural rhythm of the words. The rhythmic distortion between content and form—the way in which the words' content is represented—might affect our appreciation of the poem to a great part. The crucial point with regard to the topic of this thesis is that some aesthetic effects in art seem to require an according simultaneous dichotomy between content and form: a disappointment of familiar perceptual patterns, a breakdown of fluency.

This chapter discussed three arguments for the specific link between *semantical instability* and art: first, *semantical instability* is a cultivated, historical feature of art. Second, also the reception and appreciation of *ambiguity* in art is dynamic and linked to conventions; nowadays *semantical instability* is a normative quality characteristic. Third, representational art always entails ambiguity by a conflict between material layer and illusory layer. The question if this conflict equals a simultaneous incongruence is strongly debated and underlies the theoretical conception of *ambiguity* as well as the examination of its effects on perception in general.

With an examination of phenomena and art-specific aspects of *semantical instability* at hand, the next chapter turns to theoretical accounts of psycho-aesthetics which are tightly related to the main question of this thesis and the subsequently presented research projects.

1.3.3 The appeal of semantical instability

The psychological examination of art perception is a focus of the research field of psycho-aesthetics having itself a large intersection with neuro-aesthetics. A typical definition of aesthetic experience in these domains reads like this:

> an aesthetic experience is one that allows the beholder 'to perceive-feel-sense' an artwork (from the Greek aisthese-aisthanomai), which in turn implies the activation of sensorimotor, emotional and cognitive mechanisms (Di Dio & Gallese, 2009, p. 682).

This dissertation indeed investigates such processes of perception, affect, and appreciation during the perception of visual art. Still, we certainly can imagine aesthetic experiences which cover a wider range of situations and encounters than the ones including art works—for instance during the observation of nature. Furthermore, we might even doubt if every encounter with an artwork necessarily leads to an aesthetic experience. And vice versa, aesthetic experience might have more specific facets than the activation of perceptual, emotional and cognitive mechanisms in general—which is true for many objects. We can differ for instance between effects of beauty and the sublime as well as between affective qualities of aesthetic peak experiences—the *Aesthetic Trinity Theory* for instance differentiates between three concepts with regard to the quality of experience as well as to the frequency of its appearance (increasing with order) "aesthetic awe, being moved or touched, and thrills" (Konečni, 2005, p. 27; see also a recent discussion of according empirical data in Konečni, 2015). Psycho-aesthetic research and theory provides at least three different theoretical models which are highly relevant to the investigation of the appeal of perceptually and cognitively challenging visual objects. As it is referred to them repeatedly throughout the reported publications, they shall be introduced here in short.

a) Appeal by fluency of processing

Easy, familiar, symmetrical, or prototypical objects can be processed more fluently than their counterparts and according to the *Hedonic Fluency Model* (e.g., Winkielman et al., 2003) such high processing fluency is marked by positive affect (for a review see Reber et al., 2004). Fluency can be perceptual—when it "reflects the ease of low-level, data-driven operations that deal primarily with surface features of the stimulus, or its perceptual form" as well as conceptual—referring to "the ease of high-level operations concerned primarily with categorization and processing of a stimulus' relation to semantic knowledge structures" (Winkielman et al., 2003, pp. 199-200). The *Fluency Attribution Model* (Bornstein & D'Agostino, 1992) furthermore states that their positive effect is then misattributed to the object itself: a prototypical object might for instance be liked more than a non-prototypical one because of its fluent processing characteristic. Evidence for the relationship between familiarity and liking is provided, e.g., by the *mere exposure* effect (originally reported by Zajonc, 1968). Here, liking increases with

the number of unreinforced presentations of a stimulus—and thus supposedly by an increase in fluency of processing via familiarity. With regard to the main question of this thesis how non-easy stimuli might appeal, it is thinkable that in some cases conceptual fluency (e.g., an interpretation) is high although perceptual fluency (e.g., with regard to processing of contrast or complexity) is low. For instance,

> [c]omplexity may sometimes be preferred because it facilitates access to the meaning of the stimulus. That is, a decrease in perceptual fluency due to complexity may be outweighed by an increase in conceptual fluency due to meaningfulness (Reber et al., 2004, pp. 373-374).

Also, the appeal of *ambiguity* might be explainable by positive effects of fluency via expectation as "when processing is expected to be difficult, yet turns out to be easy, it creates a particularly strong experience of aesthetic pleasure" (Reber et al., 2004, p. 373). After all, aesthetic pleasure certainly is multifaceted (see Faerber, Leder, Gerger, & Carbon, 2010, for an overview on multiple variables of aesthetic appreciation). Thus, low fluency might affect liking in a different way as it affects, e.g., interest. Importantly, the *Hedonic Fluency Model* (Winkielman et al., 2003) was recently discussed with regard to the role of valence: do we actually prefer an object—be it of negative or of positive valence—if it can be more easily processed than its counterparts? Or does fluency rather amplify the evaluation *in the according direction* with objects of negative valence being actually disliked more the more fluent they are processed (see *Fluency Amplification Model* by Albrecht & Carbon, 2014)?

b) Appeal by moderate increases of arousal potential or decreases of high arousal

Familiarity does not always result in increases of liking but is limited by boredom instead (Bornstein, 1989). The integration of a positive effect of familiarity and a negative effect of boredom can be achieved by interpreting both as influences on arousal: Berlyne (1971) proposed that one of two neural reward systems reacts to a moderate rise of "arousal potential or, if one prefers, the psychological strength (…) of stimulation" (p. 91). Such a pleasure can be induced for instance by a moderate value with regard to *collative* stimulus properties (like complexity, instability, novelty, etc.; see chapter 1.3.1). One crucial point hereby is that while arousal might rise with the "degree of change, rate of change, and range of variability" of hypotheses induced by a

pattern (Berlyne, 1971, p. 141), not every kind of *semantical instability* inevitably leads to an irritation in the perceiver. We live quite well with contradictory mental models: we know that the earth turns around the sun but state at times that the sun "rises" and we accept that a photograph is an illusory image on the one hand and paper and color on the other hand. Still, Jakesch and Leder (2009) found indeed that moderately *ambiguous* stimuli are preferred over those of low and high *ambiguity*. *Ambiguity* was defined here as incompatibility between an artwork and additional auditory statements. This idea implies that if we encounter an easy, for instance familiar, object arousal might be too low to appeal; if we encounter a difficult or novel object arousal might be too high to appeal (for a study which—in contrast—points to positive links between novelty and activation of the reward system see Wittmann, Bunzeck, Dolan, & Düzel, 2007). Berlyne (1971) suggests that the reluctance to highly arousing stimuli might stem from the link to dangerous—highly arousing—situations which we should react to with aversion. On the other hand, we might seek novelty and with it high arousal as it motivates exploration and enables us to learn something after all (e.g., Hekkert, 2006). But also from Berlyne's (1971) perspective, difficult objects can allow pleasure via a secondary reward system which inhibits the aversive system and thus "produces reward when arousal is lowered after rising to an uncomfortably high level" (Berlyne, 1971, p. 85). This mechanism might be effective for instance if we decrease the difficulty of a new—highly arousing—stimulus by increasing its familiarity via the number of presentations (see *mere exposure* effect, Zajonc, 1968). Here, it's the reduction of arousal potential which leads to appreciation (for an overview on studies which—in contrast—link high arousal with pleasure see Silvia, 2006). If such a familiarization with the object goes on for too long, arousal becomes too low and boredom sets in. With regard to the focus of this thesis, it is relevant that simple stimuli lead to boredom more quickly than difficult ones:

> The role of boredom as a limiting condition on the exposure effect is supported by the finding that stimulus complexity seems to enhance affect ratings. Presumably, simple stimuli become boring more quickly than complex stimuli, resulting in a more rapid downturn in the frequency-affect curve (Bornstein, 1989, p. 279).

A combination of both processes—an increase in arousal *together* with its decrease—might induce pleasure, as can be exemplified in non-art domains as well:

> There are plenty of examples connected with mild hunger and subsequent eating, sexual activity, or simply the anticipation and consummation of unwrapping a birthday present. Aesthetic patterns may likewise give pleasure through both arousal increase and closely following arousal reduction (Berlyne, 1971, p. 92).

Furthermore, we can imagine objects which are new *and* typical at the same time—in other words *Most Advanced, Yet Acceptable* (*MAYA*, a principle set up by the designer Raymond Loewy and tested in psychological studies by Hekkert, 2006). This fruitful combination inspired Hekkert (2006) to the claim that instead of an exclusive preference for either novelty or typicality "[w]e tend to prefer products with an optimal combination of both aspects" (p. 167). With regard to the main question of this thesis it can thus be assumed that there are suitable, namely moderate, degrees at which *ambiguity* appeals most. As will be reported later-on, Core publication II examined this hypothesis in reference to *ambiguous* artworks.

c) Appeal by reduction of uncertainty

The idea of *predictive coding* states that perception is not a passive reception of information but guided by expectations and knowledge. It is based on the concept of perception as inference by Von Helmholtz (1866; and discussed recently in Clark, 2013). It states that we constantly make predictions, form hypotheses about the world, and match them to current sensory inputs. If there is no consistency between these predictions and actual cues provided by perception our expectations are disappointed. Such a *prediction error* is for instance marked by being surprised, uncertain or irritated. To induce surprise in their participants, Ludden, Schifferstein, and Hekkert (2012) presented objects which looked very similar but differed in tactual characteristics. The level of surprise can be defined here by the level of visual-tactile incongruity: if the hypothesis based on visual cues (e.g., "this looks soft") is disappointed (e.g., "this feels hard"), people are surprised. *Prediction errors* can occur either by such a mismatch between perception and expectation (surprise) or by unusual or contradictory collation of elements (incongruity). This differentiation between a conflict by succession or by simultaneity is hard though because the perception of incongruities involves dynamics, too:

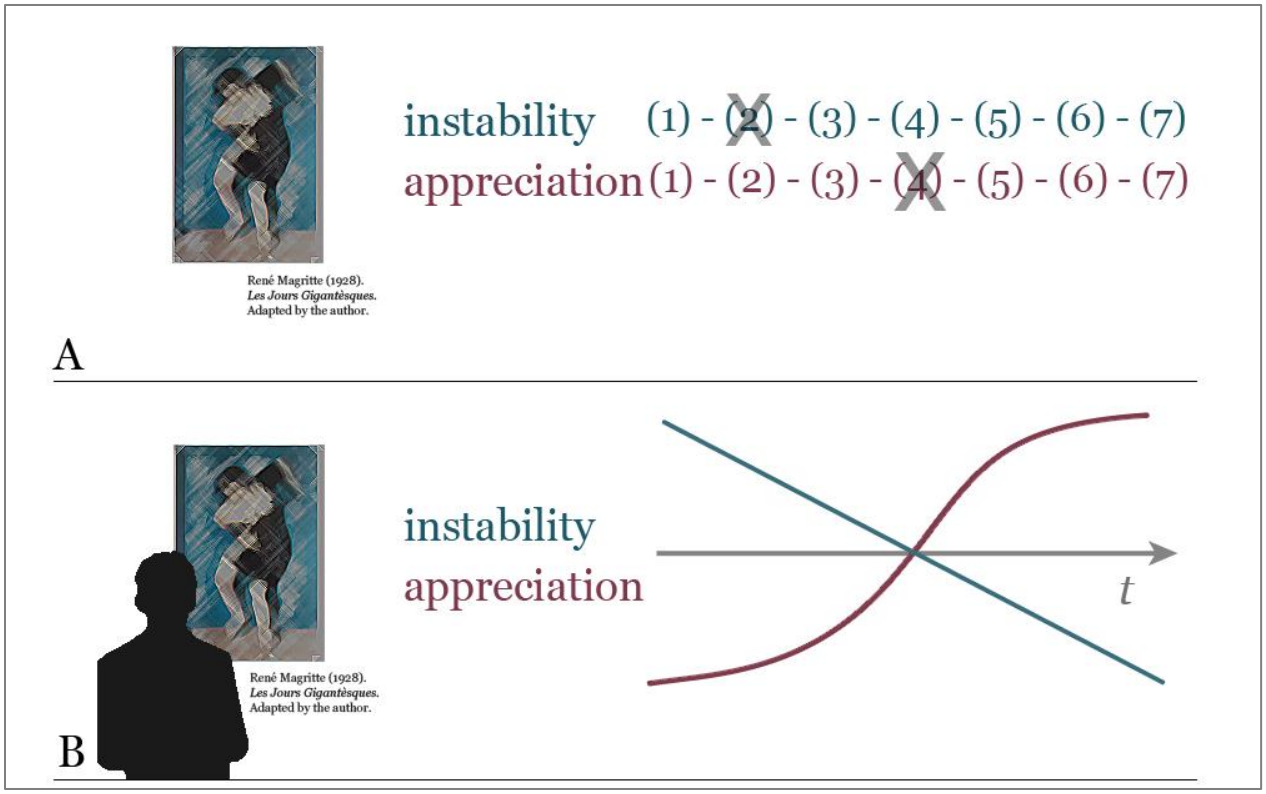
> Elements that are present at the same time are likely to be examined in turn, so that when we are, for example, looking at a large complex painting, what we see in one area arouses expectations that cannot be confirmed or disconfirmed until our eyes move to focus on another area (Berlyne, 1971, p. 145).

Furthermore, Berlyne (1971) suggests three ways in which artists manipulate the beholders' expectations: by violation of expectations (see also Van de Cruys & Wagemans, 2011), by inducing contradictory hypotheses, and by providing no cues at all to form hypotheses in the first place (it is unclear though if it is possible at all not to not provide any cues by which hypotheses can be formed). In the rationale of *predictive coding*, such *prediction errors* would lead to negative affect as the predictions prove to be wrong (Van de Cruys & Wagemans, 2011). Also, in case of high discrepancy between elements or hypotheses "emotional disturbance, exploratory behavior, and thinking" as well as an orienting reaction would set in along with heightened arousal (Berlyne, 1971, p. 144). If our predictions are—in contrast—of high accuracy, they are thought to be reinforced by positive affect. This idea can be related back to the *Hedonic Fluency Model* (Winkielman et al., 2003) stating that high processing fluency induces positive affect: easy objects provide more (or more determinate) cues for and thus a high accuracy of predictions. On the other hand, it might be relevant that the object provides opportunity for novel predictions. Accordingly, the limitation of the *mere exposure* effect by boredom, as reported above, was transferred to *predictive coding* by Chetverikov (2013) stating that "when we are forced to continue our interaction with an object but cannot make any novel and correct predictions about it, we will begin to dislike it" (p. 387).

What does the framework of *predictive coding* tell us about the appeal of visual, *semantically instable* artworks? Like for all kinds of *prediction errors* the encounter with these artworks might at first result in negative affect because "they signal that there is something wrong with the mental model we use to generate the predictions" (Van de Cruys & Wagemans, 2011, p. 1038). In succession, our perceptual system would try to reduce *prediction errors* to increase the accuracy of our hypotheses by refining them. According to the *tentative prediction error account of visual art* (Van de Cruys & Wagemans, 2011) such a process of decreasing uncertainty increases positive affect again. Accordingly, it was found that appreciation of innovative objects—which are

initially disliked because they don't match common visual habits—benefits from intense elaboration (Carbon & Leder, 2005). Also challenging artworks might repel us at first but a subsequent active elaboration might increase appreciation again. Following a crucial point made by Van de Cruys and Wagemans (2011) pleasure might actually be even greater if a *prediction error* precedes uncertainty reduction than without an encounter of incongruence in the first place. Similarly, Dörner and Vehrs (1975) showed that patterns are most appreciated if the perceiver experiences difficulties in finding order in them at first, but succeeds in the end. Such a contrast effect on appreciation (being repelled at first by the challenge and rewarded then by its solution) is compatible with Berlyne's (1971) idea that a combination of an increase in arousal with a subsequent reduction of arousal is effective on the reward system as well as with Van de Cruys and Wagemans' (2011) idea of reward by reduction of uncertainty.

The introduction to the phenomenal variety of *semantical instability* as well as the psycho-aesthetic accounts of its appeal clarify: to explain the appeal of *semantical instability* in art we have to focus on the relationship between artwork and observer and we have to include temporal and semantical dynamics of perception and appreciation in our conception. Instead of applying a static model relating the appeal of an object with its instability of meaning (see Figure 5A) we have to reveal how *semantical instability* and appreciation evolve with elaboration. Figure 5B visualizes one exemplary and idealized model of such a relationship. The main question of this thesis—how *semantical instability* in art can induce pleasure—is strongly bound to exactly these dynamics. The first publication presented in the next chapter will accordingly examine how sudden increases in stability, *Aha* moments, affect the appreciation of *hidden images*.



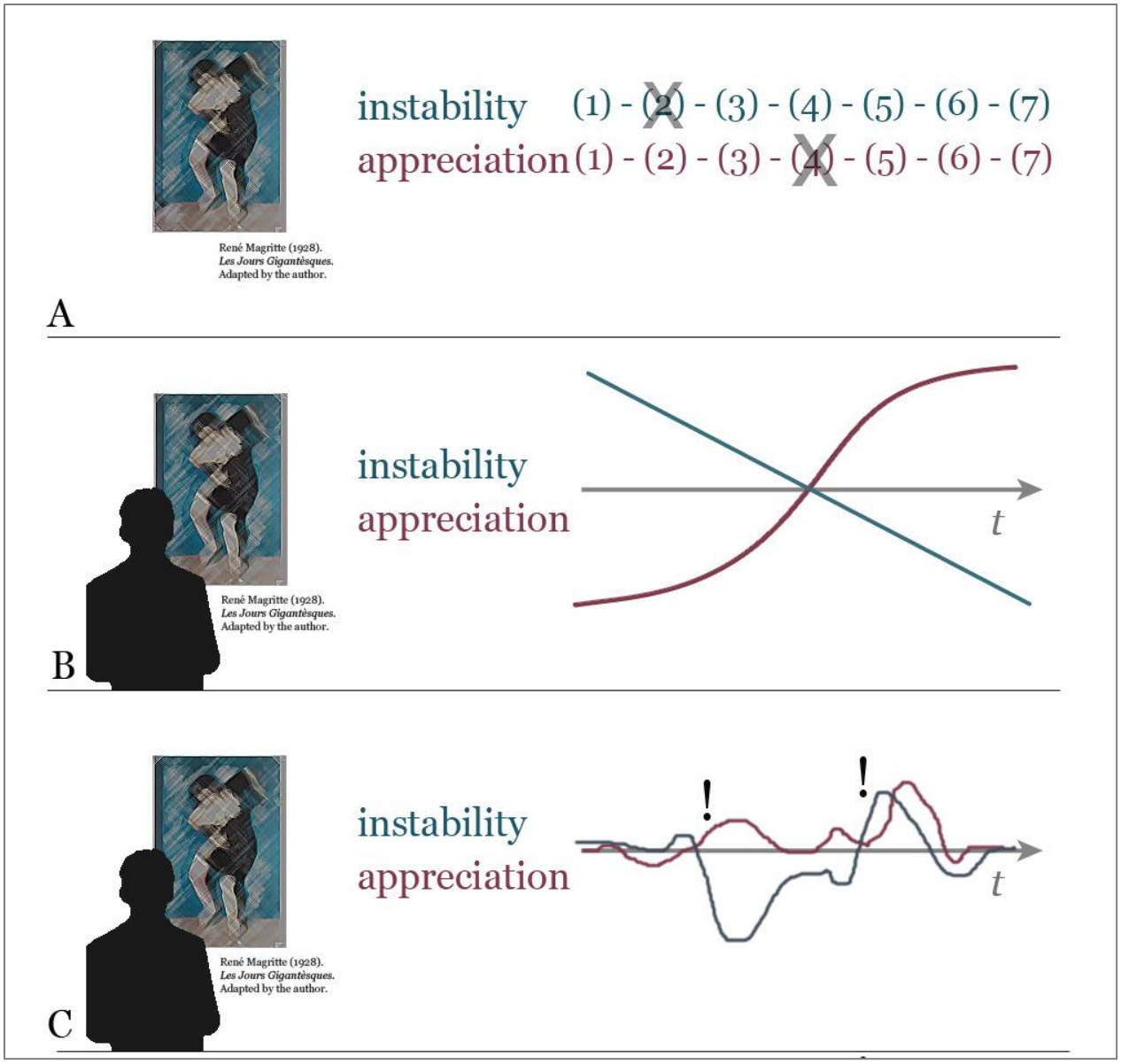
Figures 5. Models of a static (A) and a dynamic (B) account of *semantical instability* and appreciation. The sketched pattern of changes in B represents a mechanism by which appreciation is negatively linked to *semantical instability*: an increase in stability leading to an increase in appreciation. Note that the curve would look different for *multistable* images as in these cases *semantical instability* is one between stabilities over time and thus would create at most a short and sharp-edged interruption of an otherwise constant low value for *semantical instability*.

2. Empirical part

2.1 Peripheral publication I. The Aesthetic Aha: On the pleasure of having insights into Gestalt

Motivation

The introduction to the phenomenon of *semantical instability* in art and on theories explaining its appeal revealed that the key to determine relevant factors is to include dynamics within the examination of its perception and appreciation (see Figure 5B). Hereby, one relevant mechanism might be the gain of reward by a decrease in uncertainty, especially if the material is challenging (e.g., Dörner & Vehrs, 1975; Van de Cruys & Wagemans, 2011; see previous chapter). With regard to the main question of this thesis it can thus be hypothesized that appreciation of *semantical instability* in art benefits from a decrease in uncertainty during its elaboration. A further idea which considers the dynamics of perception and appreciation of *semantical instability* states that the struggle to find meaning within artworks might itself be pleasurable (Ramachandran & Hirstein, 1999). Within the research project discussed in this chapter our idea was to integrate both accounts by suggesting that we do not need a linearly progressive reduction of uncertainty to gain pleasure from *ambiguous* objects but that insights gained during their elaboration are pleasurable. The creation of meaning itself might be rewarding because the sudden decrease of uncertainty by such an *Aha* insight leads to a temporal increase in positive affect—an effect which we labelled as *Aesthetic Aha*. Instead of a progressive increase in certainty, such *Aha* moments might happen at several times during processing and sometimes even without a final resolution of *semantical instability*. This idea allows for comprising phenomena which are strictly speaking "unsolvable" with regard to determinacy of meaning—like the ones exemplified by the artworks in Figures 2 and 4B. The aim of this study was consequently to arrive at a third model complementing those depicted in Figures 6A and 6B. Figure 6C clarifies how it differs from the others with regard to the described pattern of changes (insights are marked by "!").



Figures 6. Models of a static (A) and two dynamic accounts of *semantical instability* and appreciation (B, C). In model B the pattern of changes represents a mechanism by which appreciation is negatively linked to *semantical instability*. Model C considers the positive effect of one or several *Aesthetic Ahas* (!) on appreciation.

To provide initial empirical support for this idea an investigation of the effect of the sudden recognition of Gestalt on appreciation seemed suitable. Drawing on the previous theoretical analysis of different kinds of *semantical instability* such an *Aha* insight (a sudden and easy solution with high confidence, see e.g., Bowden, Jung-Beeman, Fleck, & Kounios, 2005; Topolinski & Reber, 2010) can be best achieved

during the perception of *hidden images* as they entail the characteristic phases of initial *indeterminacy* (seemingly random pattern) and subsequent *determinacy* (detectable hidden figure). Consequently, Peripheral publication I used non-art *hidden images* concealing facial structures within patterns of black and white organic shapes and dots (as in Figure 4A).

Besides the choice of the stimulus material, it was a methodological challenge to test the hypothesis of reward by insight. This concerned on one hand the detailed assessment of dynamics of perception and appreciation. With the *Repeated Evaluation Technique (RET)* Carbon and Leder (2005) introduced a study design which comprises two time points of evaluation—one before and one after an elaboration phase—to investigate the influence of elaboration on appreciation. An extension of the *RET* (Carbon & Leder, 2005) by additional repetitions of test phases allowed us to capture the relevant dynamics in perception and appreciation of a *hidden image* in a more fine-grained way. Another challenge for the design of this study was that a sudden detection of Gestalt changes the target of evaluation: when asked to evaluate the level of appreciation of such a picture without further explication, participants might at first judge the composition of the *indeterminate* pattern (e.g., on harmony) whereas after recognition the attractiveness of the detected face might be the target of evaluation. Such an intervention by the effect of facial attractiveness was avoided by controlling the stimuli for low variety in this regard.

The following article thus provides both: empirical evidence for a theoretical model of dynamics between *semantical instability* and appreciation as well as a methodological model for assessing such dynamics in a more fine grained way than designs employing one or two time points of measurement only.

Original article

Acta Psychologica 144 (2013) 25–30

Contents lists available at SciVerse ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/ locate/actpsy

The Aesthetic Aha: On the pleasure of having insights into Gestalt

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ARTICLE INFO

Article history:
Received 27 November 2012
Received in revised form 24 April 2013
Accepted 3 May 2013
Available online xxxx

PsycINFO classification:
2300 Human Experimental Psychology
2320 Sensory Perception
2600 Psychology & the Humanities
2610 Literature & Fine Arts

Keywords:
Aesthetics
Aha insight
Gestalt
Face perception
Ambiguity
Elaboration

ABSTRACT

Are challenging stimuli appreciated due to perceptual insights during elaboration? Drawing on the literature regarding aesthetic appreciation, several approaches can be identified. For instance, fluency of processing as well as perceptual challenge are supposed to increase appreciation: One group (Reber, Schwarz, & Winkielman, 2004) claims that fluency of processing increases appreciation. Others link aesthetics to engagement: Creation and manipulation of sense itself should be rewarding (Ramachandran & Hirstein, 1999). We experimentally tested the influence of insights during elaboration on liking. Pairs of stimuli – hardly detectable two-tone images including a face (Mooney face) and meaningless stimuli matched for complexity – were presented repeatedly. Having an insight as well as the intensity of the insight predicted subsequent gains in liking. This paper qualifies the role of insight (—aha!) on aesthetic appreciation through the effects of elaboration and problem-solving on understanding the processing of modern art.

1. Introduction

1.1. Appreciating difficult pictures: reward by fluency or challenge?

Why do we like perceptually challenging pictures? This ostensibly simple question is still yet to be answered: Fluency of processing as well as perceptual challenge are said to increase appreciation. Fluency theories assume that the more fluent the processing, the higher the appreciation (Reber et al., 2004). Evidence is provided by, e.g., the "mere exposure effect" (Zajonc, 1968), proposing an increase in preference with repeated, unreinforced exposure to stimuli. Also the preference for prototypes (Winkielman, Halberstadt, Fazendeiro, & Catty, 2006) and symmetric stimuli (Reber, 2002) is explained by fluency, as they are supposed to be easier to process than their opposites. These classical findings do, however, conflict with findings that associate novelty or innovativeness with high reward and liking (Blijlevens, Carbon, Mugge, & Schoormans, 2012; Carbon & Leder, 2005; Wittmann, Bunzeck, Dolan, & Düzel, 2007). Modern art also often impedes everyday perceptual routines while being popular at the same time. It offers various examples of perceptual challenge and sometimes sheer unresolvable contradictions (Meinhardt, 2009) and elicits "states of ambiguity, arousal, and uncertainty" (Jakesch & Leder, 2009, p. 2105) — like the football which is made of concrete in the artwork 'jeu' by Kristof Georgen. It produces a conflict between anticipated action and heavy material. Similar prediction errors were discussed and exemplified by Van de Cruys and Wagemans (2011), who claim that many artists combine familiar patterns with "a minimal deviation of default expectations" (p. 1043; see also the definition of indeterminacy by Pepperell, 2011, which "suggests the presence of objects but denies easy or immediate recognition", p. 2). Also designers make use of visual–tactual incongruities to induce surprise in perceivers, which was found to augment a variety of emotions like interest, fascination, amusement, confusion, indignation and irritation (Ludden, Schifferstein, & Hekkert, 2012). In a similar fashion to the domain of music perception (Blood & Zatorre, 2001), these violations of expectation from visual cues might be linked to reward processing (Van de Cruys & Wagemans, 2011). The popularity of indeterminacy, surprise and contradiction in modern art and design obviously contradicts the often cited rule of 'the easier the better' once more and points to the necessity of incorporating further factors aside from fluency into research on aesthetic appreciation. Still, both ideas – that either easy or difficult stimuli increase appreciation – could have evolutionary advantages: Links between processing-fluency and reward could have been selected because familiarity signals harmlessness and fluency implies successful processing (Reber et al., 2004). Searching for novelty and challenges, on the other hand, might be rewarded in order to trigger exploration (Wittmann et al., 2007).

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http://dx.doi.org/10.1016/j.actpsy.2013.05.001

A third line of research proposes that neither easy nor difficult stimuli are preferred but that moderate amounts of ambiguity are maximally pleasurable (Jakesch & Leder, 2009). This is linked to the claim by Berlyne (1974) that the relationship between preference and arousal is described by an inverted U-shaped function. Too little arousal, as well as too much, decreases liking. When a stimulus is repeatedly presented, the increase in fluency thus would decrease arousal and increase liking as revealed by the "mere-exposure-effect". Over-exposure after saturation, on the other hand, would lead to "under-arousal" and a decrease in liking. This limiting factor of boredom on the "mere exposure effect" is reflected by the discovery that complex objects increase the positive effect of exposure to a greater extent than simple ones (for the visual domain Bornstein, 1989; for the tactile domain; Jakesch & Carbon, 2012). Remarkably though, boredom was found not only to be associated with decreased (Pattyn, Neyt, Henderickx, & Soetens, 2008), but also in some cases with increased, arousal (London, Schubert, & Washburn, 1972) (for an overview see Eastwood, Frischen, Fenske, & Smilek, 2012).

It is possible to combine typicality and novelty in music and design for the enhancement of pleasure (e.g., for consumer products see Hekkert, Snelders, & van Wieringen, 2003). This idea was recently re-investigated, stressing that arousal (by novelty) and familiarity (by prototypicality) both contribute, albeit independently, to aesthetic appreciation (Blijlevens et al., 2012). Such findings might explain the contradictory findings of preference for familiar stimuli (e.g. prototypes; Winkielman et al., 2006) and unfamiliar (or innovative) stimuli (Blijlevens et al., 2012; Carbon & Leder, 2005; Wittmann et al., 2007) discussed above. Nevertheless, a unified theoretical basis explaining the appeal of easy-to-process vs. difficult indeterminate stimuli is missing.

1.2. Connecting fluency and challenge by insights during elaboration

While fluency as well as arousal theories (Belke, Leder, Strobach, & Carbon, 2010; Reber et al., 2004) take into account that aesthetic appreciation can be "dynamic" (Carbon, 2011), they still focus on the stimulus level of the material, but frequently neglect elaboration, attitude and expertise on the side of the perceiver. In contrast to mere *passive* exposure, the interaction with a stimulus can involve active perceptual and cognitive engagement comprising a range of processes from a simple visual search to elaborate analyses of an artwork. Carbon and colleagues showed that after such 'elaboration' of material (Carbon & Leder, 2005), the perception process (Carbon, Hutzler, & 2006) as well as the preferences (Carbon & Leder, 2005; Faerber, Leder, Gerger, & Carbon, 2010) for innovative designs change quite dramatically. Here, elaboration was realised by conducting ratings on the presented designs of various variables like comfort or elegance. Other experiments varied the level of elaboration by supplementary information, be it interpretive titles (Leder, Carbon, & Ripsas, 2006; Millis, 2001) or stylistic information (Belke, Leder, & Augustin, 2006). The sum of regarding findings reveals that the appreciation of perceptually challenging pictures is dynamic and strongly dependent on the quality and extent of elaboration.

Looking at aesthetic appreciation as a dynamic process allows us to connect the contradictory accounts by assuming that perceivers re-familiarise themselves with a challenging stimulus by on-going elaboration, and thus increase their processing-fluency. This is strongly related to the proposal of Van de Cruys and Wagemans (2011) that the effort of reducing prediction errors changes initially negative arousal into perceptual pleasure; the reduction of uncertainty is rewarded. Such dynamics play a big role in the perception and evaluation of modern art if we define it as rather a kind of complex problem solving than as simple processing (Dörner & Vehrs, 1975). In other words, the processing of perceptually challenging situations is said to be particularly pleasurable, as the revealing of meaning is rewarding in itself (Ramachandran & Hirstein, 1999). This has also been explicitly noted by Leder et al.'s model of visual aesthetic processing (Leder, Belke, Oeberst, & Augustin, 2004) and Carbon and Jakesch's (2013) haptic aesthetic model.

The fact that changes in the elaboration of a stimulus result in changes in appreciation (Carbon & Leder, 2005; Faerber et al., 2010) reveals dynamics in processing that are not accounted for by mere exposure. While we might ask if processing during mere exposure is ever purely passive (concerning eye movements as well as concerning changes in perception and cognition) we cannot presume that it leads to higher fluency with repeated presentation in every case. We argue that the quality of elaboration might instead lie in the emergence of insights during elaboration, which might be linked to a temporally limited increase in fluency that even decreases again in the course of elaboration. This idea is in line with the claim by Ramachandran and Hirstein (1999) that the process of synchronisation of different activity patterns by ambiguous stimulation is itself rewarding. Similarly, it has been proposed within art theory and the perception science community that the detection of relationships or order (Hekkert & Leder, 2007), uniformity in variety (Berlyne & Boudewijns, 1971), or simplicity in complexity (Dickie, 1997; Reber et al., 2004) respectively might be enjoyable in themselves. Indeed, detectability of objects within Cubist artworks was recently shown to correlate strongly with liking (Muth, Pepperell, & Carbon, in press). On the basis of these lines of argumentation we claim that fluency of processing might not increase in a linearly progressive fashion by mere exposure, but along with insights during elaboration. Thus, perceptual Gestalt formation during the elaboration of difficult indeterminate pictures should increase their appreciation. We tested this hypothesis by tracking the dynamics of liking with regard to the detection of faces in indeterminate two-tone images that are difficult to process.

2. Methods

The major aim of the experiment was to test whether aesthetic appreciation benefits from insights during the elaboration of indeterminate stimuli. Two-tone images either containing a hidden Gestalt (i.e. a face) or not were repeatedly presented for half a second. Aha-insight moments of Gestalt detection were then related to the dynamics of liking ratings.

2.1. Preparation of material

Two pre-studies were conducted in order to evaluate and filter out a set of appropriate stimuli for the experiment. We used *Face* and *NonFace* stimuli. Pictures pertaining to the first category were based on photographs of faces taken from the website pixelio.de and the database of the Psychological Image Collection at Stirling (PICS). The original face was first blurred and then reduced to black and white so that recognition of the face was possible only after a period of elaboration [similar to so-called Mooney faces (1957); see Fig. 1].

Each of the *Face* pictures had a counterpart in the *NonFace* category that contained exactly the same elements arranged in a different non-facial composition by rotation and/or shift of parts of the face. In a first pre-study, six participants rated 98 stimuli (49 *Face* and *NonFace*, respectively) 11 times block-wise, after 500 ms of presentation on the question of whether they could detect a face in them, by pressing a key for either *yes* or *no*. Results showed that stimuli revealed faces too soon. Therefore the distance from the eyes to the screen was reduced from 40 to 30 cm in the experiment and random elements were added to the composition to make recognition harder. The face then appeared in the middle or at one corner of the picture so that the process of visual search was less efficient due to increased task demands. The possibility cannot be excluded that people interpreted unintended figural associations as faces. To reduce this risk, the composition of a stimulus was refined in cases when *NonFace* stimuli were reported to contain a face. Furthermore, an example of a face-pattern was given before the experiment. Instead of *yes* or *no* answers, the experiment used gradual scales for clearness of the face and similarity to a face to differ between recognition and guessing. Scaling also enabled a definition of 'insight' as the biggest difference between ratings for a stimulus in two succeeding blocks.

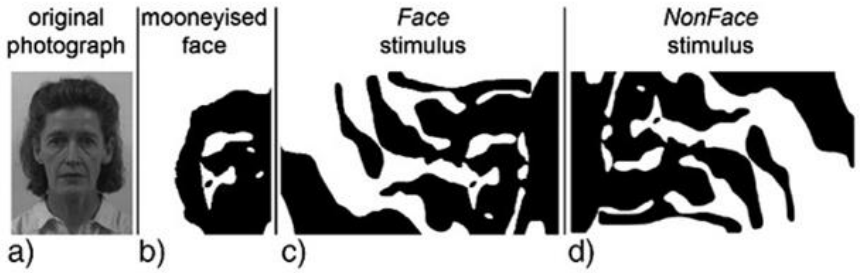

Fig. 1. Example of a pair of stimuli with (c) *Face* stimulus and (d) *NonFace* stimulus, plus the original photograph, the face was based on (a) and the mooneyised version of it (b).

A further pre-study was conducted to exclude the possibility that a change in liking after such an insight was due to the attractiveness of the identified face. Eight participants rated the Mooney faces hidden in the *Face* stimuli on liking. Stimuli were excluded if a) they were liked significantly more or less than the empirical average liking rating and b) if participants noted verbally that they could not detect a face in one of them at all.

2.2. Experiment

2.2.1. Participants

Thirty participants aged 20 to 59 years (M_{age} = 29.5 years, SD = 9.4; 18 female, 12 male) volunteered for the experiment. Among them were seven university students of Psychology, nine university students of other disciplines, 11 workers, two high-school pupils, and one unemployed person. For their participation the Psychology students received course credits. All participants proved to have normal or corrected-to-normal vision through a standard Snellen Eye-chart test and normal colour vision assured by a short version of the Ishihara colour test consisting of four plates. None of them had participated in any of the pre-studies; they had no information about the aim of the study nor were they trained in art.

2.2.2. Apparatus and stimuli

The stimulus material consisted of 36 pictures, 18 belonging to the category *Face* or *NonFace*, respectively, selected on the basis of two pre-studies as described above. Participants were tested individually via PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993) with an Apple Powerbook 17 in. with a resolution of 1440 × 900 pixels.

2.2.3. Procedure

A chin rest guaranteed that the distance between the eyes and the monitor was fixed at 30 cm, yielding an initial visual angle of the stimuli of 57.64° horizontally × 35.41° vertically and a final, minimal visual angle of 20.48° horizontally × 11.95° vertically. Participants were told that the aim of the study was to test the influence of presentation time on liking as a cover story. Stimuli were shown for 500 ms in a randomised order block-wise 13 times. The tasks alternated block-wise between choosing from a 7-point scale (1 = "not at all", 7 = "very good") how much one liked the picture and a detection block. The latter comprised two ratings on a 1 plus 7-point scale; first, how clearly one saw a face and in direct succession how similar it was to a human face (0 = "no face recognised", 7 = "very clear" or "very", respectively for similarity to a face; for an overview on the procedure see Fig. 2). The clearness and similarity tasks were explained after the first liking block to avoid the participants having searched for faces already during that first presentation. Additionally, an

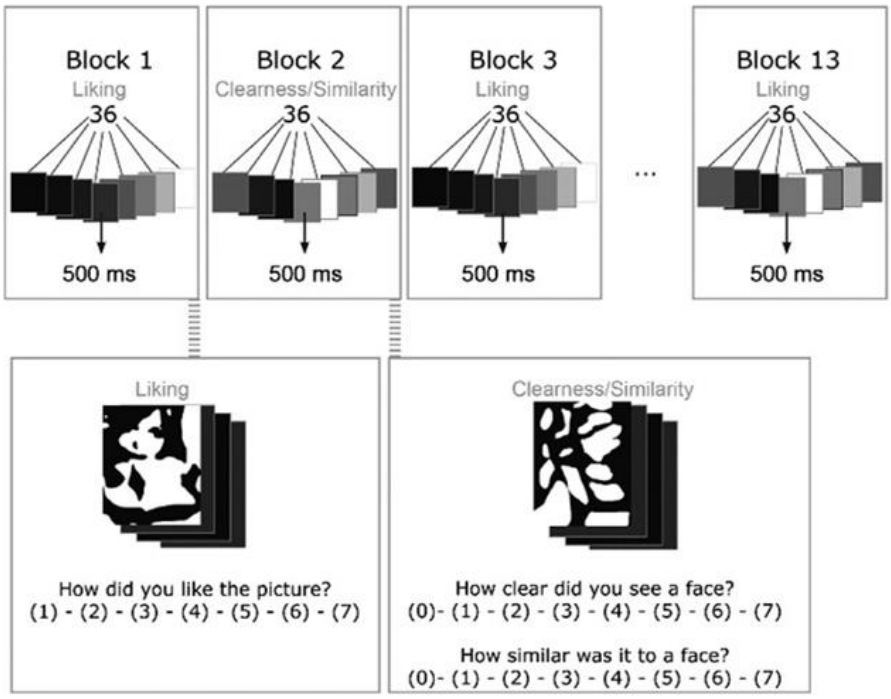

Fig. 2. Procedure of the experiment: Stimuli were shown block-wise each for 500 ms. The task alternated between liking ratings and clearness/similarity ratings.

example of a clear and face-like face was given before the second block. For the purpose of demonstration, elements that constitute the face were highlighted in red. The size of the pictures decreased every 2nd block by 20% (referring to the edge lengths) to make recognition easier within the course of the experiment as a result of more holistic processing [decreasing size is known to assist the recognition of visual closure and consequently Gestalt, see Gori and Spillmann (2010)].

2.2.4. Data analysis

We sought to analyse whether and how insights during elaboration influence aesthetic appreciation. Consequently, an analysis of changes in liking due to an insight was conducted. Insight was defined by the highest gain in clearness of, or similarity to, faces respectively, between two subsequent blocks per participant and stimulus (=maximum of all differences: block n minus block $n-1$ per participant and stimulus). While in some cases clearness of, or similarity to, faces decreased and increased again in the course of elaboration, we chose only the first peak gain. That way the difference between the first sudden recognition of a Gestalt and the supposedly weaker experience of re-finding that pattern again was accounted for. We defined two types of insights: clearness insight for the highest clearness gain and similarity insight for the highest similarity gain. All liking ratings per participant and block were then shifted in regard to their temporal occurrence relative to this insight block: liking ratings directly after an insight formed one group, liking ratings in the subsequent liking block another, and analogously for all other pre- and post-insight liking ratings. This was done for clearness and similarity insights as well as for *Face* and *NonFace* stimuli separately (although we did not intend to induce an insight by *NonFace* stimuli, in some cases ratings of clearness or similarity were bigger than 0. These unexpected reports of increase in detection were consequently classified as insights in accordance with the described procedure). That way it was possible to compare liking directly before and after the insight block ("Δ to insight-block = 0"), liking ratings 2 blocks before the insight to those directly before the insight ("Δ to insight-block = −1") and so on adding up to 10 comparisons per stimulus category (*Face* or *NonFace*, respectively). Ratings were analysed by two-tailed paired *t*-tests, simple Regression Analyses and repeated measurement Analyses of Variance (ANOVAs).

2.2.5. Results

Both types of insights had a major impact on the liking of *Face* stimuli, clearly demonstrated by the fact that liking only significantly increased directly after having an insight, revealed by two-tailed paired *t*-tests (significance levels were adjusted by using Bonferroni correction; significant *p*-values and effect sizes in Fig. 3a and b). Although *NonFace* stimuli also induced insights according to our definition, none of the differences between liking ratings before and after the insight was significant.

Furthermore, the intensity of insights, defined as degrees of clearness or similarity ratings, showed direct influences on the degrees of liking. Simple regression analyses indicated explained variances of .685–.946 (i.e. R^2, see Table 1). Thus, liking increased in accordance with the insight's intensity.

Importantly, analyses of the development of liking over blocks revealed *no* evidence of increased liking over time and block progression as originally assumed by Zajonc (1968) and subsequent literature on the "mere exposure effect" (see Fig. 4): Repeated measurement Analyses of Variance (ANOVAs) with a 2 [*category*: *Face* vs. *NonFace*] by 6 [*block*] factor design showed a main effect of *category*, $F(1,29) = 29.0$, $p < .0001$, $\eta_p^2 = .500$, with the category *Face* being more liked than *NonFace* (but liking of *Face* stimuli was not significantly higher during the first block, as a two-tailed paired *t*-test revealed, $M = .15$, $t = 1.6$, $p = .1369$, *n.s.*). The small but significant effect of *block* $F(6,174) = 2.8$, $p = .0117$, $\eta_p^2 = .089$, showed effects contrary to the typical results identified by "mere exposure effects", because liking decreased over time. As the interaction failed to reach significance, $F(6,174) = 1.3$, $p = .2759$, *n.s.*, this decrease was found to be not category-specific.

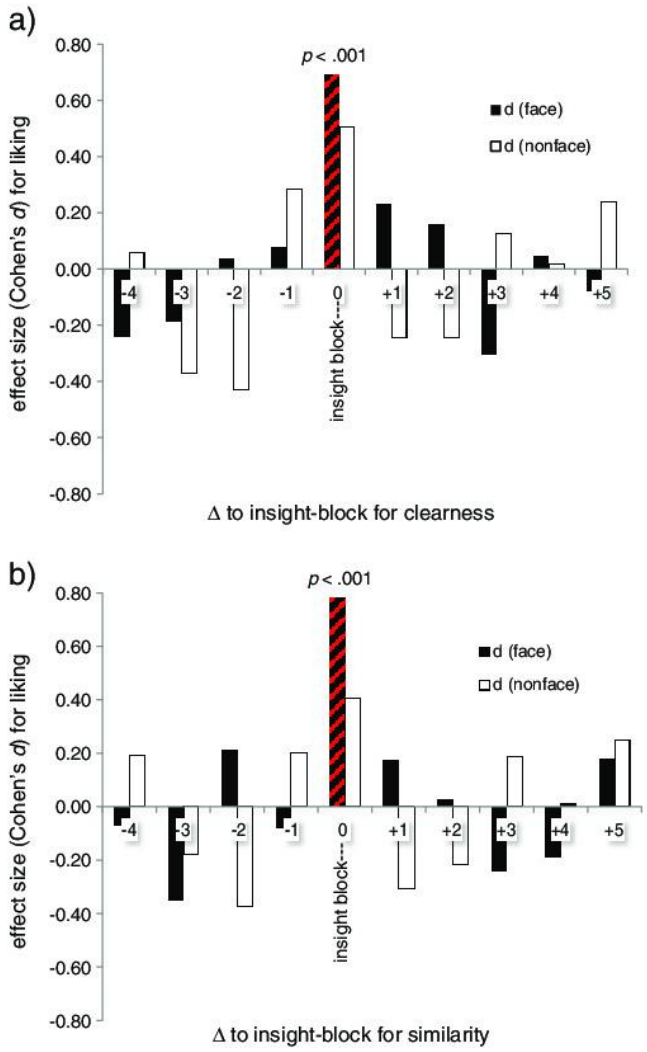

Fig. 3. Changes in liking before and after the occurrence of an insight represented by effect sizes. Cohen's *d* of the mean difference between liking ratings directly before and after an insight (Δ to insight-block = 0), two blocks before and directly before an insight (Δ to insight-block = −1), directly after and two blocks after an insight (Δ to insight-block = +1) and so on for the following classes of insights: a) clearness insight and b) similarity insight. All significant effect sizes are highlighted by red diagonal stripes and added by the corresponding *p*-value. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3. Conclusion

The present study revealed a major impact of insights into perceptual Gestalt on liking, which we will refer to as the "Aesthetic Aha effect" in the following. Participants who elaborated on indeterminate stimuli and gained insight into face-like appearance, showed strongly increased liking in a subsequent block of liking ratings. Importantly, during the whole course of the experiment we detected no other

Table 1
Summary of the predictability of liking by clearness and similarity. Analysis was based on mean liking ratings for each level of clearness or similarity, respectively (scale: 0–7). *SEB* lists the standard error of the regression coefficient *B*.

	Face stimuli					*NonFace* stimuli				
	n	*B*	*SEB*	ß	R^2	*n*	*B*	*SEB*	ß	R^2
Clearness on liking	8	.211	.039	.913	.833	8	.151	.042	.828	.685
Similarity on liking	8	.303	.030	.973	.946	8	.306	.058	.908	.825

Note: All reported regressions are significant at an alpha level of .01.

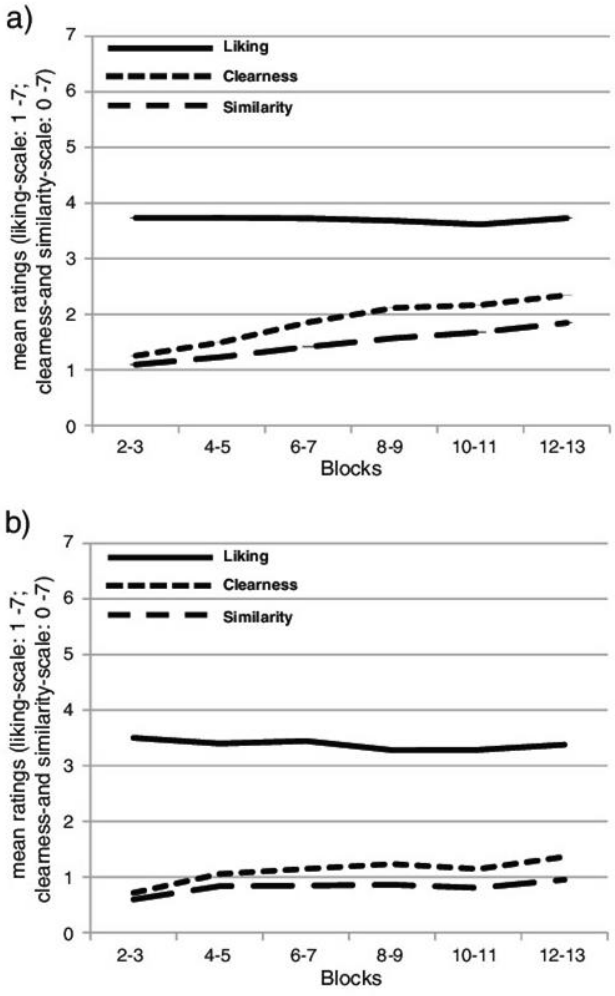

Fig. 4. Ratings of clearness, similarity and liking over blocks 2–13 for a) *Face* stimuli and b) *NonFace* stimuli. Ratings of liking are of subsequent blocks.

significant gain in liking between subsequent blocks. Meanwhile, we could not detect any signs of mere exposure.

4. Discussion

Our results stress that it is not the repeated presentation (i.e. the "mere exposure") that increases liking when processing indeterminate stimuli. Rather the results point to the high relevance of the dynamics of elaboration and specifically of perceptual insight on the aesthetic process. We further revealed that such an Aesthetic Aha has quite a direct, but also temporarily limited effect on liking. Thus we propose that the assessment of perceptual and appreciative dynamics is indispensable for the understanding of the appreciation of difficult, indeterminate or otherwise challenging pictures as we find them in modern art (Jakesch & Leder, 2009). Our results are in accordance with the idea that the reduction of uncertainty is rewarding (Van de Cruys & Wagemans, 2011) and highlights the relevance of problem solving for aesthetic appreciation (Carbon & Jakesch, 2013; Dörner & Vehrs, 1975; Leder et al., 2004). At the same time, a transfer to the field of art perception demands clarification: does the Aesthetic Aha effect account for a) different kinds of aesthetic preference and b) for the variety of insights that can be induced during art perception?

a) In our study, we measured appreciation via explicit evaluations. As proposed by Makin, Pecchinenda, and Bertamini (2012) these might be much more closely related to culture, experience and expectation than implicit automatic responses and therefore influenced additionally by a variety of factors besides fluency. This explains cases of misalignment between implicit and explicit preferences (Makin, Pecchinenda, & Bertamini, 2012) and might also be important in regard to different modes of aesthetic processing governed by expertise. For instance, Cupchik (1995) proposes the distinction between reactive (relatively naïve perceivers') and reflective (relative experts') aesthetic processing. Whereas reactive processing is triggered by spontaneously pleasing or arousing features, for instance certain favourite colours or scenes but also familiar content, reflective processing is based on the active elaboration of a challenging stimulus and evokes more complex emotions. The latter consequently accounts better for modern artworks as they are defined mostly independent of superficial qualities and require deep elaboration before eliciting appreciation. The struggle to perceive a Gestalt in an indeterminate visual display might be special in this regard: beholders seem to refer the *pleasure of their elaboration* (having insights) to the stimulus' explicit aesthetic appreciation. Along with the proposal by Makin, Pecchinenda, and Bertamini (2012), the increase in fluency by insight might be even more relevant to implicit judgments which could be assessed via the Implicit Association Test as used by Makin, Pecchinenda, and Bertamini (2012) or via the recently validated multidimensional IAT (md-IAT Gattol, Ditye, Carbon, & Hutzler, 2007). Explicit judgments, on the other hand, might be influenced additionally by experience (Makin, Pecchinenda, & Bertamini, 2012). We could thus use modern artworks instead of two-tone images in a follow up study and assess whether artistic expertise mediates the Aesthetic Aha effect on explicit judgments.

b) A second point concerns the problem-solving character of aesthetics. Our study predefined a problem (where is the face?) along with the according insight (detection of the facial Gestalt) quite explicitly. Elaboration of modern art, however, is mainly not a matter of easy processing and simple problem solving towards one specific pre-set solution. Instead, modern artworks often induce a firework of association dynamics, analogies, and transfers that serve to open up new levels of elaboration *aside* from the perceptual "core problem". They force us to reflect on unsolvable ambiguities and even on perception itself (Meinhardt, 2009). Take the aforementioned example of Kristoff Georgen's football made out of concrete. The reflexion on one's own perception mechanism produces a valuable insight which however does not reduce the perceptual prediction error; the contradiction between felt affordance and given material. We thus suggest that insights can happen on various levels of elaboration, without necessarily leading to a unified "solution" or attribution of determinate meaning to the artwork (which might even offer unsolvable indeterminacy). Are there *Cognitive* Aha effects on appreciation analogous to the here reported *Aesthetic* Aha effect? Can we speak of problem-solving in terms of the sudden emergence of a Gestalt at all? This point exposes a methodological issue: to evoke and control for an insight, it is necessary to pose a task to participants and thus induce a search for a solution which might hinder free and spontaneous elaboration. Furthermore, Makin, Wilton, Pecchinenda, and Bertamini (2012) found that people show positive affective responses to symmetry (by smiling) if they are asked to look for it — interestingly, the same accounts for randomness. In accord with our findings, it might thus not only be the features of an object (e.g. symmetry) or of processing (fluency) but the successful discovery of a target pattern itself that influences appreciation.

Our results reveal that perceptual insights into Gestalt within difficult pictures increase appreciation — an effect which might play an important role in the appreciation of modern art. Nevertheless, the spontaneity and variety of possible insights during art perception pose challenges for empirical research. A phenomenological approach

might find various levels of ambiguity and insight aside from Gestalt-detection bringing us closer to the multisided nature of aesthetic experience — and the on-going fascination for it.

Acknowledgements

We would like to thank Claudia Gorr and Stefanie Wolz for text revision and Alun Brown for proofreading. Thanks also for very valuable comments and *insights* (!) provided by Alexis Makin, Johan Wagemans, Marco Bertamini and Sander Van de Cruys.

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Critical reflection

The findings of this initial study induce a new perspective on processes involved in the perception of *semantically instable* stimuli: the detection of facial Gestalts within a hard-to-solve black and white image induced an increase in the liking of the image (*Aesthetic Aha* effect). By providing a more detailed look at the development of liking and clarity of Gestalt over time, we were able to reveal dynamics which are compatible with the previously mentioned idea of reward by reduction of *prediction errors* (proposed, e.g., by Van de Cruys & Wagemans, 2011). In this rationale, the *semantical instability* of the presented stimuli induced uncertainty in the perceivers which was reduced by recognition during moments of insight. The increase in prediction accuracy thus might have induced the positive affective feedback mirrored by the increases in liking.

There are several interesting points to be discussed concerning the crucial mechanism involved in the *Aesthetic Aha* effect (Muth & Carbon, 2013). First, we can ask if it is exclusive for Gestalt recognition or more generally valid for decision making and task fulfillment. Chetverikov (2013) summarized findings with regard to preferences of real-life decisions and states that "there seems to be a postdecisional 'spread of alternatives', with chosen items becoming more attractive and non-chosen items becoming less attractive" (p. 385). Also in a study by Makin, Wilton, Pecchinenda, and Bertamini (2012) people showed positive affective reactions (by smiling) to the target which they were asked to look for; and this accounted for symmetry as well as for randomness. Consequently, the fulfillment of a task was the relevant predictor of a positive physiological reaction and not, e.g., the symmetry itself. The positive effect of Gestalt detection could thus be linked to the appeal of task fulfillment—a mechanism which might actually be relevant in art perception as well. Despite the lack of a well-defined task in art perception, the beholder might follow certain goals predefined by general perceptual mechanisms (e.g., to reduce uncertainty) or by social convention (e.g., to detect stylistic elements as trained in art courses in school).

More recent findings provide further evidence for an *Aesthetic Aha* effect (Muth & Carbon, 2013). Following a similar rationale and using similar black and white *hidden*

images as we did in the presented study Chetverikov and Filippova (2014) tested the effect of recognition on liking by applying a categorization task. They found that correct classifications of Gestalts into "human" and "animal" categories were followed by higher liking ratings than errors in classification. Classifications into an "object" category though proved to be not effective on liking; supposedly due to higher uncertainty about the classification. Additionally, Chetverikov and Filippova (2014) manipulated the valence of their stimuli—which in our case were kept on a neutral level by controlling that none of the faces' attractiveness differed significantly from the empirical mean. In their study, both pleasant and unpleasant pictures were liked more after accurate classification. This point is an important argument ruling out the alternative interpretation that an *Aesthetic Aha* (Muth & Carbon, 2013) occurs as we rate the valence of the detected Gestalt after its recognition. Still, we cannot exclude the possibility that people generally prefer Gestalt-like images over random patterns; in this case the reward of the detection itself might play just a minor role.

In accordance with accounts of reward by an increase in certainty Chetverikov and Filippova (2014) propose an *affective feedback account of hypotheses testing* suggesting "that correct hypotheses are reinforced with positive affect even in the absence of external feedback" (p. 211). While a moment of insight might reflect a sudden increase in processing fluency as well (suggested, e.g., by Topolinski & Reber, 2010), liking did not increase with the number of presentation of the stimuli. In the rationale of a processing fluency account (for a review see Reber et al., 2004), this should have been the case though due to increased familiarity as evident from the *mere exposure* effect (Zajonc, 1968). Furthermore—contrary to *mere exposure* effects and in line with the idea of a positive affective feedback by uncertainty reduction—the *Aesthetic Aha* effect (Muth & Carbon, 2013) takes the *quality* of elaboration into account: the achievement of resolving *semantical instability* is relevant to appreciation, not the mere increase in familiarity.

This aspect motivates to go one step further by suggesting that the dynamics of reward by increasing *semantical stability* do not necessarily follow the pattern of a unidirectional progress (see Figure 6B) but might rather equal—at times sudden and even repeated—changes in *semantical instability*. These are neither limited to one

direction nor in number: stability might be gained at one moment and lost again at another to be gained once again, etc. (see Figure 6C). As an analogy think of the various identifications of the murderer when reading the thriller *The Murder of Roger Ackroyd* by Agatha Christie; you might be misled several times to identify the wrong suspects before you gain final insight into the fact that the story's narrator himself is the murderer. The idea propagated throughout this thesis is consequently that perception and appreciation are no static concepts but dynamically bound to insight-driven elaboration, not only in narratives but also if the object itself is relatively stable, not undergoing changes besides decay or changes in context—like a painting.

The next article examines if such insights are beneficial to appreciation even if the final insight—catching the murderer so to say—fails to appear. This aspect seems especially relevant to *semantical instability* in art which is (often) not resolvable into a determinate interpretation. A transfer to the domain of art perception consequently requires at least three extensions of the currently presented state of research:

A) A replication with regard to art objects: while the domain of objects potentially inducing *Aesthetic Ahas* can be extended from faces to humans, animals, and objects with reference to Chetverikov and Filippova (2014), none of these categories might be consistent with insightful targets within artworks. Is the revealed mechanism relevant in the case of art perception as well?

B) A differentiation between insight and solution: many artworks might not allow for a determinate interpretation but might in contrast provide ongoing *indeterminacy* or *incongruence* (for instance between form and content, as described in chapter 1.3.2). Does the *Aesthetic Aha* effect also account for partial and peripheral insights not providing full determinacy of an artwork’s meaning?

C) An examination of the need for challenge: as a last point, it might be relevant for the effect to occur that the pattern which allows for the rewarding *Aha* moment poses a challenge to the perceiver at first; in other words: it should allow for a “creation of order in disorder” (Hekkert & Leder, 2008) by providing disorder in the first place.

The next two articles, Core publication I and Core publication II, attempt to give first answers to these questions by making use of artworks as stimulus material.

2.2 Core publication I. Give me Gestalt! Preference for Cubist artworks revealing high detectability of objects

Motivation

The *Aesthetic Aha* effect (Muth & Carbon, 2013) contributes to the central aim of this thesis by suggesting that the appreciation of challenging objects benefits from insights gained during their elaboration. The current section discusses if this effect is also valid for the domain of art perception. Another key question is if the rewarding effect reported for non-art *hidden images* is valid only in the light of a determinate recognition of a Gestalt—a "solution" in its strictest sense. To see if detectability is also beneficial to appreciation if the targets are at most fragmented and the material consists of artworks instead of non-art patterns we extended the set of *semantical instability* from *hidden images* to *indeterminate* artworks.

Participants evaluated Cubist artworks on liking and on detectability of objects within them to examine if the detectability of Gestalt affects appreciation. Following the three crucial preconditions for an extension of the *Aesthetic Aha* effect to art perception discussed in the previous chapter this choice of stimulus material and design allowed us to provide first steps to:

A) A replication with regard to art objects by using Cubist artworks.

B) A differentiation between insight and solution: In contrast to *hidden images*—providing determinate solutions—Cubist artworks are suitable examples of *indeterminate* objects. Although they are evocative of a recognizable Gestalt, they defy determinacy by evoking contradictions between perceptual cues. This combination of potential recognition and *indeterminacy* motivates a constant search for Gestalt by the perceiver (Gombrich, 1960/2002).

C) An examination of the need for challenge: this specific kind of ongoing *collation* or *conflict* between expectation and actual percept in the perception of Cubist artworks (Berlyne, 1971) might even be beneficial to the reward by insight.

This work appeared in Muth, C., Pepperell, R., & Carbon, C.-C. (2013). Give Me Gestalt! Preference for cubist artworks revealing high detectability of objects. *Leonardo, 46*(5), 488-489. doi: 10.1162/LEON_a_00649. See also http://www.mitpressjournals.org/doi/abs/10.1162/LEON_a_00649

Original article

GIVE ME GESTALT! PREFERENCE FOR CUBIST ARTWORKS REVEALING HIGH DETECTABILITY OF OBJECTS

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See <www.mitpressjournals.org/toc/leon/46/5> for supplemental files associated with this issue.

Submitted: 21 November 2012

Abstract

In cubist paintings by Picasso, Braque and Gris it is possible to detect everyday objects like guitars, bottles or jugs, although they are often difficult to decipher. In this art-science collaborative study the authors found that participants without expertise in cubism appreciated cubist artworks more if they were able to detect concealed objects in them. The finding of this strong correlation between detectability and preference offers wide implications for art history and human cognition as it points to a mechanism that allows us to derive pleasure from searching for and finding meaningful patterns.

Introduction

The human visual system continually constructs order out of highly ambiguous and instable stimuli we receive from the world. Artworks often exploit, reveal, and play with the perceptual and cognitive mechanisms involved by presenting viewers with prediction-errors [1], contradictions [2], indeterminacy [3,4], or ambiguity [3, 5] inducing elaboration of various interpretations at the same time. Cubist paintings are especially open to interpretation, as they are full of everyday objects that are concealed because they are depicted in a fragmented way that makes immediate recognition very difficult. In this paper we show that viewers' appreciation of cubist paintings is closely linked to the viewers' ability to identify an object, or a Gestalt, from partial clues.

Many art theorists and perception researchers have proposed such a relation between appreciation and emerging order from disorder, ambiguity, or indeterminacy. The philosopher of art George Dickie stresses the recognition of "uniformity in variety" or "simplicity in complexity" [6], while according to the psychologists Hekkert and Leder: "we like to look at patterns that allow us to see relationships or create order" [7]. Reber et al. claim that increased fluency in processing a complex topic enhances appreciation [8]. Meanwhile, Van de Cruys and Wagemans suggest that artworks often violate viewers' perceptual predictions, and that they are then able to derive aesthetic pleasure from reducing the cognitive uncertainty induced by those violations [1]. The neurologists Ramachandran and Hirstein argue that perceptual grouping processes in general are linked with the neural structures known as the 'reward system' [9].

But despite the frequent claims that detecting Gestalt, or recognizable form, in challenging visual stimuli is inherently pleasing, to date this has not been demonstrated empirically. In this study we chose as stimuli cubist artworks by Picasso, Braque and Gris because they offer a high degree of visual indeterminacy and ambiguity yet at the same time are full of recognizable depicted objects [3, 4]. Thus, they provide a perfect opportunity to test whether the viewers' ability to detect these objects is linked to their appreciation of the paintings.

Participants

Twenty participants (M_{age}= 23.8 yrs; range: 19-36 yrs; 13 females) volunteered in the study. They had normal or corrected-to-normal vision ensured by a Standard Snellen's eye chart test and by a short version of the Ishihara color vision test. They had no expertise in cubist art.

Apparatus and Stimuli

Stimuli consisted of photographs of 120 cubist artworks by Pablo Picasso (47), Georges Braque (33), and Juan Gris (40), all of them being adapted to 450 pixels width and 600 pixels height (if the proportion was not 4.5:6 we cropped the pictures accordingly). The participants sat at an approximate distance of 55 cm in front of a LG W2220P screen with 22-inch screen size at a resolution of 1680 × 1050 pixels yielding a visual angle of about 16.6° x 21.6° for the stimuli.

Procedure and Results

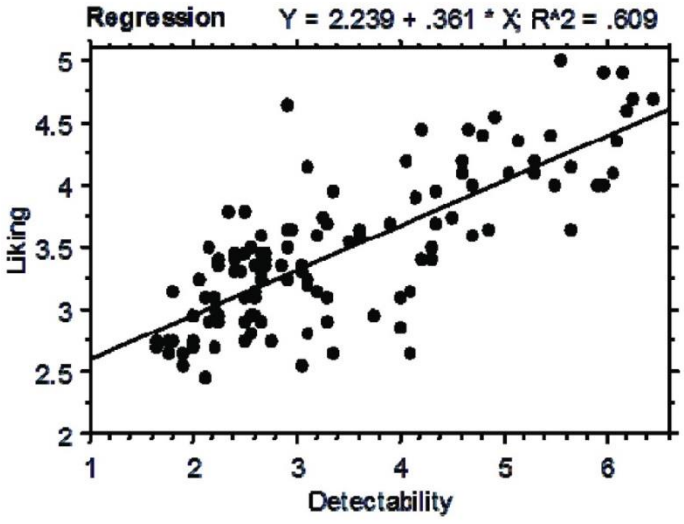
The study was structured in two blocks, each showing the stimuli in a randomized order. During the first block, subjects had to rate the pictures on liking. During the second block, participants rated how well they could detect objects within the artwork. All ratings were chosen from a 7-point-Likert-scale from 1 ('not at all') to 7 ('very').

For both variables we aggregated data across participants, revealing a strong relationship between the detectability of objects within cubist artworks and liking indicated by a Pearson correlation of R= .781, p<.0001 (see Fig. 1).

Discussion

The results show that Gestalt formation is closely linked to appreciation; viewers much preferred paintings in which they were able to decipher concealed objects. This finding is in line with previous proposals about the link between detecting order and appreciation [7], reward by

Fig. 1. Data points represent detectability of objects and liking per stimulus revealing that the better the participants could detect objects within an artwork, the more they liked it. The amount of explained variance is 60.9% indicated by R^2. The equation gives the relationship of X (Detectability) and Y (Liking).



 doi:10.1162/LEON_a_00649

uncertainty reduction [1] and the detection of simplicity in complexity [6, 8]. We did not replicate previous findings showing that over-familiar [10] or insufficiently ambiguous stimuli [5] had a negative effect on appreciation.

The reason why Gestalt recognition is linked to positive appreciation in the case of cubist paintings, however, may not be due merely to the fact that hitherto invisible objects are recognized, or because enjoyment is derived from increased fluency in coping with a complex perceptual process [8]. As the art historian Dario Gamboni demonstrates, cubist paintings of this period (1909-1914) never show explicit or complete objects but rather 'potential' objects, as he puts it, which cannot be fully resolved [3]. Ernst Gombrich points out that the experience of reading a cubist painting is unsettling because the paintings present us with "contrary clues which will resist all attempts to apply the test of consistency…We will always come across a contradiction somewhere which compels us to start afresh" [11]. Another art historian, Robert Hughes, writes of the paintings that "as a description of a fixed form they are useless"; their value lies in the way they "report on multiple meanings, on process" [12].

Unlike images that offer effortless and determinate recognition, cubist paintings present the viewer with ongoing perceptual indeterminacy while offering clues to enable Gestalt recognition. Our finding of increased preference for paintings revealing high detectability of objects might then be attributable not just to the mere recognition of forms but also to the fact that recognition is occurring against a background of ongoing uncertainty. The principle of 'uniformity in variety' noted above highlights this point while holding that we can appreciate the qualities of uniformity and variety at the same time. As the critic and early supporter of cubism Guillaume Apollinaire emphasized, this requires great involvement and effort of the viewer, which enhances aesthetic pleasure [13].

This link between elaboration and appreciation is supported by empirical studies showing that appreciation increases with the elaboration of innovative material but not with that of conventional and easy stimuli [14] – a result that is consistent across different types of measurement [15] and different age groups [16]. In line with Van de Cruys and Wagemans we thus propose that it is the presence of novelty, uncertainty or other challenges evoked by a stimulus that promotes dynamic aesthetic processes [1], not the fluency or immediacy of recognition per se. Further studies might assess in which way Gestalt detection influences those dynamics: is there an immediate effect of the insight [17] during Gestalt recognition on aesthetic appreciation, and how does this relation unfold with time?

Getting the balance right between unrecognizability and recognizability seems critical to maximizing aesthetic response. This can be illustrated by a key episode in the history of the development of cubism: In 1910 Picasso spent the summer in the Spanish town of Cadaqués where he produced a large body of highly abstract paintings in which objects were barely discernible. Art historians now refer to this as the 'hermetic' phase of cubism. Picasso's main dealer, Daniel-Henry Kahnweiler, declined to buy any of these works (with one exception) – a sign that he had concerns about selling them on to collectors [18]. Probably stung by this (the dealer had purchased nearly all of the artist's cubist works up to that point) Picasso quickly embarked on a major portrait of Kahnweiler (1910, Art institute of Chicago) which is notable for the reintroduction into the cubist language of much more identifiable cues about the objects being depicted [19]. Kahnweiler soon resumed purchasing Picasso's works, which thereafter explicitly avoided indecipherable abstraction.

Together with our empirical findings, this episode suggests that part of the reason we value perceptually challenging images, and cubist paintings in particular, is that they offer us an opportunity to wrestle with our own perceptual processes and discover hidden patterns and order. When this process of discovery becomes too difficult, appreciation is diminished; when the struggle is rewarded, then it is increased. The motivation for and success of the perceivers' efforts are likely to be linked to the interplay between determinacy and ambiguity or order and disorder, which the cubist artists were highly successful at manifesting in their works.

Our findings have relevance beyond aesthetic perception and art history as they might point to a general principle of cognition: we derive pleasure from stimuli in which we can detect meaning and ambiguity at the same time. Understanding the appreciation of works of art thus offers insights into the way the human mind operates.

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Critical reflection

The here provided article revealed that we like Cubist artworks more the better we are able to discern identifiable objects in them—although they never provide a determinate interpretation. This finding was later-on replicated with regard to the duration of responses signaling detection and to the likelihood of detection (Muth, Pepperell, & Carbon, 2013b). Here, participants pressed a button when they detected objects within the artwork. While the first study established a strong relationship between judged detectability of Gestalt and liking the second study revealed that people liked Cubist artworks more the faster and the more often they detected objects in them. In another study on Cubist art, Kuchinke, Trapp, Jacobs, and Leder (2009) found as well that the content accessibility—here realized via inversion of ratings on abstractness—was positively linked to appreciation.

There are at least two different ways to interpret the results of these studies: Kuchinke et al. (2009) stated that the positive effect of content accessibility on appreciation might have been mediated by processing fluency in accordance with the *Hedonic Fluency Model* (Winkielman et al., 2003). Another idea is that the positive effect of detectability, speed, and likelihood of detection reflects the opportunity for insight provided by non-fluent material. From this perspective, the reported relationship between detectability and liking would be in line with theories pointing to appeal by a reduction of uncertainty (proposed, e.g., by Dörner & Vehrs, 1975 and Van de Cruys & Wagemans, 2011) and the idea of reward by insight (Muth & Carbon, 2013). In other words: this alternative reading suggests that artworks were preferred not because they were easy to process but because they *promised* rewarding perceptual insights. Note though that this differentiation between a fluency account and the one of reward by insight is not clear-cut: Topolinski and Reber (2010) suggest in their *fluency account of insight* that an insight might actually be a "surprising fluency gain in processing" (p. 402). And the anticipation of insight might consequently be one of increased processing fluency by a solution of *indeterminacy*. But taken into consideration that Cubist artworks are never fully resolvable (Gombrich, 1960/2002), this promise was most probably never fulfilled. Instead these artworks provide the detection of "fragmented Gestalt". It can even be speculated that the challenge of

fragmentation might have been crucial for appreciation as might have been the challenge induced by the seemingly random patterns in the study by Muth & Carbon (2013): it is the challenge which enables a rewarding reduction of uncertainty and with it a contrast effect on appreciation in the first place. An ongoing level of indeterminacy might keep interest for the artwork alive. We can even speculate that without a remaining level of *semantical instability*, appreciation might not have benefited from detectability in the same way.

It is not straight forward to explain the findings in one of these directions on the basis of the reported evidence—especially so as the mentioned studies did not clarify what "detectability" or "content accessibility" refer to exactly with regard to the "fragmented Gestalt" in Cubist artworks. The paradox of the juxtaposition of "fragment" and "Gestalt" renders the lack of clarity even more apparent. In other words: the discussed empirical accounts did not differ between two factors: A) A determinate solution of an *indeterminate* pattern. We can refer to this as the *solvability of ambiguity* eliciting increased fluency of processing. B) A partial or temporary semantical stability within an *indeterminate* pattern. We can refer to this as a partial, temporary, or peripheral *insight* which does not provide a final solution but might still elicit a rewarding *Aesthetic Aha*. The subsequent study attempted to draw the according differentiation between the variables of *solvability of ambiguity* and *strength of insight* by providing a comparison of their effects on appreciation.

2.3 Core publication II. The appeal of challenge in the perception of art: how ambiguity, solvability of ambiguity, and the opportunity for insight affect appreciation

Motivation

So far, evidence was provided for a dynamic relationship between *semantical instability* and appreciation via the rewarding impact of insights (*Aesthetic Aha* effect, Muth & Carbon, 2013). Furthermore, it was shown by the previous study that the detectability of objects within Cubist artworks affects liking positively (Muth et al., 2013a). With regard to the main question of this thesis we can thus state that the reward by gaining insights might be an important factor for the appeal of challenging artworks. But as, e.g., Gadamer (1960/2002) points out: "There is no absolute progress and no final exhaustion of what lies in a work of art" (p. 100). How could the elaboration of an artwork thus be rewarding like the solution of a riddle if many artworks are not even "solvable"? Strictly speaking we cannot "master" these artworks to arrive at a determinate solution; they don't even pose a well-defined problem to us. Taking into consideration that fluency of processing might be a relevant factor for appreciation, too: do such non-easy artworks appeal at all? And if yes, which facets of appreciation are affected by them? Also, we should be aware of the point that *ambiguity* might not be pleasing per se but can even be banal (Hyman, 2010). Actually, the persistence of residual semantical insolubility might be crucial for an aesthetic experience in contrast to a trivial amusement. Does the *Rubin-Vase* (Figure 3) for instance have strong aesthetic qualities or are its resources for rewarding insights depleted too soon?

The study reported in this section aims at an according differentiation between effects of *solvability of ambiguity* and *strength of insight*s on appreciation as described in the previous chapter. Furthermore, it examines if *ambiguity* is related to appreciation: a multidimensional assessment allows for a specification of the facets of appreciation which are relevant candidates for representing the appeal of challenge in art.

Original article (preprint)

The appeal of challenge in the perception of art: How ambiguity, solvability of ambiguity and the opportunity for insight affect appreciation

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Abstract

We asked whether and how people appreciate ambiguous artworks and examined the possible mechanisms underlying the appeal of perceptual challenge in art. Although experimental research has shown people's particular appreciation for highly familiar and prototypical objects that are fluently processed, there is increasing evidence that in the arts people often prefer ambiguous materials which are processed less fluently. Here, we empirically show that modern and contemporary ambiguous artworks evoking perceptual challenge are indeed appreciated. By applying a multilevel modeling approach together with multidimensional measurement of aesthetic appreciation, we revealed that the higher the subjectively perceived degree of ambiguity within an artwork, the more participants liked it and the more interesting and affecting it was for them. These dimensions of aesthetic appreciation were also positively related to the subjectively reported strength of insights during elaboration of the artworks. The estimated solvability of the experienced ambiguity, in contrast, was not relevant for liking and even negatively linked to interest and affect. Consequently, we propose a critical view of the frequently reported idea that processing (modern) art simply equals a kind of problem-solving task. We suggest the dynamic gain of insights during the elaboration of an ambiguous artwork, rather than the state of having solved a problem, to be a mechanism possibly relevant to the appeal of challenge in the perception of ambiguous art.

Keywords: Ambiguity, Modern art, Problem solving, Insight, Aesthetic Aha

Introduction

Psychological aesthetics research has repeatedly shown that people like visual stimuli that are easy to process; for instance, participants in different studies preferred typical objects in comparison to their less typical alternatives (e.g., Halberstadt, 2006) and rated familiar faces as being more attractive than less familiar ones (e.g., Langlois, Roggman, & Musselman, 1994). The corresponding results are often explained by referring to the so-called fluency hypothesis (Reber, Schwarz, & Winkielman, 2004; Reber, Winkielman, & Schwarz, 1998)—although the explanation that fluency always increases preference has been challenged only recently (Albrecht & Carbon, 2014). The success of many ambiguous or indeterminate pieces of modern art—think of Picasso's famous portraits or the concealing and fragmentation of objects in Cubist artworks—seems to run counter to the fluency hypothesis as well: Despite challenging our perceptual and cognitive habits rather than being easily processed, these items are particularly appreciated—in terms of aesthetic as well as monetary value. For a thorough investigation of the aesthetic impact of ambiguous art, it is therefore necessary to explore mechanisms aside from the fluency of processing. One of these might be the possibility of deciphering recognizable patterns, which was described as a relevant factor for the success of Cubist artworks, especially those of Picasso, in regard to the art market (Muth, Pepperell, & Carbon, 2013).

(How) do we appreciate ambiguity in art?

Do we indeed appreciate ambiguous art? Evidence from psychological aesthetics makes us question the overall appeal of challenging art objects. However, there is evidence in favor of the appreciation of perceptual challenge being induced by ambiguity and other collative variables like novelty, complexity, uncertainty and conflict (affording collation among elements of an object or among actual and expected information, respectively; Berlyne, 1971) which includes various dimensions of appreciation and perceptual challenge.

Jakesch and Leder (2009) provided a first indication that moderate instead of low degrees of ambiguity might be preferred in the domain of art perception. A positive connotation of nonfluent material was revealed inter alia for ambiguous surrealistic artworks. Though these artworks were rated as being harder to process, they were still preferred to their nonambiguous counterparts (Jakesch, Leder, & Forster, 2013). Concordant evidence for the appreciation of other, nonfluently processed material was found for design objects with low degrees of typicality (Blijlevens, Carbon, Mugge, & Schoormans, 2012) as well as for highly innovative and novel design objects (Carbon & Schoormans, 2012; Hekkert, Snelders, & van Wieringen, 2003). Furthermore, Wittmann, Bunzeck, Dolan, and Düzel (2007) showed that the anticipation of novelty alone can already activate the reward system.

Although these findings relate to liking and reward, the appeal of ambiguous artworks might be assignable to other facets of aesthetic appreciation (as well), for example, to the powerfulness of affect, which is assumed to cover a wider range of emotional reactions toward artworks even if they are not beautiful (Pepperell, 2011). Powerfulness of affect was indeed found to increase with the difficulty of object detection with regard to indeterminate paintings (Ishai, Fairhall, & Pepperell, 2007). Furthermore, ambiguity, novelty, complexity, uncertainty, and conflict were repeatedly reported as being positively linked to interest—mostly in a linear fashion (for judged complexity see Berlyne, Ogilvie, & Parham, 1968; for high effort and interest see Ellsworth & Smith, 1988; for ambiguity see Jakesch et al., 2013). A positive relationship between ambiguity and interest was found even when the ambiguous material was judged as less beautiful by the beholders (Boselie, 1983; in this case, nonartistic simple line drawings which elicit disjunctive ambiguity by offering two incompatible figures were used). Turner and Silvia (2006) found that high interest does not necessarily need high pleasantness—actually the disturbingness of a painting predicted interest in a positive way whereas it was negatively related to pleasantness. Although interest is linked to positive emotions (Ellsworth & Smith, 1988), it is separable from enjoyment or happiness in several regards: As previously described, perceptual challenge is often positively linked to interest but negatively to enjoyment, and effects of interest and enjoyment are further divergent (e.g., interest is a better predictor of viewing time than

enjoyment, Berlyne, 1971; for an overview on these differences see Silvia, 2006). It seems essential for variables associated with affect and interest, respectively, that the stimulus or artwork offers some difficulty or at least "a certain amount of disorientation" to the perceiver (Berlyne, 1971, p. 215). These factors might come along with uncertainty and perceptual challenge thought to be evoked by many ambiguous pieces of art (Jakesch & Leder, 2009; Van de Cruys & Wagemans, 2011) not only during the historical era of modernity (Gamboni, 2002).

In sum, it is reasonable to assume that ambiguity in (modern) art affects these two important further dimensions of aesthetic appreciation (i.e., affect and interest), to a larger extent than liking. Therefore, we use a multidimensional concept of aesthetic appreciation in this study (see Faerber, Leder, Gerger, & Carbon, 2010).

Why might we appreciate ambiguity in art?

Ambiguity refers to multiple meanings attributed to an object and varies with information, context and interaction between an observer and an object (Gaver, Beaver, & Benford, 2003). It is thus more a subjective than an objective variable. Consequently, in order to understand why ambiguity in art is or can be appreciated, it is important to follow an experimental approach that not only focuses on specific features of the aesthetic object, but considers the dynamic interplay between observer and artwork itself. In reference to appraisal approaches, Silvia (2005b) claimed that "it is misleading to assert a general law of stimulus intensity and emotional response that is independent of the subjective meaning of the stimulus" (p. 353). This opposes ideas relating the intensity and the arousal-potential of a stimulus to liking (e.g., Berlyne, 1971). Approaches that further integrate a dynamic perspective claim, for instance, that processes such as (a) running through loops of hypothesis testing during aesthetic processing (Carbon & Jakesch, 2013; Leder, Belke, Oeberst, & Augustin, 2004) and the understanding of art (Leder, Carbon, & Ripsas, 2006), (b) the elaboration of aesthetic qualities (Carbon & Leder, 2005), or (c) "struggling" with an ambiguous artwork itself bring pleasure (Ramachandran & Hirstein, 1999) and influence the aesthetic value we

ascribe to it. Accordingly, Hekkert and Leder (2008) assumed that we like patterns that "allow us to see relationships or create order" (p. 262). In the case of ambiguous artworks, there might be multiple opportunities for such struggling and pattern recognition in the course of elaboration. In line with the dynamic perspective, Zeki (2004) claimed that "it is not ambiguity itself . . . that is aesthetically pleasing . . . It is rather the capacity of multiple experiences" (p. 192). A recent study on repeated evaluations of two-tone images (Muth & Carbon, 2013) reported an increase in liking for an image when participants detected a hidden Gestalt. Multiple opportunities for detection might be able to induce multiple of these so termed Aesthetic Ahas, which should, in line with Zeki's proposal, induce even higher appreciation.

The Aesthetic Aha effect (Muth & Carbon, 2013), or the impact of perceptual insight, respectively, is also in accord with the suggestion of Van de Cruys and Wagemans (2011) that an increase in certainty (e.g., by the detection of a face) after the encounter of a perceptually difficult situation (e.g., an indeterminate pattern) might be rewarding. Berlyne (1971) similarly speculated that for interest we might need both: "disorientation" (p. 215) as well as a promise of success after a period of processing. This idea was originally linked to his suggestion of rewarded reduction of arousal (Berlyne, 1960, later he discarded this view, as subsequent studies pointed to links between high arousal and reward; see an overview by Silvia, 2006). Although this might be the case for some artworks, the question remains whether such a kind of dissolution of uncertainty is necessary for assessing the valence of ambiguous art in general. In a study on Cubist art (Muth et al., 2013), detectability (i.e., the ease with which objects can be detected within the artwork) was indeed strongly correlated with liking. It is important to note that Cubist artworks typically "hide" objects, often instruments or bodies; but, in contrast to two-tone images, the objects always remain, to a degree, indeterminate so that visual searching will continue even after cues have been detected (Gombrich, 1960). Therefore, it can be assumed that people do not necessarily have to completely resolve a given ambiguity before they can appreciate the respective stimulus. For a person to gain at least a partial perceptual or cognitive insight concerning the artwork, it might be sufficient to receive just a bit of information or an initial clue. In the case of art, it could be important to avoid complete resolution of a given ambiguity so that the piece is not

perceived, per Hyman's (2010) description of less pleasing ambiguities, as "banal, conventional or academic, and . . . gimmicky or fanciful or kitsch" (p. 256).

The question of reward by ambiguity resolution also potentially relates to the role of appraisal in art perception: An artwork might be challenging in the eyes and the mind of an observer and elicit nonfluency of processing. At the same time, the observer might create subjective meaning during the elaboration of the artwork. Rather than solutions to the posed "problem" of ambiguity, these self-produced insights might be perceived or anticipated as an ability to cope with the challenge posed by the artwork and thus evoke the observer's interest. In terms of appraisal theory, interest might be elicited by a combination of two appraisals: one concerning the challenging character of an object and the other concerning one's own ability to cope with this challenge by understanding (see Silvia, 2005b).

Thus, two major lines of argumentation concerning potential mechanisms influencing the appreciation of ambiguous art can be identified as follows:

1. The processing of ambiguous artworks is a kind of problem solving and appreciation is influenced by the progress (and result) of ambiguity reduction.

2. Insights during processing are rewarded irrespective of a progress in regard to ambiguity reduction and/or its full resolution.

Who might particularly appreciate ambiguity in art?

It is important to note that there might be neither the ambiguous object nor a specific object with a certain level of ambiguity. In contrast, the intensity of ambiguity might be strongly dependent on the recipient's personality and experience.

> Esthetic appreciation of art, then, may be a route by which the individual obtains mastery over the challenges of novelty, complexity, and ambiguity and faces emotion and responds to its challenge too . . . But exposing a person to art which can offer challenging experience does not in itself guarantee that he will have such experience. He may shut himself off from seeing the complexities, he may disregard all features not familiar and realistic. (Child, 1971, p. 9)

This description refers to the personality variable termed ambiguity tolerance, which might be especially relevant in the perception and appreciation of ambiguity (in art). It differentiates among people in regard to their tendency to reduce ambiguous cognitive patterns to certainty (Frenkel-Brunswik, 1949); their tendency to perceive contradictions, inconsistencies and ambiguous information; and to be positively affected by it (Reis, 1996). To ambiguity-intolerant people, ambiguous situations or stimuli might be perceived as threatening (Budner, 1962). Frenkel-Brunswik (1949) linked the concept of ambiguity intolerance to various behavioral features, including perceptual reversals, rigidity in categorization, and seeking for certainty. Reis (1996) later classified different domains of ambiguity tolerance: ambiguity tolerance for seemingly unsolvable problems, for social conflicts, in regard to the image of the parents, for role stereotypes, and for new experiences. In sum, there are various instruments measuring ambiguity tolerance, whereas a clear operational definition is still missing (Furnham & Marks, 2013). The impact of ambiguity tolerance with regard to aesthetic perception and judgment is revealed by a few studies that relate higher ambiguity tolerance to preference for surreal paintings (but only if they contain few elements, see Furnham & Avison, 1997) and for surreal film clips (Swami, Stieger, Pietschnig, & Voracek, 2010). Child and Chapman (1973) examined age-dependent links among aesthetic sensitivity and ambiguity tolerance and de Bont, Schoormans, and Wessel (1992) showed that people with high ambiguity tolerance are more likely to accept unconventional designs than are people with low ambiguity tolerance.

Table 1

Examples of how participants described their insights during the elaboration of the artworks (obvious spelling mistakes have been corrected for better readability)

Artwork	Translated description	Original description (in original wording)
Bellmer, H. (1966). *Transfert des Sens*.	some of the depicted women look directly at the observer → that contributes to agitation	die dargestellten Frauen blicken den Betrachter tw. direkt an → das trägt zur Unruhe bei
Bellmer, H. (1966). *Transfert des Sens*.	thrilling to reflect on why bodies are intertwined so unclearly, which body belongs to whom? Do all love all?	spannend zu überlegen, warum Körper so unklar verschlungen sind, welcher Körper gehört wem? Lieben alle alle?
Bellmer, H. (1960). *Untitled*.	the longer the observation the clearer the forms get, hachures support the spacial impression of the object	je länger die Betrachtung, desto deutlicher werden Formen, Schraffuren unterstützen räumlichen Objekteindruck
Boden, B. (1966). *Kleiner Mann im Ohr*.	Sometimes most subtle indication suffices to convey a message By the ring, strong look, legs Rest is circumstantial	Manchmal reichen subtilste Andeutungen um Botschaft zu übermitteln Durch Ring, starker Blick, Beine Rest nebensächlich
Collien, P. (1964). *Daphne*.	presumably by the same artist like picture 3; vegetable and human are not as exclusive as thought	vermutlich von selben KünstlerIn wie Bild 3; Pflanzliches und Menschliches nicht so trennscharf wie gedacht
Cragg, T. (2000). *Can-Can*.	Assumption what it could be; parts of a technical device	Annahme, was es darstellen könnte; Teile aus einem technischen Gerät
Cragg, T. (2000). *Can-Can*.	I like the work, it dissolves the black and white thinking a bit: something can be very massive, heavy and solid and at the same time plastic in such a way that the work makes a light and delicate impression. I see furthermore two music instruments (most probably two French horns) which strengthen the positive association with this work.	Mir gefällt das Werk, es löst das schwarz weiß denken ein wenig auf: etwas kann sehr massiv, schwer und fest und trotzdem in so einer Art verformbar sein, dass das Werk einen leichten und filigranen Eindruck macht. Ich sehe außerdem zwei Musikinstrumente (am ehesten zwei Waldhörner), die die positive Assoziation mit diesem Werk noch verstärken.
Gober, R. (1990). *Untitled*.	This is where the curse word "you bag" comes from	Daher kommt das Schimpfwort „Du Sack“.

Maar, D. (1930). *Doppelporträt mit Huteffekt*.	Sometimes when one sits in a train and looks out of the window, one sees oneself in the pane and one's neighbor and the faces mix exactly like this	Manchmal wenn man im Zug sitzt und aus dem Fenster schaut sieht man in der Scheibe sich und seinen Sitznachbar und die Gesichter mischen sich dann genauso.
Maar, D. (1930). *Doppelporträt mit Huteffekt*.	(…) this is the fascinating thing here. The brokenness is not solvable and the central motive, terrific.	(…) Dass ist das Faszinierende hier. Diese Zerbrochenheit ist nicht auflösbar und zentrales Motiv, grandios.
Maar, D. (1930). *Doppelporträt mit Huteffekt*.	Clever composition can (with little means) also induce an effect.	Geschickte Anordnung kann (mit wenigen Mitteln sonst) auch Effekt bringen.
Maar, D. (1930). *Doppelporträt mit Huteffekt*.	I interpret the painting like this, that a person can have many faces, so can be very multifaceted. Here one part is proud and intent on doing something (the profile with the nose), the other part is longing and melancholic.	Ich interpretiere das Gemälde so, dass eine Person mehrerer Gesichter haben kann, also sehr facettenreich sein kann. Hier ist ein Teil stolz und festentschlossen (das Profil mit der Nase), der andere Teil sehnsüchtig und wehmütig.
Magritte, R.(1928). *Les Jours Gigantesques*.	It seems to me that the woman is threatened by the man; he touches her although she does not want that. Her hair seems strangely heavy and also her face is not very feminine, but rather hard and rough and frightened. The first impression of a dancing, happy woman faded entirely+.	Mir scheint, dass die Frau von dem Mann bedroht wird; er fasst sie an obwohl sie das nicht möchte. Ihr Haar wirkt seltsam schwer und auch ihr Gesicht ist nicht sehr weiblich, sondern eher hart und grob und angsterfüllt. Der erste Eindruck von der tanzenden, fröhlichen Frau ist vollständig verschwunden.
Miller, L. (1937). *Raumportrait Ägypten*.	hm… impression: sadness and melancholy, a little bit; at the same time also freedom… (This image is somehow specifically interesting; it has something intangible in its effect…)	hm… Eindruck: Tristesse und Wehmut, ein wenig; zugleich aber auch Freiheit… (Dieses Bild ist irgendwie besonders interessant; es hat etwas Ungreifbares in seiner Wirkung…)
Miller, L. (1937). *Raumportrait Ägypten*.	Mirror or image? (upper side of the picture) torn cloth= new freedom or disappointment as there lies only desert behind?	Spiegel oder Bild? (oben im Bild) zerrissenes Tuch= neue Freiheit oder Enttäuschung weil dahinter nur Einöde liegt?
Oppenheim, M. (1936). *Frühstück in Pelz*.	The furred cup might hint at the barbaric methods with which we partially obtain our food. In everyday life, and what would be less mundane than drinking a cup of tea, we are repeatedly pointed to that, the cup of fur (like ”tearing the fur over the	Die fellerne Tasse könnte auf die barbarischen Methoden hinweisen mit denen wir z.T. unsere Lebensmittel gewinnen. Im Alltag, und was könnte weniger alltäglich sein als eine Tasse Tee zu trinken, werden wir immer wieder darauf hingewiesen, die Tasse aus Fell (wie "das

	ears“) [in German meaning something like ”to take someone for a ride“] imposes on us how cruel and inhuman or -animalistic, respectively, some food production is (...)	Fell über die Ohren ziehen") drängt einem gerade auf wie grausam und tier-/ bzw. menschenverachtend manche Lebensmittelerstellung ist (...)
Oppenheim, M. (1938). *Steinfrau*.	from the warm colors the picture seems peaceful, the woman is almost like a Rubens-woman	durch die warmen Farben wirkt das Bild friedlich, die Frau fast wie eine Rubens-Frau
Teige, K. (1951). *Collage 374*.	Insight is hard to say; thoughts alternate constantly between the different aspects of the image. And I wonder; why does the picture seem a little bit spooky	Einsicht schwer zu sagen; Gedanken wechseln dauernd zwischen den verschiedenen Bildaspekten hin und her. Und frage mich; warum das Bild etwas gespenstisch wirkt
Teige, K. (1951). *Collage 374*.	grotesque motives besides the image (female body, breast) demarcate themselves strongly from the landscape in terms of color and technique.	groteske bildfremde Motive (Frauenkörper, Brust) grenzen sich zur Landschaft farblich wie technisch stark ab
Teige, K. (1951). *Collage 374*.	Reference moon/ female cycle? Moon in pre-Columbian cultures of central America always female (goddess of the moon); also in the Romance languages "the" moon is female...	Bezug Mond/ weiblicher Zyklus? Mond z.B. in präkolumbianischen Kulturen Mittelamerikas immer weiblich (Mondgöttin); auch in den romanischen Sprachen ist "der" Mond weiblich...
Thiele, P. (1984). *Der große Bruder*.	We "tinker" (mentally) a lot together, what artists again know and use. And: somehow one is happy about the "hidden" image (otherwise this work here would maybe be boring...)	Wir „basteln“ (gedanklich) viel zusammen, was Künstler wiederum wissen und sich zu Nutze machen. Und: irgendwie freut man sich doch über das „versteckte“ Bild (sonst wäre das Werk hier vielleicht langweilig...)
Thiele, P. (1984). *Der große Bruder*.	it is fun to look at the many small details, I wonder whether the life of the old man is shown in the little pictures	macht Spaß, die vielen kleinen Details anzusehen, ich frage mich, ob wohl das Leben des alten Mannes in den kleinen Bildern gezeigt ist

Research questions and hypotheses

The present study asks how and why people appreciate perceptually challenging, ambiguous artworks. We aimed to shed further light on the appreciation of artworks that are ambiguous and therefore cannot be processed fluently. The theoretical ideas and empirical findings described in the introductory paragraphs of this article suggest that appreciation of non fluent material might consist in its positive effects on dimensions aside from the typically measured liking, such as interest and affect. We thus used a three-dimensional concept of aesthetic appreciation and expected ambiguity to primarily affect the aesthetic appreciation dimensions interest and affect (see also Faerber et al., 2010). As artworks can potentially have a different effect on perception than on cognition (Carbon & Jakesch, 2013; Leder et al., 2004), we further differentiated between perceptual affect and cognitive affect in the present study.

As described above, two different processes can be considered as potentially underlying the appeal of ambiguity in art: the reward by insights triggered during the processing of ambiguous material and the reward by solvability of ambiguity. Accordingly, we compared the effects of strength of insights and solvability of ambiguity on aesthetic appreciation. "Insights," in the terms used here, might refer to perceptual insights (e.g., an emergent Gestalt), cognitive insights (e.g., stylistic aspects or symbolic interpretations) or reflexive insights (e.g., into one's own perceptual mechanisms) during the perception of ambiguous art (see Table 1 for examples extracted from free descriptions of insights by participants looking at ambiguous visual artworks in the course of the study). We supposed that the factor strength of insights might be more crucial for the aesthetic appreciation of ambiguous artworks than the estimated solvability of ambiguity (e.g., how easy it is to resolve via elaboration the "riddle" posed by the ambiguous artwork). In order to account for differences in personality between participants, we assessed ambiguity tolerance via the IMA questionnaire (Inventory for Measuring tolerance of Ambiguity, Reis, 1996).

Methods

Participants

Thirty-nine participants took part in the experiment on a voluntary basis (21 female and 18 male; age range [years] = 18–41, *M* = 25.0, *SD* = 5.9). One additional dataset was excluded from the analysis because of monotonous response behavior to avoid higher error variance of the experimental result, an effect recently reported in regard to participants' inattention (Maniaci & Rogge, 2014). A Snellen eye chart test and a subset of the Ishihara color cards assured that all of them had normal or corrected-to-normal visual acuity and normal color vision. The participants were naïve to the purpose of the study and did not have any training in art or art history besides regular school education.

Apparatus and stimuli

Photographs of 17 ambiguous artworks of the 20th and 21st centuries were shown on an LG W2220P screen with a 22-in screen size at a resolution of 1680 X 1050 pixels. Of each stimulus, an additional paper-mounted version was created using a color print of the respective artwork. A list of the artworks used can be found in Table 2. To assess participants' level of ambiguity tolerance, we used the "Inventar zur Messung der Ambiguitätstoleranz" (Inventory for Measuring tolerance of Ambiguity; IMA) by Reis (1996) comprising 40 items that reflect four subscales describing the various domains of ambiguity, including ambiguity tolerance for seemingly unsolvable problems, for social conflicts, in regard to the image of the parents, for role stereotypes, and for new experiences (internal consistencies of scales are between Cronbach's α=.74 and α=.86; entire scale: α=.87).

Table 2

The study used photographs of the following artworks:

Artist	Year of creation	Title
Bellmer, H.	1960	Untitled
Bellmer, H.	1966	Transfert des Sens
Boden, B.	1966	Kleiner Mann im Ohr
Breitling, G.	1966	Maleditia Calumnia
Collien, P.	1964	Daphne
Coste, C.	2007	Corps viscéral V
Cragg, T.	2000	Can-Can
Gober, R.	1990	Untitled
Lin, W.	2004	Landscape
Maar, D.	1930	Doppelporträt mit Huteffekt
Magritte, R.	1928	Les Jours Gigantesques
Miller, L.	1937	Raumportrait Ägypten
Oppenheim, M.	1936	Frühstück in Pelz
Oppenheim, M.	1938	Steinfrau
Táborský, H.	1933	Self portrait 2
Teige, K.	1951	Collage 374
Thiele, P.	1984	Der große Bruder

Procedure

The experiment consisted of two phases (see Figure 1) with a fixed order of blocks. The first phase comprised five rating blocks in which all stimuli were shown in randomized order. During the rating blocks, the participants sat at an approximate distance of 55 cm in front of the screen and rated the stimuli with regard to the following variables: (1) liking, (2) interest, (3) powerfulness of affect ("how strong does the artwork affect you?"), (4) perceptual affect ("how strong does the artwork affect your perception?"), and (5) cognitive affect ("how strong does the artwork affect your thoughts?"), respectively, using a 7-point Likert-type scale, ranging from 1 (not at all) to 7 (very much). Blocks 4 and 5 were introduced to discern relevant elements of the variable powerfulness of affect.

In the second phase of the experiment, the participants saw the whole set of stimuli again, this time in a fixed, nonrandomized order. Participants rated each picture concerning its degree of ambiguity, described the ambiguities they perceived in the picture in a free-typed report on a second computer (viewing an additional paper-mounted version of the according picture, no time constraints), rated the level of solvability of ambiguity, described their insights in a free-typed report on a second computer (viewing an additional paper-mounted version of the according picture, no time constraints) and rated the strength of their insights. The rating scales followed the same scheme as before (i.e., Likert-type scales, ranging from 1 [not at all] to 7 [very much]). Description phases were introduced to guarantee that the collected ratings for the solvability of ambiguity and the strength of insights were based on deep elaboration of the material. Pictures were shown in a nonrandomized order to avoid participant distraction due to the reordering of the paper-mounted versions by the experimenter.

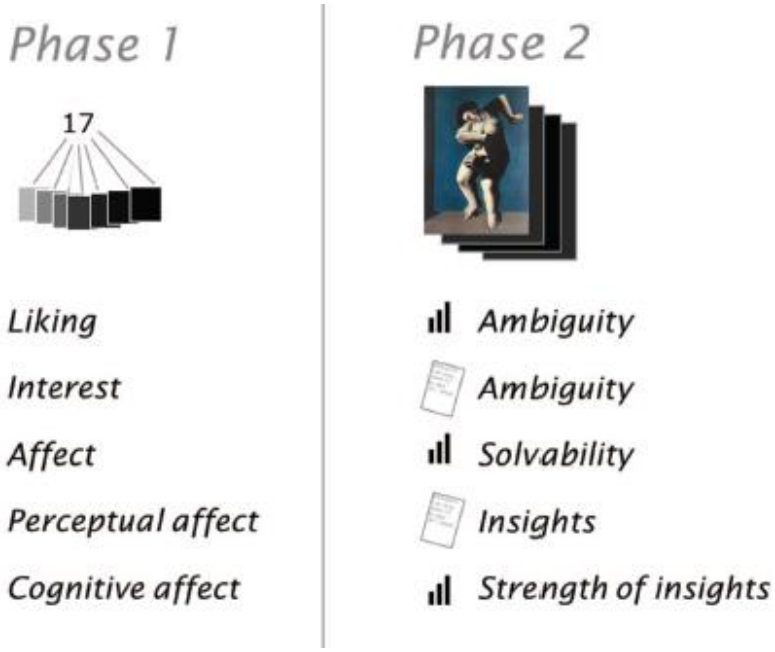

Figure 1. Procedure of the study. Example for stimulus material: Adapted from "Les Jours Gigantesques" by R. Magritte, 1928, Kunstsammlung Nordrhein-Westfalen, Düsseldorf. Copyright 2014 by VG Bild-Kunst, Bonn, Germany. Black bars symbolize rating trials; sheets of paper symbolize trials in which a free report on ambiguities within the artwork or on evoked insights were typed in. See the online article for the color version of this figure.

Results and discussion

Following Silvia's (2007) proposal to consider the use of multilevel modeling for research in psychological aesthetics, we analyzed the data accordingly. This kind of analysis allows for testing within-person effects that are particularly interesting in a field in which standards of evaluation are hardly achievable (thus scaling of aesthetic appreciation potentially differs to a high degree between subjects). The experimental design also called for multilevel models because we were interested in how personality factors such as tolerance of ambiguity modulate the aesthetic appreciation of ambiguity, solvability of ambiguity, and strength of insights during the processing of the artworks. We thus conducted five identically structured multilevel models, one for each of the five

dependent variables (each person–mean centered): (1) liking, (2) interest, (3) powerfulness of affect, (4) perceptual affect, and (5) cognitive affect.

Each multilevel model contained the following predictor structure as fixed coefficients: (a) ambiguity aspects of the artworks (ambiguity, solvability of ambiguity, and strength of insights), each variable centered on the stimulus mean; (b) interactions of ambiguity aspects with personality factors (tolerance of ambiguity: problem solving [IMA-PR] and open for experiences [IMA-OE]), each factor centered on the grand mean; (c) ambiguity aspects of the artworks, but this time each variable as stimulus mean. Additionally, we fed the models with random coefficients regarding ambiguity aspects of the artworks, each variable centered on the stimulus mean. The models also contained the 17 stimuli as repeated effects yielding a total number of 34 parameters. To increase the readability of the data analysis, we have presented all significant effects in an overall table comprising all five multilevel models (see Table 3).

Table 3

Results of the five multilevel models

Model/parameter	Estimation	*SE*	*df*	*t*	*p*
Model 1 Liking					
Ambiguity-deviation	.147	.039	37.3	3.76	.001
Insights-deviation	.148	.040	40.6	3.76	.001
IMA-PR × ambiguity-deviation (interaction)	.021	.008	25.0	2.73	.012
Insights-stimulus	.477	.168	209.4	2.84	.005
Model 2 Interest					
Ambiguity-deviation	.231	.040	27.9	5.85	<.0001
Insights-deviation	.146	.048	36.1	3.01	.005
Solvability-stimulus	−.405	.126	237.4	−3.20	.002
Insights-stimulus	1.087	.175	256.0	6.19	<.0001
Model 3 Affect					
Ambiguity-deviation	.166	.044	33.0	3.78	.001
Insights-deviation	.231	.044	39.8	5.29	<.0001
Solvability-stimulus	−.413	.123	238.3	−3.35	.001
Insights-stimulus	1.228	.178	246.0	6.89	<.0001
Model 4 Perceptual-Affect					
Ambiguity-deviation	.136	.052	39.6	2.61	.013
Insights-deviation	.179	.038	31.6	4.70	<.0001
Ambiguity-stimulus	.444	.114	200.0	3.90	<.0001
Solvability-stimulus	.253	.110	213.3	2.31	.022
Model 5 Cognitive-Affect					
Ambiguity-deviation	.220	.043	29.6	5.01	<.0001
Insights-deviation	.121	.050	41.6	2.40	.021
IMA-PR × ambiguity-deviation (interaction)	.024	.008	18.4	2.90	.009
IMA-PR × solvability-deviation (interaction)	.016	.006	495.2	2.58	.010
Ambiguity-stimulus	.305	.127	202.6	2.38	.018
Insights-stimulus	.467	.173	200.9	2.70	.006

Note. Only significant parameters are reported.
"Deviation" signifies that the according variable was centered on the stimulus mean; "stimulus" signifies that the stimulus mean itself was used.

For all models—meaning for all dependent variables—we revealed significant positive effects of ambiguity (centered on the stimulus mean): the higher participants assessed the ambiguity of a stimulus, the more they appreciated it in terms of liking, interest, affect, perceptual affect and cognitive affect. The same was the case for strength of insights. Importantly, these main effects were only modulated by personality factors for liking and cognitive affect: When IMA-PR was higher, ambiguity was more appreciated in terms of liking and cognitive affect—these modulations as well as the main effect of ambiguity on both variables are also illustrated in Figure 2 (for liking) and Figure 3 (for cognitive affect). We can detect that the majority of persons (each regression line refers to one single participant) showed a positive relationship between ambiguity and the corresponding dependent variable, but people who showed low IMA-PR scores more often tended to break this general trend—although this effect is of course far from being clear-cut. IMA-PR additionally showed an interactive effect with solvability of ambiguity. People who assessed the solvability of ambiguity in a picture as being higher were more cognitively affected the higher they scored on the IMA-PR scale. Furthermore, we detected several effects on the mean ratings of stimulus properties, such as positive effects of ambiguity on perceptual affect and cognitive affect, negative effects of solvability of ambiguity on interest and affect, a positive effect of solvability of ambiguity on perceptual affect and positive effects of strength of insights on all variables but only a trend with regards to perceptual affect.

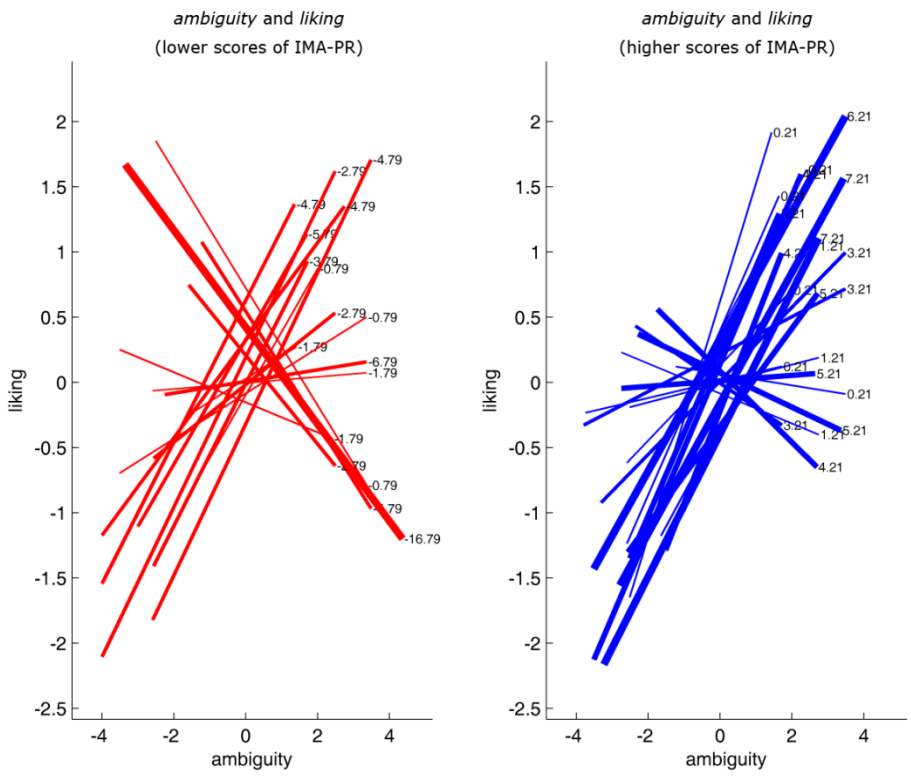

Figure 2. Relationship between ambiguity (i.e., ambiguity-deviation) and liking (person-mean centered) for persons with low versus high scores in the IMA-PR (deviation from grand mean), expressed as within-person analyses. The thicker the line the stronger the degree of deviation of IMA-PR from the grand mean (exact IMA-PR scores as deviations from the grand mean are given for each regression at the right end of the regarding line). See the online article for the color version of this figure.

At least two major conclusions can be drawn from the whole bunch of analyses: First, the complexity of the data pattern demonstrates how important it is to use a multidimensional approach to do justice to the multiple facets of ambiguity—most importantly, we have to differentiate between aspects of ambiguity, solvability of ambiguity and strength of insights. We could not find any evidence that the solvability of ambiguity is an important factor for appreciating ambiguity. There is a direct relationship of solvability to interest as well as affect, but contrary to simple ideas of art perception as a kind of problem solving it is a negative one. Second, although exerting only a modest influence, specific and art-relevant personality factors such as tolerance of

ambiguity seem to be promising candidates to explain person-specific effects in regard to the appreciation of artworks, especially to those artworks that do not offer one determinate meaning.

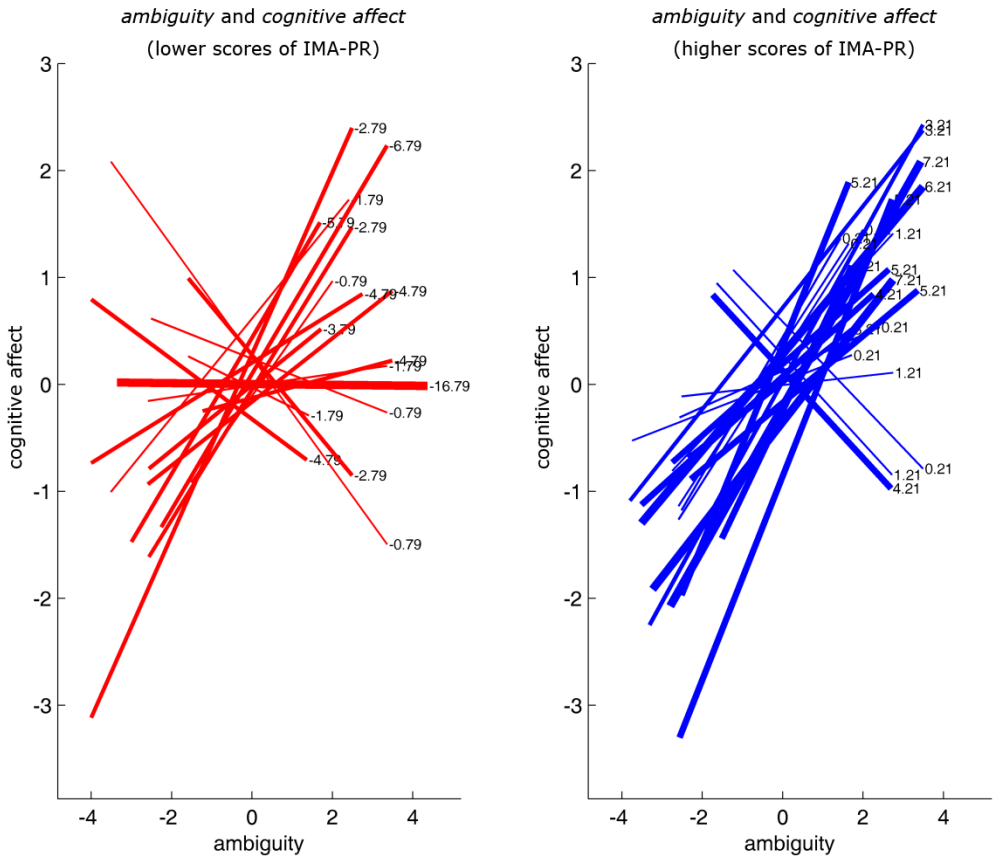

Figure 3. Relationship between ambiguity (i.e., ambiguity-deviation) and cognitive affect (person-mean centered) for persons with low versus high scores in the IMA-PR (deviation from grand mean), expressed as within-person analyses. The thicker the line the stronger the degree of deviation of IMA-PR from the grand mean (exact IMA-PR scores as deviations from the grand mean are given for each regression at the right end of the regarding line). See the online article for the color version of this figure.

General discussion

We asked how and why beholders appreciate ambiguity in art. In contrast to previous reports, we found no evidence for a pref- erence for low (Reber et al., 2004) or moderate (Jakesch & Leder, 2009) levels of ambiguity but a clear positive relation of high levels of ambiguity with liking, interest and powerfulness of (perceptual and cognitive) affect. We revealed the largest effect for interest—which indicates that this dimension is especially crucial concerning the aesthetic appreciation of ambiguity in modern art.

The appraisal approach to aesthetic emotions as proposed, for example, by Silvia (2005a) essentially defines aesthetic emotions as based on cognitive evaluations (that are expected to be, most often but not necessarily, unconscious and automatic). This means how the recipient will react to an artwork cannot simply be reduced to objectively measurable properties, but depends on the perceiver's subjective perception and experience of the respective aesthetic object. The appraisal approach further states that different aesthetic emotions are each based on specific appraisal structures which are understood in terms of specific combinations of multiple appraisal components. Common appraisal components suggested by appraisal theorists are, for instance, novelty, intrinsic pleasantness, certainty/predictability, goal significance, agency, coping potential and compatibility with social or personal standards (Ellsworth & Scherer, 2003). For the aesthetic emotion "interest" Silvia (2005a) suggests two main appraisal components: first, the appraisal of novelty (related properties are: being "new, sudden, unfamiliar, ambiguous, complex, obscure, uncertain, mysterious, contradictory, unexpected, or otherwise not understood" p. 122) and, second, the appraisal of one's own potential to cope with that object ("people's appraisal of whether they can understand the ambiguous event" p. 122). In the present study, we investigated different kinds of coping with ambiguity: the subjectively estimated strength of insights and the subjective solvability of ambiguity. Strength of insights during the elaboration of an artwork was found to be a significant indicator for aesthetic appreciation. This linkage of insights to (aesthetic) emotions is in accord with ideas that stress interactionist features of art processing rather than the search for effects of objective features of an aesthetic object. The relevance of personality factors like ambiguity tolerance furthermore underlines this point.

Uncertainty reduction might be rewarding (Dörner & Vehrs, 1975; Van de Cruys & Wagemans, 2011); however, a complete resolution of ambiguity is not necessary for the appreciation of an artwork (see, for instance, Leder et al., 2004). In our study, subjective solvability of ambiguity indeed was not significantly linked to liking and was even negatively linked to interest and affect. Taken together, these two findings could mean that insights are linked to appreciation even (or even more so) if the problem posed by the present ambiguity stays unsolved during processing. This is a conceptual challenge, if we understand both variables as being related to problem solving. Examples of participants' insight descriptions (see Table 1), however, might help to discern them on a theoretical basis: for instance, one participant described her insight into René Magritte's (1928) Les Jours Gigantèsques (see Figure 1) simply as: "the insight is, that I cannot fully solve the picture." Others described insights on the level of the content of the piece (e.g., identifying the scene as a rape), sudden Gestalt perception (when detecting a second person in the picture), insights into one's own perceptual mechanisms (e.g., "I recognize something although it is not really there") or into one's own affective reactions (e.g., "maybe I am so disgusted because . . ."). Reflective statements like that first cited above particularly exemplify that insights during the processing of an artwork can be triggered by the ambiguity of the artwork without resolving it. This point might be a usable extension to Leder et al.'s (2004) model of aesthetic appreciation and aesthetic judgments, in which evaluation is linked to cognitive mastering by a loop "in relation to their success in either revealing a satisfying understanding, successful cognitive mastering or expected changes in the level of ambiguity" (p. 499). We also suggest that insights—which do not necessarily resolve or promise to resolve the ambiguity of an artwork—might positively influence aesthetic evaluation. At the same time, ambiguity and the expectation of its resolution might be a motivation for (prolonged) involvement in art perception in the first place. This is in accord with our finding that ambiguity is linked to interest which has repeatedly been reported to motivate exploration and engagement (Izard & Ackermann, 2000; for an overview on the motivational effects of interest see Silvia, 2006). The variance in people's descriptions of a single stimulus furthermore reveals that an object is not ambiguous, interesting or affecting per se but only as a consequence of people's active elaboration of it.

Beyond this, it is plausible that if interest needs "disorientation" (Berlyne, 1971, p. 215), ambiguity should not be too easily decipherable in order to be—or stay—interesting. Furthermore these findings might explain how artworks can be appealing without offering a determinate solution or interpretation, respectively (cf., Muth et al., 2013 for Cubist artworks).

It is important to note that the concept of insight used by our participants is not entirely in accordance with a classical definition of insight (Einsicht, in German) as the sudden, smooth and fluent solution to a problem (see, e.g., Bowden, Jung-Beeman, Fleck, & Kounios, 2005). Taking our participants' descriptions into account, insight might also be construed as the sudden understanding of something after all ("Oh yes, I see that . . .") whereas this "something" does not (fully) dissolve a problem that was directly posed by the ambiguity of the artwork. Another case of nonclassical insights is given by Cubist artworks that force the perceiver to restart their search for identifiable objects again and again by offering contradictory cues (Gombrich, 1960): although the perceiver will never reach a definite solution, there are insightful moments marked by a relative stability of meaning. As these examples show, aesthetics research is potentially confronted with different kinds of insights in the context of art perception. This must also be taken into account when dealing with the question of whether insights in art perception are produced by analytic thinking or rather by a process involving insight-specific mechanisms (e.g., recomposing) or by a combination of both (see, e.g., Bowden et al., 2005; see also Weisberg, who offers an integrative approach to this topic). On the one hand we can state that not every artwork poses a classical insight problem: although they often challenge the perceiver, artworks do not always offer unexpected sudden solutions. On the other hand artworks are not riddles to be solved via analytic steps (as exemplified by Cubist artworks). In contrast: the differentiation between solvability of ambiguity and strength of insight as described above reveals that people might well also experience insight (in the broad sense) even if it does not refer to a previously perceived problem, and that an insight does not necessarily have to lead to the solution of any such problem at all in order to be appreciated.

Our results further support the notion that, in order to advance toward the specific insights to be gained from ambiguous and challenging artworks, the dynamics of

stability and instability of meaning during elaboration must be taken into account. Such a dynamic perspective also allows for recognition of the multiplicity of insights that one and the same artwork can offer: during elaboration the perceiver gets into various shades of the piece, each of which might present another subproblem or challenge offering the opportunity for another insight. Such subproblems concern, for instance, the "style" of an artwork (eventually leading to an insight via a categorization of the features), or the sujet (eventually leading to insightful associations, for instance on the social role of women in the 18th century), or even the "insolvability" of indeterminacy itself (eventually evoking a gain of insight on own perceptual mechanisms). Importantly, these subproblems are connected within the artwork, this way a certain style might influence the associations we have concerning the sujet and ambiguities among them form new subproblems (evident, for instance, in artworks from the postexpressionist art stream of New Objectivity, i.e., Neue Sachlichkeit, in German).

Conclusion

In the present study, we investigated the effect of ambiguity on a rather broad, multidimensional concept of aesthetic appreciation which we measured using the variables liking, interest, powerfulness of affect, perceptual affect and cognitive affect. Taking these diverse key dimensions of appreciation of ambiguous art into consideration, a fine-grained picture of aesthetic processing emerged that allows us to further specify the involved mechanisms. We asked whether the solvability of ambiguity was really crucial for the aesthetic appreciation of ambiguous modern artworks, as is supposed by ideas that consider the processing of modern art as a kind of problem-solving. Our results did not confirm the according claims but suggest, in contrast, that the subjective strength of insights to be gained from an artwork is the most important factor here. Consequently, we advocate that the process of elaborating ambiguous artworks and gaining insights, rather than the state of having solved "a problem" posed by these artworks, is essential for explaining the aesthetic appreciation they receive. It is also important to note that further variables beyond liking seem to be highly relevant especially for modern artworks—above all interest. The role of ambiguity tolerance is yet

to be clarified but our preliminary findings highlight the potential relevance of this personality variable in regard to the relationship between liking and ambiguity.

To sum up, the various and diverse streams of modern art might prevent us from getting easy clues about how such works appeal to us, but if we integrate further variables associated with aesthetic appreciation, for example, interest and powerfulness of affect, as well as personality factors like ambiguity tolerance we might obtain deeper insights into how pieces of ambiguous art prompt such strong aesthetic experiences as they do.

Authors' note

We thank Manuela Härtel for support during data collection. Furthermore, we are very grateful to the intense and constructive comments by two reviewers who helped to improve and to develop further the entire approach presented in this paper.

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Critical reflection

The reported study clearly reveals: yes, we can derive pleasure from artworks which defy a fully determinate interpretation. This accounts not only for liking, but as well for interest and affect. Furthermore, it gives an idea of how the appeal of challenge evolves in line with previous speculations drawn on the basis of the *Aesthetic Aha* effect (Muth & Carbon, 2013) and on findings of preference for Cubist artworks providing high detectability of objects (Muth et al., 2013a): the strength of insights induced by an artwork has a significant impact on appreciation. Also, these rewarded insights do not have to lead to a resolution of *ambiguity* to make the artwork appeal. In contrast: *solvability of ambiguity* was found to be negatively related to interest as well as to affect.

These results neither rule out nor contradict that high processing fluency (e.g., Reber et al., 2004) or uncertainty reduction (e.g., Dörner & Vehrs, 1975; Van de Cruys & Wagemans, 2011) are pleasurable. In contrast, it seems reasonable to assume that these approaches are related to each other. For instance, although *solvability of ambiguity* was not a positive predictor of appreciation, the expectation of *ambiguity resolution* or of an increase in processing fluency might have motivated the elaboration of an *ambiguous* artwork in the first place. We can furthermore assume that processing fluency indeed might temporarily increase at moments of insight (as suggested by Topolinski & Reber, 2010). The crucial point is that we have to take dynamics into account: an experience of an artwork might neither equal the pattern of unidirectional progress with regard to uncertainty reduction nor might it include a "finish line" which we cross when we "solve the riddle". Instead we can imagine different phases of elaboration marked by *indeterminacy* and uncertainty but also by moments of insight, a fleeting stability of meaning. Furthermore, expectations might change as we suddenly detect either mismatches or links between elements which did not appear to us before. As it was visualized above in Figure 6C, the resulting dynamic model of these processes thus resembles reoccurring changes between ups and downs in *semantical instability* rather than static or progressive patterns. Furthermore, we can even think of artworks which provide *indeterminacy* by random forms but conceptual *determinacy* as well—analogous to the differentiation into perceptual versus conceptual fluency (see, e.g., Reber, et al., 2004).

With reference to the main question of this thesis—how *semantical instability* in art can induce pleasure—we can state that evidence reported so far suggests the relevance of a specific mechanism: reward can be gained by the induction of insights—the activity of sense-making itself. To transfer this effect to the domain of art perception, three conditions were set up. Their fulfillment can be further supported by the present results of Core publication II:

A) A replication with regard to art objects was achieved by utilizing Cubist artworks in Core publication I and a set of modern and postmodern artworks in Core publication II.

B) A differentiation between insight and solution was explicitly drawn on the basis of subjective ratings on according concepts and an extensive theoretical discussion by Core publication II. The here reported findings furthermore give an explanation of the finding reported in Core publication I that the detectability of objects within *indeterminate* artworks increased liking without providing a determinate interpretation: not the solution of ambiguity might be the relevant factor here, but the promise of a gain of insight.

C) As speculated for Cubist artworks in Core publication I, the current findings of Core publication II suggest that the appeal of art might benefit from a remnant of *semantical instability*—especially with regard to the variable of interest. It might thus be crucial for appreciation that the struggle with *semantical instability* is not fully resolvable by elaboration.

In conclusion, the current findings suggest that sense-making might itself be rewarding even if *semantical instability* is not entirely resolved during the process. They furthermore indicate that interest is a promising variable which seems crucial for the appeal of challenge in art and hereby points to the relevance of a multidimensional account of appreciation. The last research project to be presented attempted accordingly to integrate the dynamics of the *Aesthetic Aha* effect with multidimensionality. To do so, it refined the previous findings with regard to temporal resolution of changes in perception and appreciation and with regard to the inclusion of further relevant factors. Before its presentation an additional publication provides its necessary methodological grounds.

2.4 Peripheral publication II. M5oX: Methoden zur multidimensionalen und dynamischen Erfassung des Nutzererlebens

Motivation

Before we could assess changes in perception and appreciation of artworks in a more fine-grained way, it was necessary to develop a procedure and a device capturing a continuous stream of data. The following article discusses how methodological approaches in psycho-aesthetics vary with regard to the captured dimensions of an experience as well as to the temporal resolution of the captured dynamics. Furthermore, it provides examples of continuous measurements—among them the method which was used in the subsequently presented research project.

This work appeared in Raab, M.H., Muth, C., & Carbon, C.C. (2013). M50X: Methoden zur multidimensionalen und dynamischen Erfassung des Nutzererlebens. In S. Boll- Westermann, S. Maaß & R. Malaka (Eds.), *Workshopband Mensch & Computer 2013* (pp. 155-164). München: Oldenburg Verlag.

Original article

M^5oX: Methoden zur multidimensionalen und dynamischen Erfassung des Nutzererlebens

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1 Dimensionalität und Dynamik des Nutzererlebens

Wie erleben wir Design? Welche kognitiven, affektiven und körperlichen Bestandteile zeichnen dieses Erleben aus? Welche Faktoren spielen bei der Bewertung und Nutzung von Objekten eine Rolle? Wie verändern sich Präferenzen von Objekten oder Kunstwerken im Laufe der Zeit? Diese Fragen verweisen auf verschiedene Perspektiven des Nutzererlebens, die spezifische methodologische Ansätze erfordern. Einerseits variiert hierbei die Erfassung in der Dimensionalität des Erlebens, andererseits wird sie in unterschiedlichem Maße der Dynamik des Erlebens gerecht (aufgeschlüsselt in Abbildung 1).

Abbildung 1: Multidimensionalität und Dynamik als Facetten der User Experience.

Wir stellen im Folgenden verschiedene Arten der methodischen Erfassung des Nutzererlebens unter diesen Gesichtspunkten dar und präsentieren konkrete Beispiele des Einsatzes kontinuierlicher Messungen.

1 Eine Toolbox für verschiedene Facetten des Nutzererlebens

Die Erfassung von Produkt- oder Nutzereigenschaften mittels expliziter Abfrage durch Fragebogen, aber auch durch indirekte Erfassung impliziter Haltungen zu Produkten [beispielsweise über Reaktionszeiten bei Assoziationsaufgaben durch den Test „md-IAT“ (Gattol, Sääksjärvi, & Carbon, 2011)] ermöglicht die Abbildung multidimensionaler Faktoren des Nutzererlebens. Veränderungen innerhalb des Erlebens lassen sich allerdings erst durch den Vergleich mehrerer Testzeitpunkte feststellen. Vor allem im Bereich des Designs und der Kunstbetrachtung spielen solche dynamischen Prozesse eine große Rolle: Bei der Erfassung des Gefallens von Produkten während eines einzigen Zeitpunkts schneiden beispielsweise innovative im Vergleich zu vertrauten Stimuli schlechter ab (Reber, Schwarz, & Winkielman, 2004), während bei wiederholter Abfrage nach einer intensiven Beschäftigung mit dem Material ein Anstieg der Präferenz innovativer Designs zu verzeichnen ist (Carbon & Leder, 2005). Die Methode der „Repeated Evaluation Technique (RET)“ (Carbon & Leder, 2005) erfasst in der Minimalversion mit zwei Messzeitpunkten bereits Veränderungen verschiedener Variablen der Wertschätzung; höhere Wiederholungsraten ermöglichen ein feineres zeitliches Abbild [bspw. k=4 in Carbon, Faerber, Gerger, Forster, & Leder (in press)]. Während sich, wie von Zajonc (1968) als „Mere-Exposure Effect“ beschrieben, Präferenzen bereits aufgrund mehrfacher bloßer Präsentation eines Stimulus ändern, konnten Muth und Carbon (2013) mit dem „Aesthetic Aha“-Effekt zeigen, dass nicht nur die Präsentationshäufigkeit, sondern vielmehr die Dynamik des Erkennens eine Rolle spielt: Nur direkt nach einer perzeptuellen Einsicht (in Form plötzlicher Gestalterkennung) stieg das Gefallen signifikant an. Hier wurden Bilder alternierend je sechs Mal auf Erkennbarkeit der Gestalt und nach Gefallen bewertet, um eine wiederum feinere Abbildung der Prozesse zu ermöglichen und so einen bisher verborgenen Zusammenhang aufzudecken. Die nächste Stufe der zeitlichen Auflösung von dynamischen Prozessen des Erlebens stellen Erfassungsmethoden dar, die den temporalen Aspekt des Erlebens abbilden. Sie werden exemplarisch im nächsten Kapitel beschrieben.

Abbildung 2 veranschaulicht den Zusammenhang der hier präsentierten Erfassungsmethoden mit den oben beschriebenen Facetten des Erlebens: Multidimensionalität und Dynamik. Mit der Abbildung dynamischer Prozesse gehen Einschränkungen der Erfassung von Multidimensionalität einher. Während zwei Messzeitpunkte noch ausführliche Befragungen und Testungen ermöglichen [bspw. 6 Dimensionen in Faerber, Leder, Gerger, & Carbon (2010)], muss bereits bei fünf Messzeitpunkten mit hohem Zeitaufwand und Störfaktoren wie Langeweile, Frustration und Ermüdung gerechnet werden, soll Multidimensionalität gewährt bleiben. Die Erfassung mittels kontinuierlicher Messmethoden ist im Falle von beispielsweise der Posturographie, der Hautwiderstandsmessung oder auch dem Eye-tracking auf eine Modalität beschränkt. In Kombination mit anderen Methoden ermöglicht sie allerdings Multidimensionalität bezüglich der Prozessmodalitäten (wie affektive und kognitive Modi, siehe Abbildung 1) – beispielsweise durch die Erfassung des Hautwiderstands während einer kognitiven oder perzeptuellen Aufgabe. Im Folgenden stellen wir anhand von drei Studien beispielhaft verschiedene kontinuierliche Messmethoden vor und diskutieren Vor- und Nachteile für Fragestellungen aus dem Bereich des Nutzererlebens.

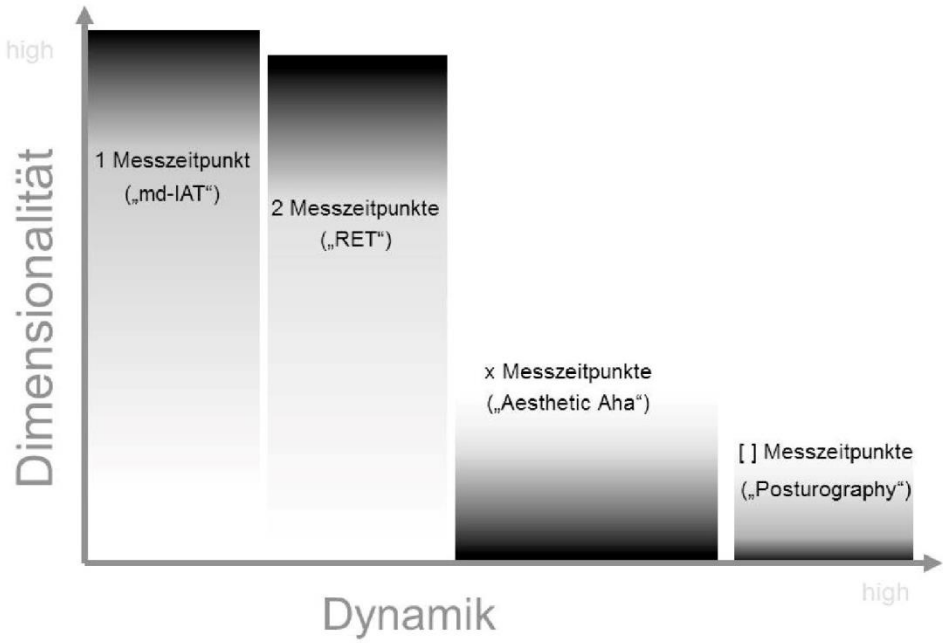

Abbildung 2: Verschiedene Erfassungsmethoden und ihre Positionierung hinsichtlich Dimensionalität und Dynamik des Nutzererlebens. Während ein Messzeitpunkt hohe Multidimensionalität ermöglicht, wird sie mit steigender Abbildungsfähigkeit dynamischer Prozesse geringer. In Klammern werden im Text besprochene Beispiele für die verschiedenen Methoden genannt.

2 Kontinuierliche Messmethoden

2.1 Posturographie mit dem Nintendo Balance Board

Die Theorie der Ur-Affekte (Kafka, 1950), aufgegriffen und erweitert von Parrott (2009), verknüpft das emotionale Erleben untrennbar mit Motorik. Gemütsbewegung ist bei Kafka wörtlich zu verstehen, Objekte erzeugen bei uns Erregung und Spannung. Er nimmt Gibsons (1977) Affordance-Konzept vorweg, indem er in Objekten eine Aufforderung an das Individuum sieht, sie auf gewisse Art und Weise zu behandeln.

Die mögliche Handlung, und daraus abgeleitet die möglichen Emotionen, verbindet er mit vier basalen Optionen: Das Objekt näher „heranbringen“ (Ingestion, zum Beispiel bei Gier), das Objekt „hinfortstoßen“ (Ejektion, zum Beispiel Widerwille), vor dem Objekt „fliehen“ (Rezession, etwa bei Furcht) und sich zum Objekt „hinbewegen“ (Profusion, beispielsweise als Liebe). Besonders interessant für die Erforschung des Nutzer-Erlebens sind Objekte, die eine Mischung aus verschiedenen Uraffekten hervorrufen, beispielsweise eine Mischung aus Drohung und Lockung. Dies resultiert in einer Mischung aus An- und Entspannung und dementsprechend in einer komplexen emotionalen Reaktion. Eine Integration dieser Theorie

in die User-Experience-Forschung würde ein Messinstrument erfordern, das schnell und genau auch subtile motorische Annäherungs- und Vermeidungsbewegungen registriert. Diesen Ansatz verfolgen wir mit dem Einsatz des *Balance Boards* von *Nintendo*.

2.1.1 Technik und Schnittstelle

Das Balance Board des japanischen Videospiel- und Konsolenherstellers Nintendo (siehe Abbildung 3) ist ein Zubehör zur populären Spielekonsole *Wii*. Die Konsole ist seit 2006 auf dem Markt und wurde jüngst durch den Nachfolger *Wii U* abgelöst. Seit 2008 ist für die Wii das Zusatzpaket *Wii fit* erhältlich (derzeitiger Marktpreis rund 80 Euro); es besteht aus dem Balance Board und einem dafür entwickelten Videospiel.

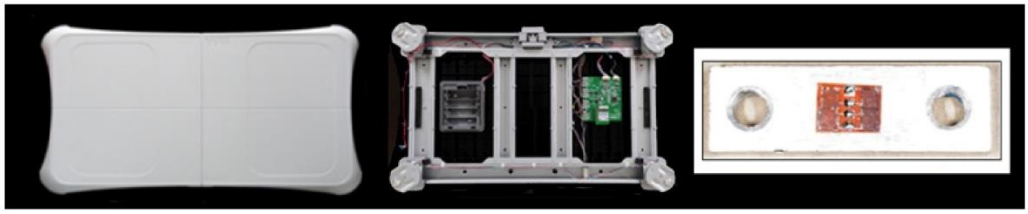

Abbildung 3: Das Nintendo Balance Board von oben (links) und von unten mit geöffnetem Boden (Mitte).In die vier Füße sind elektronische Dehnungssensoren integriert (rechts, vergrößerte Darstellung).

In einer eigenen Messreihe mit geeichten Gewichten stellten wir einen linear ansteigenden Messfehler von 100 g pro 15 kg Gewicht (auf dem gesamten Board, also über alle vier Sensoren) fest. Die tatsächliche Abtastrate betrug 100 Hz.

2.1.2 Auswertung

Ausgleichsbewegungen während des ruhigen Stehens folgen hoch komplexen Aktivierungen vieler und großer Muskelgruppen (Winter, Patla, Ishac & Gage, 2003). Schwankungen sind so als systematische Grundaktivität in den Daten vorhanden. Um sie weitgehend zu eliminieren, errechnen wir für ereignisbezogene Abschnitte der Daten Fourier-Kurvenanpassungen höherer Ordnung und subtrahieren diese Idealkurven von den tatsächlichen Kurven. Harmonische Schwingungsanteile werden so herausgerechnet. Übrig bleiben schnelle und ereigniskorrelierte motorische Reaktionen des Gleichgewichtsapparates, die unwillkürliche Anziehung und Abstoßung widerspiegeln. Entsprechend Kafkas Theorie würde ein hässliches Bild ein Weg-Bewegen induzieren, also eine Gewichtsverlagerung nach hinten Durch Betrachtung sowohl der Gewichtsverlagerungskurve als auch ihrer ersten Ableitung können wir sowohl für einzelne Individuen als auch auf Gruppenebene motorische Reaktionen identifizieren, beispielsweise im Vergleich von (zuvor entsprechend bewerteten) als schön und hässlich empfundenen Bildern (Abb. 4). Wir nennen diese Auswertung „Emotional Footprint".

2.1.3 Diskussion

Das Balance Board erlaubt es, mit einfachen Mitteln einen zeitlich hoch aufgelösten und genauen „Emotional Footprint" zu erstellen. In Kombination mit weiteren Verfahren – beispielsweise einem klassischen Fragebogen vor oder nach dem eigentlichen Board-Experiment – ist es ein wichtiger Baustein der M^5oX-Toolbox.

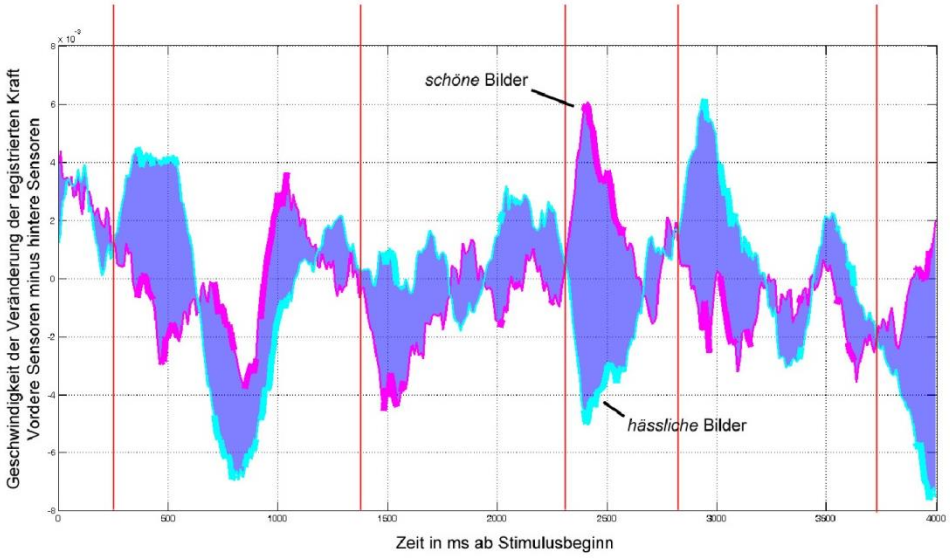

Abbildung 4: Die erste Ableitung der Sensordaten (vordere Sensoren minus hintere Sensoren), gemittelt über 30 Teilnehmer, zeigt charakteristische Unterschiede im Vergleich von schönen und hässlichen Bildstimuli.

2.2 Dynamische Erfassung ästhetischer Filmwirkung

Aus Erfahrungen mit optischen Illusionen und Suchbildern kennen wir das Gefühl des "Aha"-Erlebnisses, wenn wir etwas plötzlich deutlich erkennen. Muth und Carbon (2013) deckten diesen „Aesthetic Aha“-Effekt kürzlich anhand unbestimmter Darstellungen von Gesichtern auf. In einer aktuellen Studie untersuchen wir die Relevanz dieses Effekts für die Bewertung künstlerischen Filmmaterials, in dem eine Gestalt entsteht, sich verändert bzw. auflöst und wieder neu entsteht (siehe Beispiele ‚a‘-‚d‘ in Abbildung 5). Der Einsatz eines Schiebereglers ermöglicht die Erfassung der Dynamik der Bestimmtheit (respektive Eindeutigkeit) der verschiedenen Phasen des Films sowie der Dynamik des Gefallens. Dies ermöglicht die Betrachtung des Zusammenhangs zwischen Bestimmtheit und Gefallen mit hoher zeitlicher Auflösung.

2.2.1 Technik und Schnittstelle

Zur Erfassung kontinuierlicher Daten nutzen wir einen 10 cm langen Schieberegler mit 10 kΩ (lineare Kennlinie). Der gesamte Schiebeweg wird über 1024 einzelne Messwerte realisiert und über einen FTDI RS232-USB-Emulator an den Rechner übertragen.

2.2.2 Experiment und Datengewinnung

In den Räumen der Ausstellung „Irritation und Auflösung“ in der Griesbadgalerie Ulm betrachteten 28 Versuchspersonen vier Stop-Motion Filme (insgesamt 7 min, 15 s.). Sie bewerteten in zwei Blöcken zeitgleich mit der Betrachtung die Filmstadien auf Bestimmtheit respektive Gefallen.

2.2.3 Auswertung

Abbildung 5 zeigt den Verlauf der dynamischen Bestimmtheits- und Gefallensbewertung über alle fünf Filme. Auffällig ist hierbei die Kongruenz der Variablen zu Beginn des Films und ihr zunehmendes Auseinanderdriften (sichtbar durch die gesteigerte Differenzfläche). In Folgestudien möchten wir eruieren, ob sich v.a. bei unbestimmten Stadien andere Faktoren (z.B. Kontrast) auf Gefallen stärker auswirken und somit die erhöhten Differenzen erklärt werden können (siehe z. B. Standbild ‚b' und ‚d' in Abbildung 5).

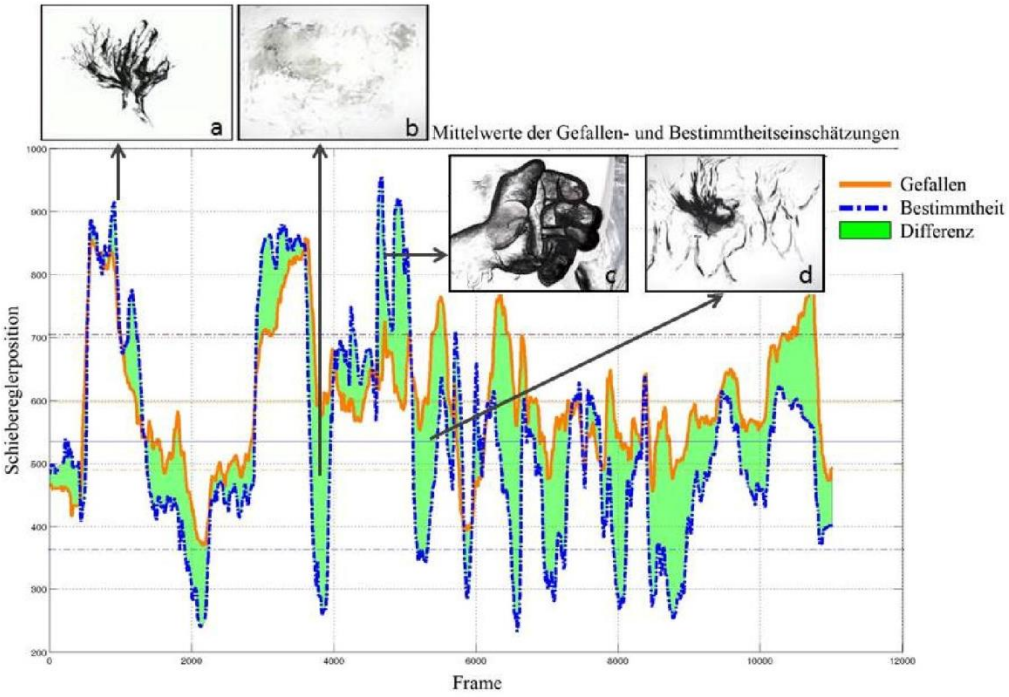

Abbildung 5: Verlauf und Differenz der dynamischen Bestimmtheits- und Gefallensbewertung des Filmmaterials gemittelt über 28 Versuchspersonen. Beispielhafte Standbilder (‚a'-‚d') veranschaulichen interessante Stadien der Kongruenz und Inkongruenz der ermittelten Variablen.

2.2.4 Diskussion

Die kontinuierliche Erfassung dynamischer Bestimmtheits- und Gefallensbewertungen kann dynamische Prozesse während des Kunstbetrachtens abbilden. Gleichzeitig zeigt sich hier deutlich, dass Multidimensionalität erheblich zum Verständnis komplexer kognitiver und affektiver Prozesse beiträgt und in diesem Fall nötig ist, um das Zusammenspiel von Bestimmtheit und Gefallen während einer ästhetischen Erfahrung zu verstehen.

2.3 Kinect zur Erfassung motorischer Konzepte

Bewegungsübungen zur Bewältigung von seelischen Belastungen – beispielsweise Yoga, Qi Gong und Tai Chi – sind weit verbreitet. Unter dem Schlagwort *embodiment* untersucht die Psychologie das Wechselspiel von Emotion, Kognition und Körperbewegungen (Koch & Fuchs, 2001). Einer Vielzahl an Studien zum Einfluss der Körperhaltung auf das psychische Erleben (beispielsweise Carney, Cuddy & Yap, 2010; Riskind & Gotay, 1982) stehen wenige Untersuchungen zu komplexen Bewegungsfolgen gegenüber. Dies könnte zum Teil an der Schwierigkeit liegen, solche Bewegungsmuster von unterschiedlichen Versuchspersonen möglichst ähnlich und damit vergleichbar ausführen zu lassen.

3.3.1 Technik und Schnittstelle

Der Microsoft Kinect-Sensor basiert auf Hardware der Firma *PrimeSense*. Ausgestattet[1] ist er mit einem 3D-Mikrofon, einer VGA-Kamera (übliche Videoauflösung 640 x 480 Pixel) und einer IR-Tiefenkamera (57° horizontaler Erfassungswinkel, nutzbare Distanz 0.8 bis 4 Meter[2]). Angesteuert wird Kinect in unseren Experimenten über die Processing 1.5.1, einer auf Java basierenden Grafik-API[3]. Über den Java-Wrapper *SimpleOpenNI*[4] kann das 3D-SDK *OpenNI* angesteuert werden, das alle Kinect-Funktionen nutzbar macht.

3.3.2 Experiment und Datengewinnung

In einer ersten Pilotstudie zur Auswirkung von Bewegungsübungen auf den affektiven Zustand ahmten 29 Versuchspersonen eine Qi-Gong-Übung nach. Aus einem zuvor gedrehten Video einer Entspannungsübung extrahierten wir die Position der Hände. Dabei variierten wir einerseits die Länge des Videos sowie die Qualität der gezeigten Bewegung (a) Kreise folgen langsam der kompletten Bewegung, b) Kreise springen ca. pro Sekunde schlagartig zur nächsten Position) Die Versuchspersonen wurden instruiert, mit ihren eigenen Händen diesen Kreisen zu folgen. Dabei wurde die Position der Hände der Versuchsperson kontinuierlich über Kinect erfasst und direkt auf dem angezeigten Video eingeblendet. So hatten die Versuchspersonen eine beständige Rückmeldung, wie gut sie der Bewegung gerade folgen. Vor und nach dieser Übung schätzten die Teilnehmerinnen und Teilnehmer ihren aktuellen emotionalen Zustand. Dazu bewerteten sie 14 Adjektive (wach, ruhig, zentriert,…) auf einer fünfstufigen Skala, die sie über Handbewegungen via Kinect auf der Leinwand „ankreuzten".

2.3.3 Auswertung

Die über Kinect abgegeben Bewertungen wurden in eine Datenmatrix gespeichert und mit SPSS ausgewertet. Die Versuchspersonen fühlen sich nach der Imitation des kurzen Videos signifikant weniger zentriert als zuvor (Mixed ANOVA, repeated measurement,

[1] http://msdn.microsoft.com/en-us/library/jj131033.aspx

[2] http://msdn.microsoft.com/en-us/library/hh973078.aspx#Depth_Ranges

[3] http://www.processing.org/

[4] http://code.google.com/p/simple-openni/

$F(1,27)=4.99$, $p=.034$); das Imitieren des langen Videos ließ die „Zentriertheit" dagegen ansteigen ($F(1,27)=5.98$, $p=.021$). Eine Interaktion ergab sich bei Berücksichtigung der Bewegungsqualität (nur langes Video): Die langsamen, geführten Bewegungen ließen die „Zentriertheit" ansteigen, das Video mit den Bewegungs-Sprüngen verringerte hingegen die „Zentriertheit" signifikant ($F(1,13)=6.086$, $p=.028$). In der Nachbefragung konnten die Versuchspersonen „zentriert" in Worten schlecht beschreiben. Auch für weitere Adjektive, beispielsweise „wach", ergaben sich signifikante, hypothesenkonforme Ergebnisse.

2.3.4 Diskussion

Unsere Ergebnisse deuten darauf hin, dass die Bewegungsqualität selbst – und nicht nur das Wissen über den Sinn einer Bewegungsfolge – den affektiven Zustand einer Person verändert. Kinect ermöglichte es, die Bewegung abstrahiert vom Entspannungs-Kontext vorzugeben. Gleichzeitig konnten die Teilnehmerinnen und Teilnehmern die Bewegungen ohne vorheriges Üben genau nachvollziehen. Wir vermuten, dass das Rating des Adjektive über Kinect begünstigt hat, dass die Versuchspersonen nach dem Video im motorischen Fluss bleiben und Armbewegungen zum Antworten nutzen konnten – ein großer Vorteil zu einem klassischen Fragebogen. Besonders deutlich zeigten sich die vermuteten Effekte beim Begriff „zentriert", den die Versuchspersonen verbal kaum definieren konnten. Offenbar ist dieser Begriff stark mit Körpergefühl und Emotionen verknüpft, die verbal schlecht zugänglich sind, mit einer auf Kinect basierenden Testungen aber gezielt manipuliert und auch abgefragt werden können.

3 Allgemeine Diskussion

Wir plädieren für ein Konzept des Nutzererlebens, das dynamische Prozesse auf der kognitiven, affektiven und körperlichen Ebene einbezieht. Je nach Fragestellung bieten sich zur Erfassung der relevanten Faktoren und Effekte unterschiedliche Methoden an, deren Qualität sich an der erzielbaren Dimensionalität und Dynamik misst. Mit der Idee der M^5oX präsentieren wir eine Methoden-Toolbox, die Möglichkeiten und Einschränkungen der einzelnen Techniken systematisch veranschaulicht.

Die beschriebenen Studien exemplifizieren das Potential kostengünstiger, robuster Techniken zur detaillierten Erfassung dynamischer Prozesse. Ziel ist nun die Entwicklung von Standard-Auswertungsroutinen für kontinuierliche Messmethoden sowie eine Fortführung der Toolbox hinsichtlich sinnvoller Kombinationsmöglichkeiten zur Optimierung des Verhältnisses von Dimensionalität und Dynamik.

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Critical reflection

This article provided an overview on methodological approaches to assess user experiences in different domains. Their quality can be estimated via two main factors: the number of captured dimensions of experience and the temporal resolution of the captured dynamics. Psychological approaches often focus on high dimensionality of the assessed variables but exclude their dynamics by applying one time point of measurement only. As mentioned above, the *Repeated Evaluation Technique* (*RET,* Carbon & Leder, 2005) comprises two time points of evaluation and thereby allows for the investigation of effects of elaboration on appreciation. Additional time points of measurement—as in Muth and Carbon (2013; see Peripheral publication I)—increase the resolution of dynamics of evaluation. But with increasing temporal resolution the number of assessable dimensions decreases as well. Continuous assessments allow for one dimension only unless combined with parallel or subsequent testing. A dynamic approach to the appeal of *ambiguous* artworks requires a tool which measures continuous data but still allows for multidimensionality. The subsequent publication utilized such a *Continuous Evaluation Procedure* (*CEP,* Muth, Raab, & Carbon, 2015) consisting of a slider box as described in the precedent article capturing data without time delay (for a visualization of the *CEP* see Figure 7). A combination of several assessments of continuous streams of data provided high temporal resolution as well as multidimensionality of the experience of *indeterminate* artistic movies.

Figure 7. Application of the *Continuous evaluation Procedure* (*CEP*) in the study by Muth et al. (2015).

2.5 Core publication III. The stream of experience when watching artistic movies. Dynamic aesthetic effects revealed by the Continuous Evaluation Procedure (CEP)

Motivation

Evidence provided by the first three publications presented within this thesis suggested one mechanism relevant to the appeal of *semantical instability* in art: sense-making is rewarding by itself; we can gain pleasure by insights during elaboration even if *semantical instability* is not entirely resolved. If this pleasure is then attributed to the elaborated object, appreciation temporarily increases. With reference to the proposed model in Figure 6C, we can ask how the actual pattern of involved processes looks like: which kinds of changes precede the moment of insight and does appreciation actually increase immediately after it (as in Peripheral publication I; Muth & Carbon, 2013)? Furthermore, findings of the appeal of *indeterminate* art—which does not provide a determinate interpretation—led to the idea that not only the actual insight but also the promise of success might be effective on appreciation (see discussion of Core publication I, Muth et al., 2013a, and discussion of Core publication II, Muth, Hesslinger, et al., 2015). This might be especially relevant to the variable of interest which was claimed to be qualified by a combination of disorientation and anticipation of success (Berlyne, 1971) or complexity and comprehensibility, respectively (Silvia, 2005). As Core publication II suggested, a multidimensional account of appreciation might therefore be highly fruitful (Muth, Hesslinger, et al., 2015).

The major aim of the next research project was consequently to set up a refined model of the appeal of *semantical instability* in art which integrates dynamic effects not only of moments of insight but also of their anticipation on multiple dimensions of appreciation. An ideal artistic material to study these effects was found in the stop-motion movies presented in the beginning of this thesis (see Figure 1 and Supplementary material 1). Like the black and white non-art pictures which were used as stimulus material in the initial study on the *Aesthetic Aha* effect (Muth & Carbon, 2013) these movies share qualities inherent to *hidden images*: they contain *indeterminate* as well as *determinate* phases during the evolution of a drawing. For this purpose, I repeatedly

took photographs of actual states of the drawing and integrated them via the stop-motion-technique to a film which enables the viewer to follow the development and metamorphosis of Gestalt within the drawing. In contrast to the black and white pictures utilized before, this stimulus material provided moving pictures with different degrees of *indeterminacy*. This enabled us to characterize stages of the movie (and thus of the represented drawing) with regard to complexity, to the opportunity for insight, and to several facets of appreciation.

To achieve a fine grained assessment of this data for each frame of the movie, we applied the *Continuous Evaluation Procedure* (*CEP*; see previous chapter and Figure 7). That way we were able to retrace how liking and interest change with reference to moments of insight: if interest is actually elicited by an increase of complexity together with a promise of understanding (as proposed by Berlyne, 1971, and Silvia, 2005) the continuous stream of interest would show an increase during an increase in complexity of the movie and already before moments of insight. Liking should—in contrast—increase shortly after moments of insight according to the *Aesthetic Aha* effect (Muth & Carbon, 2013). Furthermore, we were interested in the different facets of the conscious experience of insights gained during the perception of the movie and thus collected short written reports.

This work appeared in Muth, C., Raab, M. H. and Carbon, C. C. (2015). The stream of experience when watching artistic movies. Dynamic aesthetic effects revealed by the continuous evaluation procedure (CEP). *Frontiers in Psychology, 6*(365). doi: 10.3389/fpsyg.2015.00365

Original article

The stream of experience when watching artistic movies. Dynamic aesthetic effects revealed by the Continuous Evaluation Procedure (CEP)

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OPEN ACCESS

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Specialty section:
This article was submitted to Cognitive Science, a section of the journal Frontiers in Psychology

Received: *29 October 2014*
Accepted: *16 March 2015*
Published: *31 March 2015*

Citation:
Muth C, Raab MH and Carbon C-C (2015) The stream of experience when watching artistic movies. Dynamic aesthetic effects revealed by the Continuous Evaluation Procedure (CEP). Front. Psychol. 6:365. doi: 10.3389/fpsyg.2015.00365

Research in perception and appreciation is often focused on snapshots, stills of experience. Static approaches allow for multidimensional assessment, but are unable to catch the crucial dynamics of affective and perceptual processes; for instance, aesthetic phenomena such as the "Aesthetic-Aha" (the increase in liking after the sudden detection of Gestalt), effects of expectation, or Berlyne's idea that "disorientation" with a "promise of success" elicits interest. We conducted empirical studies on indeterminate artistic movies depicting the evolution and metamorphosis of Gestalt and investigated (i) the effects of sudden perceptual insights on liking; that is, "Aesthetic Aha"-effects, (ii) the dynamics of interest before moments of insight, and (iii) the dynamics of complexity before and after moments of insight. Via the so-called Continuous Evaluation Procedure (CEP) enabling analogous evaluation in a continuous way, participants assessed the material on two aesthetic dimensions blockwise either in a gallery or a laboratory. The material's inherent dynamics were described via assessments of liking, interest, determinacy, and surprise along with a computational analysis on the variable complexity. We identified moments of insight as peaks in determinacy and surprise. Statistically significant changes in liking and interest demonstrated that: (i) insights increase liking, (ii) interest already increases 1500 ms before such moments of insight, supporting the idea that it is evoked by an expectation of understanding, and (iii) insights occur during increasing complexity. We propose a preliminary model of dynamics in liking and interest with regard to complexity and perceptual insight and discuss descriptions of participants' experiences of insight. Our results point to the importance of systematic analyses of dynamics in art perception and appreciation.

Keywords: aesthetics, Aesthetic Aha, art, dynamic appreciation, indeterminacy, ambiguity

Introduction

An Encounter with a Salami made of Wood

If you had taken a walk along a calm side road in Nuremberg last summer, you might have encountered a strange object in a window (**Figure 1**). Surprised, you might have

FIGURE 1 | Piece of wood, detected in a window in Nuremberg in 2013. Photograph by Claudia Muth. Image courtesy of Claudia Muth.

stopped there wondering why one would put a big piece of sausage—actually appearing to be Milanese salami—in a sunny window. On second glance, it might have appeared to you that this object is actually not a sausage but a piece of wood cut into pieces, with the natural white of the birch bark looking like salami casing, and sausage-like patterns painted on the cut edges. This insight might furthermore have made you wonder about the function of this place: is it a gallery? And finally, despite being amused, you might have even felt a bit fooled as the illusion was obviously deliberately intended for pedestrians and made you an unwitting part of an artistic project. This little episode shows that we are guided by expectations, continuously forming predictions about the world, and that we are easily irritated when they are not met. The underlying mechanism is described in the cognitive sciences as "predictive coding"; a theory deeply rooted in the concept of perception as knowledge-driven inference proposed by psycho–physiologist Von Helmholtz (1866). Within this conceptual framework it is stated that instead of a bottom-up accumulation of information we engage constantly in matching sensory inputs with predictions created on the basis of prior experiences (for a recent critical examination of this account see Clark (2013). Artists widely make use of mismatches between predictions and actual sensory cues by providing deviations from beholders' expectations or perceptual habits. According to the *tentative prediction error account of visual art* (Van de Cruys and Wagemans, 2011) these mismatches motivate the perceiver to engage in the rewarding resolution of the prediction error.

Physical and Semantical Dynamics in Perception

Two main conclusions might follow on from this:

(a) Our perceptual impressions of an object and its context are in permanent flux as we move or as the object moves or transforms itself: the (perceived) world is not static but permanently *physically changing*.
(b) Meaning evolves out of interaction with our environment and is not obvious and inherent *per se*: the (perceived) world is continuously re-evaluated and thus not determinate but *semantically changing*. This means that, even if something remains physically constant, our attribution of meaning is permanently updated by cognitive and affective processes. Perception is always based on psychological processing which is highly interactive and dependent of expectations, predictions, and activation of semantic networks (see Carbon, 2014).

In the realm of this research project, we examine the dynamics of such changes. These are qualities or specific patterns of changes, respectively. Dynamics can emerge out of physical changes (e.g., the typical dynamics of an explosion), semantic changes (e.g., the dynamics of a sudden shift in valence when learning about the financial value of a vase which you are holding in your hands), or their interaction (e.g., the dynamics of a perceptual Aha insight when finding Wally in a crowd after scanning the scene via eye movements). Semantical dynamics become specifically evident in the perception of objects that offer multiple meanings and afford elaboration: the "wooden sausage" (see **Figure 1**), for instance, induces dynamics specific to the phenomenon of bistable ambiguity as we switch from one determinate interpretation (sausage) to the other (wood) and eventually back again (see the psychological concept of ambiguity by Zeki, 2004, as well as the conceptualization of multistability as defined by Kubovy, 1994).

Evidently, physical and semantical dynamics are linked as we can imagine physical changes inducing semantical changes. Varini's (2006) "Huit carrés," for instance, plays with perceptual changes induced by different viewpoints of the object. This way they surprisingly reveal appearances of Gestalt from a specific physical viewpoint (see **Figure 2**). His works thus fuse physical with semantical dynamics. By concealing an identifiable pattern his work exemplifies the art theoretical definition of "hidden images" by Gamboni (2002), challenging the recipient to search (cognitively, but also by moving around or in front of the artwork) for an object that is actually present in the image but cannot be perceived too easily. A special class of semantical dynamics is found in "potential images" which—in contrast to hidden and ambiguous images—are fully indeterminate. They do not provide any recognizable object but are evocative of something we might know (for "potential images" see Gamboni, 2002; for indeterminacy see Pepperell, 2006). The example in **Figure 3** stimulates all kinds of association and motivates intense exploration without resolving into certain, determinate identification (in contrast to ambiguity, which offers several certainties with the same probability; see definition by Zeki, 2004). As the art historian Gombrich (1960) proposed for the perception of Cubist artworks—offering a wide range of indeterminacy—here also the visual search continues after cues have been detected. Indeterminacy is thus a suitable phenomenon for studying highly dynamic experiences in regard to the attribution of meaning.

Dynamics in Liking

It is quite clear that not only are dynamics to be found in the perceptual process itself and the processing of semantics, but aesthetic appreciation is obviously changeable, too. This has been an issue of empirical studies in the domain of psychological

FIGURE 2 | Varini (2006). Huit carrés. Versailles: Orangerie du Chateau de Versailles. Image courtesy of Felice Varini.

FIGURE 3 | *Succulus*, a painting made by Pepperell (2005). Image courtesy of Robert Pepperell.

aesthetics, though there remains to be a systematic examination of this process. For instance, appreciation was found to increase with unreinforced visual presentation of a stimulus (see mere-exposure effect by Zajonc, 1968) limited by the factor of increasing boredom (Bornstein, 1989) or fatigue (Carbon, 2011). While here, increasing familiarity seems to be a crucial factor, the depth of elaboration played a role in a study by Carbon and Leder (2005): innovative car designs were liked more after elaboration of the material via the so-called Repeated Evaluation Technique (RET; cf. Faerber et al., 2010). A further example of empirical evidence for dynamics relevant to appreciation is demonstrated by the phenomenon of the "Aesthetic-Aha" (Muth and Carbon, 2013), stating that the recognition of a Gestalt within two-tone-images yields a sudden increase in liking. Positive effects of the subjective strength of perceptual and cognitive insights on appreciation were also reported in the domain of art perception (Muth et al., 2015).

The mere exposure is referred to in so called fluency theories: higher familiarity by repetition leads to an increase in processing fluency which is marked by positive affect (e.g., Reber et al., 2004). The elaboration of the car interior designs—in contrast—comprised an active engagement which probably induced changes in the perception of the material's features and qualities. Here, as well as in regard to the "Aesthetic Aha" effect, dynamics in appreciation are linked to dynamics in semantics elicited by deep elaboration or increases in determinacy (Aha!), respectively. While fluency might actually also play a role in such semantical dynamics, it might be crucial that the material itself is difficult or complex enough to induce an increase in certainty in the first place for the positive effect of an "Aesthetic Aha" to occur: while in the rationale of fluency accounts we prefer the most predictable stimulus, Van de Cruys and Wagemans (2011) point to pleasure from the "transition from a state of uncertainty to a state of increased predictability" (p. 1035). The sudden revelation of a Gestalt within an indeterminate picture thus might be a rewarding resolution of indeterminacy.

Still, as the philosopher Gadamer (1960/2002) points out "There is no absolute progress and no final exhaustion of what lies in a work of art" (p. 100). Therefore, we would like to add that even if increases in predictability or certainty, respectively, are pleasurable this does not have to mean that we derive pleasure solely from arriving at a fully determinate interpretation of an artwork (if possible at all). Here, the semantical dynamics might not equal the pattern of a unidirectional progress in regard to uncertainty reduction, but instead might consist of an alternation between indeterminate phases, moments of insight, or even an endless loop among determinate patterns within ambiguous objects. Partial insights into the semantic structures of an artwork (e.g., discovering the topic of the depicted scene while still being puzzled by the choice of stylistic means) might evoke pleasure without providing "a solution" to the "problem" posed by the work (see Muth et al., 2015). Such insights might happen several times during the elaboration of an artwork and might be an important factor why many pieces of art keep the beholders' interest in them alive.

Dynamics in Interest

Aside from the actual changes in meaning attribution, the expectation of insight might also be relevant to one crucial dimension of appreciation: interest. Berlyne (1971) assumed "disorientation" with a "promise of success" to elicit interest, while Silvia (2005) proposed a combination of appraisals for interest—one being the challenging features of an object, and the other being one's ability to cope with these challenges through understanding. Thus, even before a sudden increase in determinacy, the interestingness of an object might increase. For indeterminate objects like the one depicted in **Figure 3** this might be particularly relevant: while not providing the experience of total determinacy, interest might arise due to the ongoing "promise," the permanent unresolved "potential" of determinacy.

Aims and Hypotheses

We aim at providing a more elaborate picture of the interplay of physical and semantical dynamics with dynamics of appreciation

by assessing continuous evaluations of movies in regard to the dimensions of complexity (physical dynamics), (in)determinacy and surprise (semantical dynamics), as well as liking and interest (dynamics of appreciation). We examined (i) the effects of sudden perceptual insights (increases in surprise and determinacy) on liking; that is, "Aesthetic Aha"-effects, (ii) the dynamics of interest before moments of insight, and (iii) the dynamics of complexity before and after moments of insight. Based upon the reported findings of the "Aesthetic Aha" effect (Muth and Carbon, 2013) as well as the theoretical account of reward by uncertainty reduction (Van de Cruys and Wagemans, 2011) we predict (i) an increase in liking at moments of insight, while (ii) interest might already increase before moments of insight due to the anticipation of success (Berlyne, 1971; Silvia, 2005). For a moment of insight to happen, (iii) a certain level of complexity might be necessary.

Materials and Methods

Participants

Sixty participants took part in the experiment on a voluntary basis (28 participants in a gallery setting, $mean_{age}$ = 38.1 years; $range_{age}$ = 18–85 years and 32 participants in a laboratory, $mean_{age}$ = 20.7 years; $range_{age}$ = 18–24 years). A *Snellen* eye chart test and a test with a subset of the *Ishihara* color cards assured that all of them had normal or corrected-to-normal visual acuity and normal color vision. The participants were naïve to the purpose of the study.

Apparatus and Stimuli

As material we employed "Konstrukte"—a movie (07:18 min.) by Claudia Muth (from the year 2009) which was created in an artistic context, originally not intended to be stimulus material. It depicts the evolution and metamorphosis of Gestalt (see **Figure 4** and **Supplementary Material A**) and the changes in determinacy are well suited for the study of physical dynamics (changes among subsequent film stills and their complexity) as well as semantical dynamics (emergence, disappearance, and metamorphosis of Gestalt). The artist used an intuitive drawing technique which allows for the development of Gestalt out of arbitrarily set lines to slowly reveal order in a seemingly diffuse picture and photographed the drawings (charcoal and acrylic paint) in various stages differing only slightly in detail (stop-motion technique). This way the process of drawing as well as the artist's associations can be retraced. It is suitable as material for this study because it consists of a dynamic variation of (in)determinacy; the associations of the perceiver might be forced or destroyed and insights induced. While these preconditions might be met by static indeterminate pictures as well, utilizing a material which is dynamic in itself allows for the definition of a wide range of physical as well as semantical dynamics and their temporal comparison within and between participants' evaluations. The movie was presented on a LG W2220P screen with a 22-inch screen size and a resolution of 1680 × 1050 pixels.

As an input device we developed an apparatus that is able to capture assessments in a very time-accurate way. Research in visual perception science is often based on snapshots, moments, or stills of experience. Static approaches allow for differentiated and deep assessment, but are hardly able to catch the dynamics of affective and perceptual processes which—as we exemplified above—are actually crucial for certain aesthetic effects. **Figure 5** shows a broad overview on different kinds of assessment ranging from low (data measured at one time point) to high (interval of data) temporal resolution. One-time point-measurements allow for deep multidimensional assessments (e.g., the multidimensional extension of the IAT, called md-IAT, see Gattol et al., 2011). The more time points are introduced, the higher the resolution of captured dynamics; but also at the same time, the fewer the dimensions which can be included due to time constraints and problematic effects of order and fatigue. Two-time point measurements like the RET (Repeated Evaluation Technique, measuring appreciation before and after elaboration, see Carbon and Leder, 2005) can still include various dimensions but capture only coarse changes between distinct points of assessment

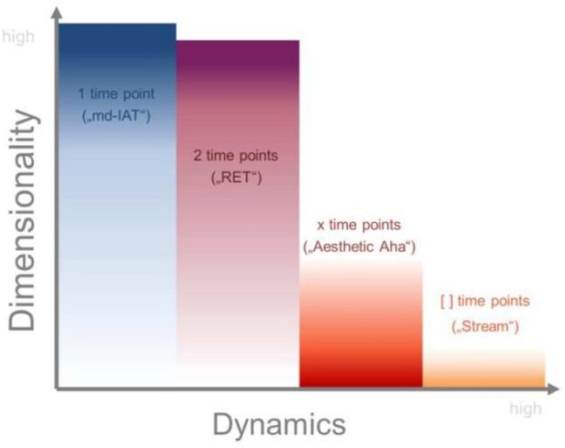


FIGURE 5 | Typical dimensionality and dynamics of assessments with different temporal resolution. Adapted from Raab et al. (2013).

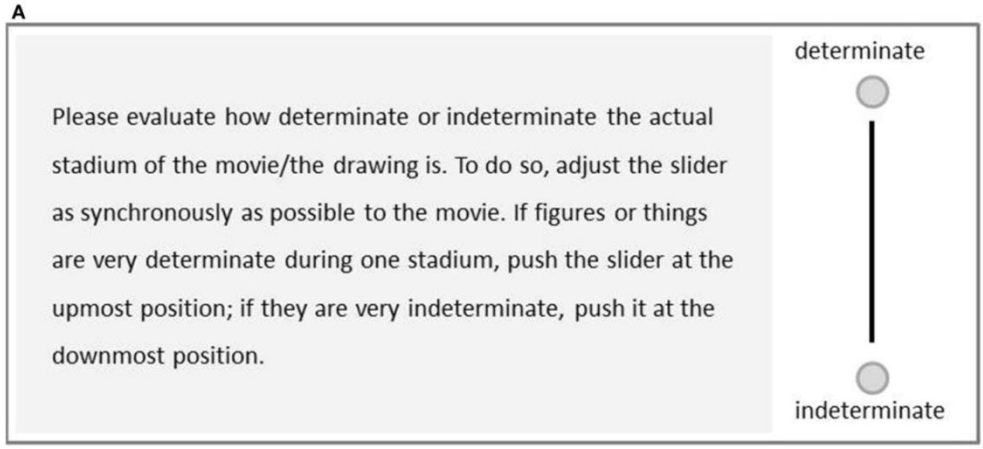
FIGURE 4 | Exemplary frames of the stop-motion movie *Konstrukte* by Claudia Muth (from the year 2009). Image courtesy of Claudia Muth.

(mostly only up to 4 such time points, see Carbon et al., 2013). The "Aesthetic Aha"-effect was revealed by a finer-grained picture of changes in face clarity and changes in the liking of a picture by introducing 12 time points of measurement (Muth and Carbon, 2013). One-dimensional but temporally highly resolved assessments are achieved by, e.g., pupillometry, electro-dermal activity, or electromyography. Nevertheless, there remains a gap between such measurements and the respective qualifications of the affective states in such instances: electro-dermal activity, for instance, might be an interesting indicator of affective strength, but not of affective valence (Carbon et al., 2008).

To provide a highly dynamic assessment of evaluations of the artistic films we used a method we would like to call Continuous Evaluation Procedure (CEP; developed by the research network *Ergonomics, Psychological Æsthetics, and Gestaltung, EPÆG*), realized by employing a do-it-yourself built slider box as the input device. The CEP provides a more fine-grained picture of aesthetic assessments, and therefore also for analyzing effects like the "Aesthetic Aha" (Muth and Carbon, 2013). The system comprises a standard lever which is typically used for audio equipment (100 mm movement range, 10 kΩ linear characteristics), mounted on wooden housing. Inside the box, an ATMEGA microprocessor continuously measured the lever's resistance, mapped the resistance to a value between 80 and 1024 (with 80 indicating the lowest and 1024 the highest lever position; referred to as "strength" in the following and transposed to a scale ranging from 0 to 1 in the figures for better readability) and sent the value via an FTDI serial-to-USB converter to the connected PC. The current slider position was stored in the box as a numerical value, and updated constantly and virtually without time delay by an ATMEGA processor. Upon each new movie frame, the current value (that is, slider position) was requested via the Serial-to-USB interface. For our setup, this meant slider positions for a movie running at 30 fps could be recorded without introducing a time lag. The video presentation was realized via the Processing Library for Visual Arts and Design (Fry and Reas, 2014) and the GStreamer library (Open-Source, 2014), in which for each movie frame the current slider position was retrieved and stored. To achieve multidimensionality we used the CEP repeatedly for all key variables.

Procedure

Every participant watched the movie twice and evaluated it continuously on one dimension each time via the CEP. The instructions were given together with a graphical representation of the slider and the two poles of the according key dimension (see **Figure 6A**). Afterwards the participants were asked to push the slider up and down to get a feeling for the usability of the apparatus. One group then evaluated the key dimensions of liking and determinacy in two subsequent trials in an art gallery ("Griesbadgalerie" in Ulm, Germany; in a room separate from the exhibition, see **Supplementary Material B**). To minimize order effects, the order of the two dimensions was counterbalanced (for a visualization of the setting and the rationale of the counterbalanced design see **Figure 6B**). These dimensions were complemented by further testing sessions with other groups of people on the dimensions of surprise at an experimental laboratory at the University of Bamberg, Germany to be able to define insight moments as



Context	Gallery		Lab		Lab	
Evaluation 1	determinacy	liking	interest	ambiguity	surprise	prototypicality
Evaluation 2	liking	determinacy	ambiguity	interest	prototypicality	surprise
Sample (N)	14	14	8	8	8	8

FIGURE 6 | (A) Exemplary instruction for key variable "determinacy"; **(B)** Experimental setting and counterbalanced procedure (variables in gray color are not integrated in further analyses; variables in black are key variables). Image courtesy of Claudia Muth.

a combination of determinacy and surprise. Furthermore, we included interest as a second dimension of aesthetic appreciation by additional assessment in the same lab setting. We decided to follow this strategy as we were mainly interested in liking and determinacy and aimed to test these variables under the ecological condition of a gallery context. But to test in a gallery also means to limit the experimental approach: precisely, when testing in a gallery, the number of volunteering gallery visitors is limited, and testing runs the risk of disturbing the experience of other visitors. This made us develop the design of capturing the two key variables of aesthetic experience in the gallery and the additional variables in the laboratory (all variables were asked for in an order-balanced way). We stuck to this one-person-two-dimensions design for the gallery testing for other aesthetic factors, too, in order to keep the design consistent. After the second evaluation phase, participants filled out a questionnaire to "describe in a few own words how it felt to suddenly recognize something clearly."

Analysis

To define moments of insight, we described the movie's dynamics in four dimensions: three of them based on empirical data for determinacy, surprise, and interest along with data on complexity based on an automatized analysis (size of each frame after jpeg-compression, see Marin and Leder, 2013). We then identified moments of insight by (a) determining local maxima in the first derivative of ratings (averaged over participants) on determinacy and surprise, respectively and (b) identifying points in time where both derivatives reach common peaks. This follows the definition of insight as a sudden (strong surprise) and clear (high determinacy) solution to a problem (as proposed in the 1930s by Gestalt psychologists and redefined recently, e.g., by Bowden et al., 2005). We selected those peaks in which (a) the highest sum of both variables is achieved and (b) the sum of both variables contributes to the peak resulting in seven moments of insight (see **Figure 7A** and **Supplementary Material C**). While these peaks mark the points of biggest change in their respective dimension, we assume that the psychologically relevant event—the insight—had occurred shortly before the rapid increase detected by the CEP. By visual inspection of the yielding data curves, we determined this insight point (when the lever movement leading to the rapid change began to show in the data) to be 45 frames prior to the peak. So for any peak showing at $t = x$ (x being the movie frame), the insight was located at $t = x - 45$.

To reveal dynamics in appreciation with regard to an insight moment, we selected seven data intervals (*insight windows*) containing liking ratings ranging from 60 frames prior to each insight moment to 60 frames (which equals 4 s overall) after that insight moment and selected the according intervals of liking data (see **Figure 7**). We then phase-shifted all seven time windows around the insights to obtain one single *insight window* in which each insight moment is marked by frame "0" to be able to compare all changes in liking in relation to insight (see **Figure 8A** left). We then averaged data (see **Figure 8** middle) and used a modified cosine value of the angle between the slope describing data before (frame "−60" to frame "0") and the slope describing data after the insight moment (frame "0" to frame "60"; see **Figure 9**).

The cosine measure is a common metric in the field of information retrieval for determining similarity between two vectors (see Singhal, 2001). It results in "1" when two (n-dimensional) vectors point in exactly the same direction; it is "0" for orthogonal vectors; and "−1" for opposing vectors. Here, we rotated and re-assembled the measure in such a way that it captures the dissimilarity between two vectors. It is "0" when both vectors (pre- and post-insight) have the same direction; it approaches "1" when the post-vector marks an increase compared to the pre-vector (where "0.5" would be an angle of 90°); and it approaches "−0.5" when the post-vector marks a decrease (**Figure 9**).

The cosine value obtained for the *insight window* thus describes changes in the corresponding variable, e.g., liking, at the insight moment. To test if this change is significantly different from the general dynamics of liking evaluations, we compared the seven cosine values at the moment of insight to those of 1000 randomly picked data intervals (*non-insight windows*) and conducted a t-test to check if the cosine values at the *insight windows* are distinguishable from the random sample.

Results

Effects of Sudden Perceptual Insight ("Aesthetic Aha")

A two-sided one sample t-test revealed that the increase in liking during an *insight window,* meaning after an insight moment, was significantly higher than other changes in liking during the evaluation of the movie, $t_{(1005)} = 2.33$, $p = 0.02$, Cohen's $d = 0.47$ (for a visual comparison to changes in adjacent windows see right panel in **Figure 8**). Changes before that time point were not significant (for a differentiated visualization of these results see **Figure 11**). Furthermore, we found a strong correlation between determinacy and liking ($r = 0.663$, $p < 0.001$; see **Figure 10**).

Dynamics of Interest before Moments of Insight

Analogous to the analysis of changes in liking in relation to insight moments, we conducted analyses on the changes in interest (with the modified cosine measure) and revealed that interest already increased 45 frames/1500 ms before the moment of insight, $t_{(1005)} = 2.53$, $p = 0.01$, Cohen's $d = 0.85$ (interestingly, even stronger than at the insight moment itself; see also **Figure 8B**, right panel and **Figure 11**). The increase was strongest 30 frames/1000 ms before the moment of insight, $t_{(1005)} = 3.78$, $p < 0.001$, Cohen's $d = 1.03$. Weaker, but still large effect sizes were found 15 frames/500 ms before the insight point $t_{(1005)} = 3.18$, $p = 0.002$, Cohen's $d = 0.75$, and at the insight moment, $t_{(1005)} = 2.64$, $p = 0.01$, Cohen's $d = 0.75$. We furthermore found a strong correlation between determinacy and interest ($r = 0.767$, $p < 0.001$).

Dynamics in Complexity before and after Moments of Insight

Plotting a phase-shifted *insight window* of complexity revealed that insights happened during an increase in complexity (**Figure 8C**).

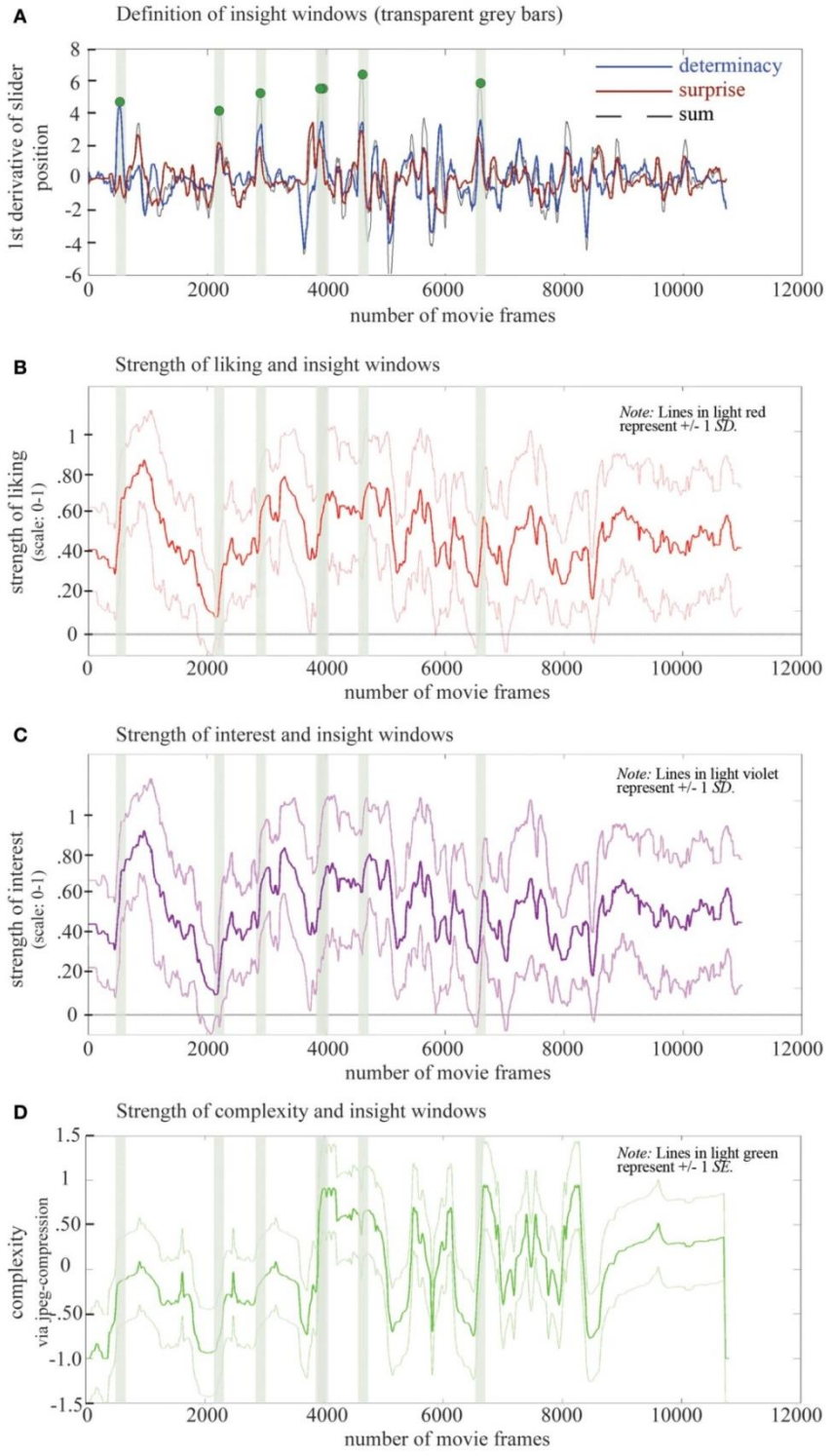


FIGURE 7 | (A) Definition of insight windows: 1st derivative of strength of determinacy and surprise (indicated by the lever position), their sum and the moments of insight, marked by green dots. **(B–D)** Dynamics in liking, interest, and complexity in relation to insight windows. Note that 2000 movie frames correspond to about 67 s.

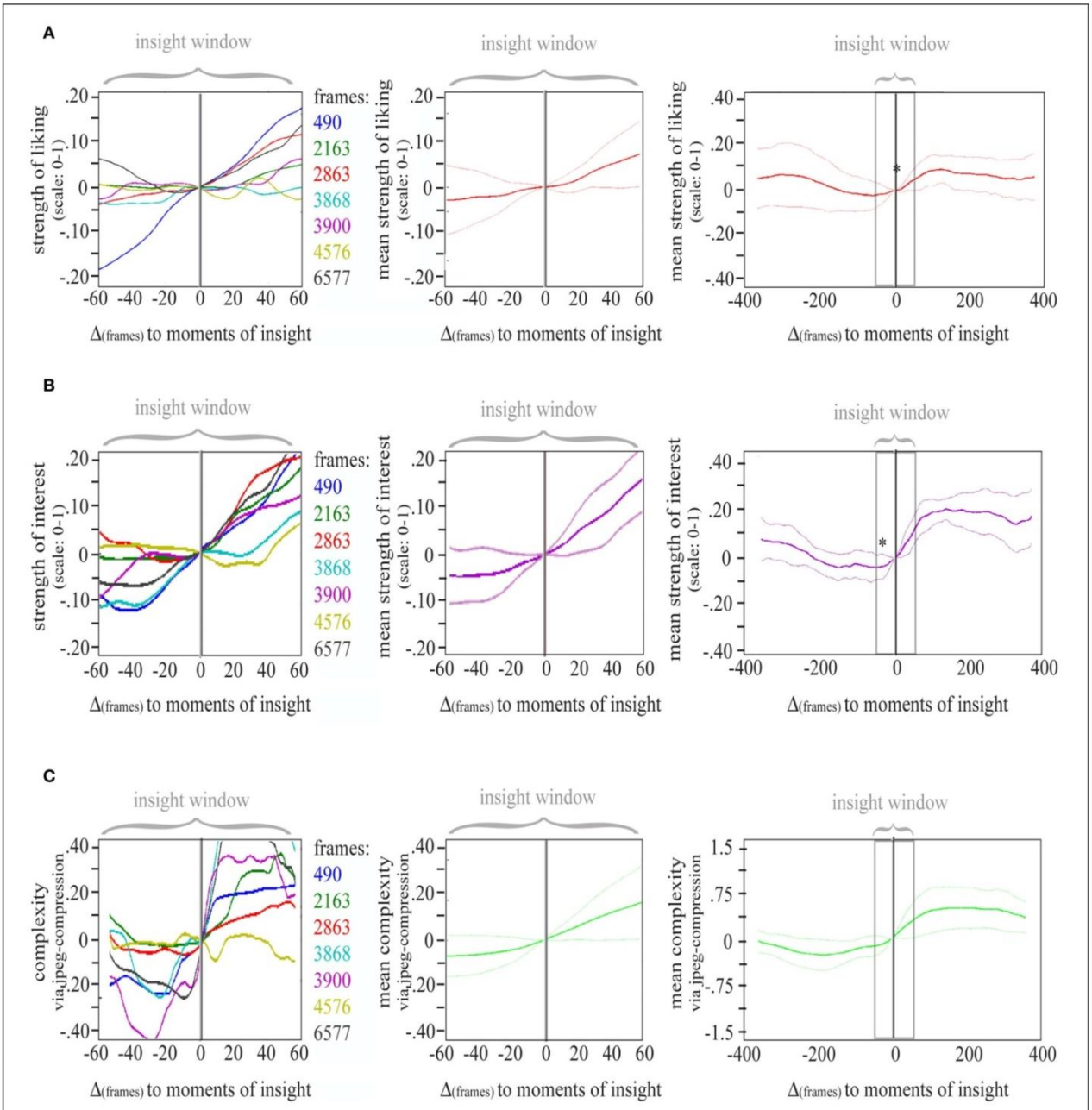


FIGURE 8 | (A) LIKING Left panel: seven phase-shifted liking evaluations at the insight windows. Middle panel: averaged liking evaluations at the insight windows. Right panel: insight window and adjacent data windows with the only significant change being marked by an asterisk. Note: lines in light red represent the standard deviation, 2000 movie frames correspond to about 67 s. **(B)** INTEREST Left panel: seven phase-shifted interest evaluations at the insight windows. Middle panel: averaged interest evaluations at the insight windows. Right panel: insight window and adjacent data windows with the only significant change being marked by an asterisk. Note: lines in light violet represent the standard deviation, 2000 movie frames correspond to about 67 s. **(C)** COMPLEXITY Left panel: seven phase-shifted complexity evaluations (size of each frame after jpeg-compression, see Marin and Leder, 2013) at the insight windows. Middle panel: averaged complexity evaluations at the insight windows. Right panel: insight window and adjacent data windows. Note: lines in light green represent the standard error, 2000 movie frames correspond to about 67 s.

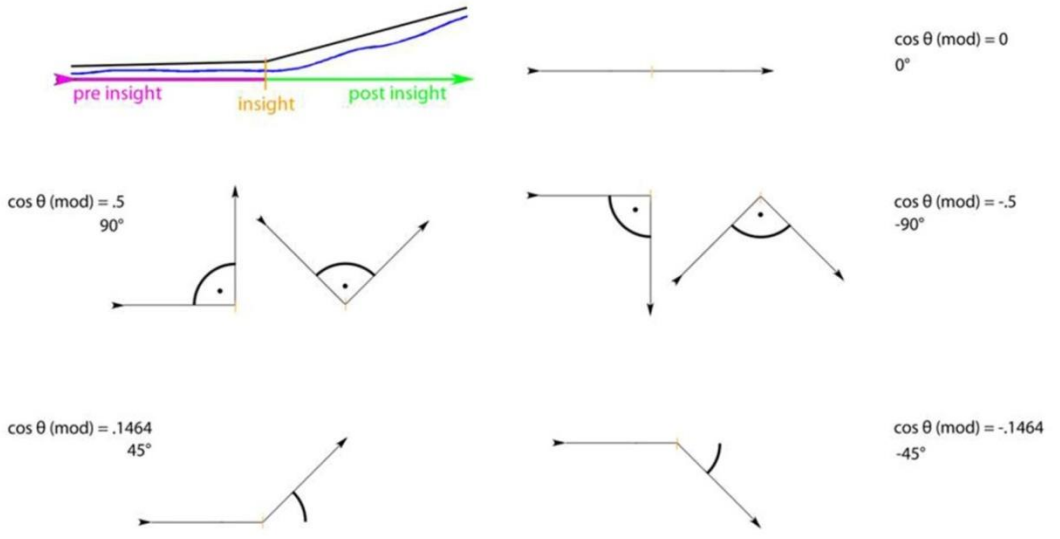


FIGURE 9 | The modified cosine theta measure (Θ) to capture dissimilarity between pre- and post-insight. The data section before the insight as well as after the insight was approximated with a line each (top left). Between these two vectors, the angle was determined. Two vectors with exactly the same direction (i.e., with no difference in direction pre- and post-insight) result in an angle of 0° between vectors and thus in a cosine theta measure of 0. A directional change upwards (second vector pointing higher than the first one) will result in a positive theta (e.g., 0.5 for a 90° upward angle between vectors); a directional change downward in a negative theta value (e.g., −0.5 for a 90° downward angle).

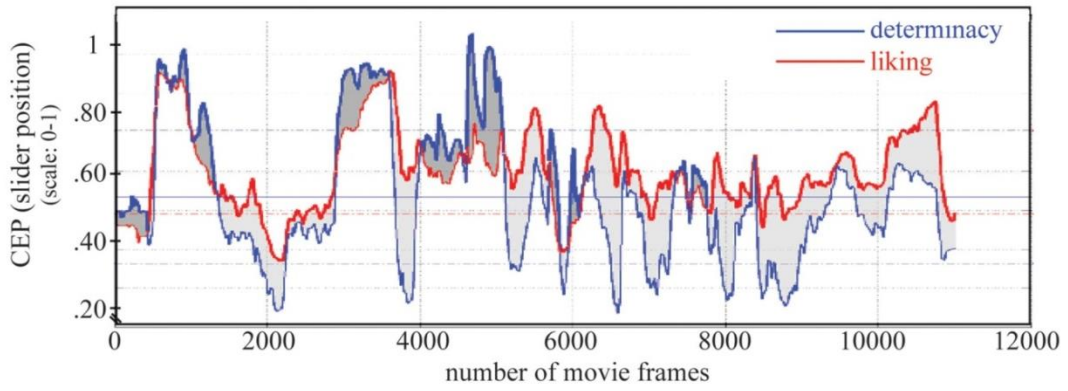


FIGURE 10 | Strength of determinacy and liking. The difference of both variables is indicated by gray colored areas.

Discussion

We examined (i) effects of sudden perceptual insights (increases in surprise and determinacy) on liking; that is, "Aesthetic Aha"-effects, (ii) dynamics of interest before moments of insight, and (iii) dynamics of complexity before and after moments of insight while watching an artistic movie. Our findings showed that the analysis of a continuous stream of data can reveal dynamic relationships between an artwork's physical and semantical dynamics and appreciation. Such analyses demonstrate that aesthetic experiences unfold in a dynamic way: (i) insights indeed elicited an "Aesthetic Aha," an increase in liking (as in Muth and Carbon, 2013). (ii) The rise in interest before an insight supports Berlyne's (1971) as well as Silvia's (2005) ideas that interest is evoked by (the appraisal of) challenge and coping potential—the expectation of success. (iii) Furthermore, it seems that for an insight to occur, stimuli have to possess a certain complexity. In dynamic terms this means that only phases in the movie in which complexity increases have the potential to lead to insightful moments—which again evoke an increase in liking. This is in accordance with the idea proposed by Van de Cruys and Wagemans (2011) that it is not predictability itself

but the reduction of uncertainty induced by prediction-errors that might bring pleasure. There are two directions of interpretation of these three results: either (a) the Aha-insight benefits from, or is more probable because of, an orienting reaction and high interest due to an increase in complexity or (b) interest arises due to "affective forecasting" ("people's predictions about their future feelings," see (Wilson and Gilbert, 2003); Wilson and Gilbert, p. 346) of this Aha-insight. In addition, the experience of an Aha-insight itself might stimulate the orienting reaction and deeper elaboration of subsequent phases as is exemplified by descriptions of participants, for instance the following: "proud of myself, motivated to continue watching (maybe one detects something else/more)," "I concentrated on the monitor and every recognition of a "picture" pleased me and incited me to search even more "intensely" (with more concentration) for more "pictures."

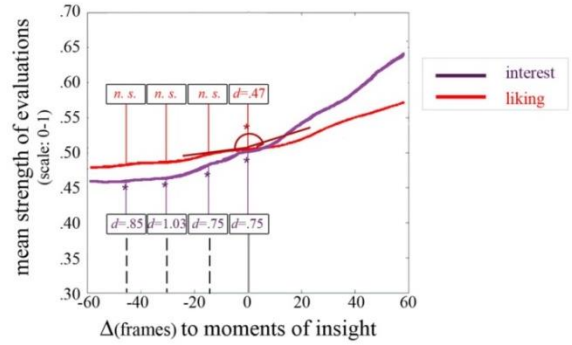


FIGURE 11 | *Insight window* revealing the dynamics of liking and interest in relation to moments of insight. An exemplary angle from which we derived the cosine value that we compared to a random set of 1000 cosine values of other changes is depicted for liking at the moment of insight. Numbers signify the strength of the effect via Cohen's *d* for significant changes at the insight moment [Δ(frames) = 0] as well as prior to the moments of insight [at Δ(frames) = −15, Δ(frames) = −30, and Δ(frames) = −45]. Note: changes which are significant at an α-level of 5% are marked by an asterisk.

Such links between perception, affection, and appreciation suggest that systematic analyses of dynamics in art perception are crucial for an understanding of the unfolding of meaning as well as the experience of art in general. Still, people's descriptions of their experiences of an Aha-insight show that there might be additional mechanisms involved in the links between complexity, insight, and appreciation. To stimulate further discussion, we exemplify three noticeable aspects which were frequently present in the *post-hoc* descriptions of the participants' own experiences of Aha-insight moments in **Table 1**. One aspect regards descriptions of familiarity or related concepts such as "control," "relatedness," "success," or "relieve" which might point to the appraisal of coping potential (see 1st column in **Table 1**). Another less frequently mentioned aspect is the relationship between expectation and resulting recognition, and their effect on appreciation. Two different possibilities were present in the descriptions: prediction confirmation as well as prediction error were experienced as pleasurable (see 2nd column in **Table 1**). A further aspect regards the distinction between process-focused and result-focused elaboration, when participants mentioned "transitions" between Gestalt perception or reported having enjoyed the process itself vs. when they described the search for recognizable Gestalt (see 3rd column in **Table 1**).

The relationship between the prediction of a Gestalt and actual recognition of a Gestalt seems to have a very different effect on appreciation for different individuals: whereas some participants described a confirmation to be pleasurable, others clearly preferred surprising transitions within a movie. This difference might be very important in the domain of art perception as it seems to imply that the valence of any experience of new insights is mediated by perceptual and cognitive habits.

TABLE 1 | Examples of participants' descriptions of their experiences of Aha Insight moments, translated by the authors.

Coping	Prediction confirmation vs. prediction error	Process-focus vs. result-focus
"A feeling of 'familiarity"'	"[…] can be negative then, if the picture (where one recognizes something) does not conform to the expectation."	"Pleasing and partially surprising. The development into a new form, the process of transition is however more interesting than the final result (in this case the clearness)."
"Insight, relief, higher relatedness to the picture"	"Pleasing because assumption got confirmed, then a little bit disappointed that it was what one suspected."	"[…] also it is fascinating to recognize something new, especially if you consider what it evolved out of."
"Relieved and maybe a bit proud"	"[…] at the same time also happy or less happy about what I saw. Sometimes also disappointed, that something other than what I thought would come became recognizable."	"It was comfortable to detect things and to see them evolving."
"Certain experience of success, positive feeling"	"[…] with the structure getting clearer and the result more foreseeable it got more 'boring'."	"I was excited by the change."
"Additionally, the recognizable contours gave me a feeling of security or also 'control'."	"Partially it is also frustrating, if you have waited for the drawing to develop but could not recognize or classify anything."	"It was interesting to recognize something out of 'nothing.' To identify something suddenly felt clearly better than the transitions among the different motives."

All of these factors are potentially different in gallery visitors compared with volunteers, mostly art-naïve students, typically tested in laboratory conditions. Another speculation concerns the mode of perception: we might focus on the process of physical and semantical transformations or on the resulting recognizable Gestalt, respectively. It would be highly interesting to systematically and explicitly investigate in future studies how the activation of these modes of processing is related to personality and context factors.

The assessment of dynamics in perception provides insights not only in regard to continuous changes and dynamic relationships but also enables us to reveal effects of expectation. We compared the two groups of participants evaluating the surprise induced by the different phases in the movie either during its first or its second presentation. The pattern of the resulting data implied that it makes a difference if an observer expects the development of Gestalt or indeterminacy due to previous exposure or if predictions are formed by the available information only. As these differences neither seem to be systematic nor easily describable, e.g., by a shift of peaks to earlier phases, this point is left for following studies with a concise focus on effects of expectation.

Art is not only an ideal medium through which physical and semantical dynamics in experience can be studied: while artworks might be insightful for perception science as they do not represent things as they are but as they are perceived (Fiedler, 1971), many artworks also do explicitly refer to and reflect on these dynamics. Some of Paul Cézanne's works hinder determinate interpretation and instead provide potential shapes of things. Gamboni (2002, p. 116) thus states that Cézanne leaves images "in perceptual formation and makes the spectator conscious of the interpretative process in which he is engaged and which will never be conclusive." Also Majetschak (2003) related Cézanne's works to the constructive activity of perception and called them consequently a "birthplace of visibility" (translated from "Geburtsort von Sichtbarkeit," p. 324). The dynamics of potential images (Gamboni, 2002) are also found in Cubist artworks by, e.g., Picasso and Braque which never provide full determinacy but contradictory cues which evoke an ongoing search for Gestalt (Gombrich, 1960). Furthermore, a Cubist artwork might allow for the retracing of part of the artist's dynamic elaboration of the original object: instead of a fixed spatial relation between painter and object, Cubist artists applied a "mobile perspective" (e.g., Metzinger, 1910), an "analytic description" of the object, or a "synthesis" of various viewpoints (translated from Kahnweiler, 1971, p. 69). This simultaneity of spatial dynamics within one picture might let us simulate an actual visual exploration which integrates several fragmented "semi-worlds" (Churchland et al., 1994)—inhomogeneous of detail and colorization—over time. Cubist artworks might thus be good examples of two kinds of semantical dynamics induced by the simultaneity of both potential identifiable forms and perspectives. Examples of the capturing of dynamics by artworks often regard the illusory layer of the artwork (the depicted objects or sceneries)—not the material layer (canvas and color). But semantical dynamics can also evolve in regard to the material itself. The carpets made by Faig Ahmed (**Figure 12**) are valuable examples of semantical dynamics due to switches between interpretations of the material (paint vs. carpet) along with other semantical levels like the historical, social, and cultural dimensions of traditional carpet weaving. Contemporary "Relational art" (Bourriaud, 2002) expands the dynamic relationship between artwork and perceiver even more as it points to or includes the social context of behavioral interactions. The Munich based group *Die Urbanauten*, for instance, organizes "Swarm-Happenings" in which people are instructed to fulfill urban interventions—actions in public space like having a picnic on a bridge—to reflect on and inspire discussions about how public space is used and the set of norms which underlie our behavioral variety. Works of art thus neither have to be exhibited in a well-defined artistic context (gallery, museum) and contemplated by one observer alone, nor is the authorship and evaluation of these works independent of the social context. This viewpoint opens up a variety of possible dynamic levels that art perception comprises; the presented investigation is a first step into this wide and thrilling field of art and research.

FIGURE 12 | *Liquid* by Faig Ahmed in the year 2014 [Handwoven rug made of wool]. Image courtesy of Cuadro Gallery, United Arab Emirates.

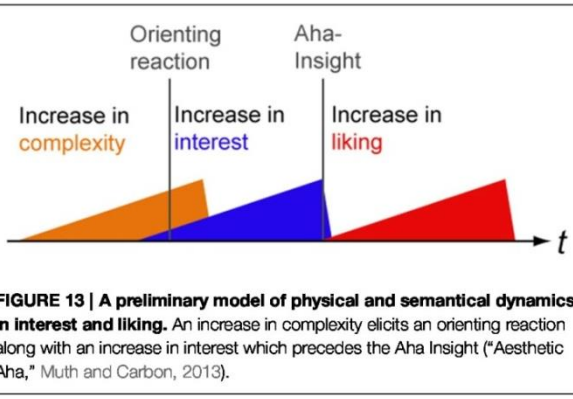


FIGURE 13 | A preliminary model of physical and semantical dynamics in interest and liking. An increase in complexity elicits an orienting reaction along with an increase in interest which precedes the Aha Insight ("Aesthetic Aha," Muth and Carbon, 2013).

Outlook: A Preliminary Model for Physical and Semantical Dynamics in Liking and Interest

Based on our findings we would like to postulate a preliminary model of physical and semantical dynamics in the perception of indeterminate material and its effects on liking and interest (see **Figure 13**): an increase in complexity might signal the potential meaningfulness of a situation or object which makes this case more interesting. Such a tag on interest triggers an orienting reaction which unleashes further cognitive resources to process the potentially relevant item. By at least partly solving indeterminacy, a Gestalt is recognized which allows an Aha-insight to occur. The result of such an "Aesthetic Aha" is an increase in liking (as in Muth and Carbon, 2013).

Conclusion

Perception and appreciation are evidently dynamic—and thus should be investigated by means of measures capturing such dynamics. This not only holds for dynamic stimulus material but also for the perception of a static object as it includes physical changes (for instance adapting one's own posture) and potential changes in semantics and appreciation over time and elaboration. Our results point to the importance of systematic analyses of such dynamics in art perception and appreciation by grasping the continuous nature of such experiences. We hope our preliminary model of dynamics in liking and interest, and their relation to complexity and perceptual insight inspires further research on the dynamics of perception and appreciation.

Acknowledgments

We would like to thank Lisa Aufleger, Stefan Breitschaft, Janina Plessow, and Johanna Günzl for assistance in testing and Alun Brown for proofreading the text.

Ethical Statement

Before the experiment, participants gave written consent for participating in the study. After the experiment had ended participants were fully informed about the aims of the study and had the opportunity to ask questions. All data were collected anonymously and no harming procedures were used. Ethical approval of the study was provided by the local ethics committee ("Ethikrat der Otto-Friedrich-Universität Bamberg"; dated 13 March, 2015).

Supplementary Material

Supplementary Material A | The movie utilized as stimulus material can be watched here: http://vimeo.com/46138003.

Supplementary Material B | Impressions regarding the exhibition at the "Griesbadgalerie" can be gained here: http://vimeo.com/68991518.

Supplementary Material C | A visualization of the development of moments of insight can be found here: https://janus.allgpsych.uni-bamberg.de/CEP_Revision/insightlow.html.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Critical reflection

Perception and appreciation of *semantical instability* in art is dynamic and thus not entirely accessible via one time point only. To understand how meaning and aesthetic experiences unfold we thus have to look at the continuous stream of experience. The reported research project adopted such a dynamic perspective and revealed that an insightful moment changes not only an artwork's *semantical instability* but its aesthetic impact as well. Via a multidimensional account this influence could be specified for different facets of appreciation: as expected—and in line with the *Aesthetic Aha* effect (Muth & Carbon, 2013)—liking increased at moments of insight. Interest—in contrast—increased already before moments of insight. This reflects the idea brought forward in the discussion of Core publication I (Muth et al., 2013a) and Core publication II (Muth, Hesslinger, et al., 2015) that the anticipation of insight might already be effective on appreciation before the actual *Aha* moment.

The preliminary model presented in the currently discussed article is indeed able to integrate such dynamic effects as well as multiple dimensions of appreciation: it states that complexity arouses an orienting reaction (as suggested by Berlyne, 1971) which induces heightened interest as well as the likeliness of rewarding moments of insight. These *Aha* moments are followed by an increase of liking. Concerning this last step, further research should take an additional potential factor into consideration: the role of the Gestalt's valence. It is plausible to assume that—despite the finding by Chetverikov and Filippova (2014) that the correct identification is rewarding in all cases— some of the insights gained during elaboration could induce a negative effect due to negative valence of the revealed motive, interpretation, or idea. The *Fluency Amplification Model* by Albrecht and Carbon (2014) similarly claims that fluency does not simply increase appreciation but amplifies it in the direction of an object's valence.

Finally, a clarification of the phenomenological quality of insights induced by an artwork can be inspired by the qualitative data on different facets of the experience of insights provided by the article. It seems that feelings of coping are as relevant to this experience as relations between perception and expectation. Also, there might be crucial differences between the experiences of persons with regard to their focus when

confronted with *indeterminate* and *hidden* objects: their descriptions targeted processes leading towards or away from Gestalt or concerned resulting Gestalts only.

General discussion

In 1935, Picasso stated:

> A picture is not thought out and settled beforehand. While it is being done it changes as one's thoughts change. And when it is finished, it still goes on changing, according to the state of mind of whoever is looking at it. A picture lives a life like a living creature (…). This is natural enough, as the picture lives only through the man who is looking at it (Picasso, 1935/2002, p. 508).

Psycho-aesthetic research often neglects these crucial dynamics of art perception by collecting and comparing static evaluations. In contrast, this thesis explored changes in perception and appreciation of *semantical instability* in art. The theoretical introduction provided a conceptual and historical background for various kinds of *semantical instability* in art with potentially different effects on perception and appreciation. The concepts of *semantical instability* and *ambiguity* were introduced as general terms naming objects which defy a determinate interpretation. These were specified in more detail by a further classification into *hidden images* which conceal identifiable patterns, *multistable* stimuli which offer several determinate interpretations and *indeterminate* or *potential* objects which promise but don't provide a determinate interpretation. The reported publications used several of these kinds of *semantical instability* to approach the question how *semantical instability* in art can induce pleasure and appeal.

They revealed that *ambiguity* in art is indeed positively linked to appreciation (Muth, Hesslinger, et al., 2015; see Core publication II). This effect contrasts—at least at first sight—predictions by the *Hedonic Fluency Model* (Winkielman et al., 2003) which links processing ease with high appreciation as well as approaches which link a moderate level of arousal (Berlyne, 1971) or *ambiguity* (Jakesch & Leder, 2009) with high appreciation (see an introduction of the according theories in chapter 1.3.3). One potential mechanism inducing the appeal of non-easy stimuli was introduced in Peripheral publication I: insights gained during the elaboration of *hidden images* led to an increase in appreciation (Muth & Carbon, 2013) suggesting that the creation of meaning is rewarding by itself. Accordingly, a crucial quality of many *ambiguous* artworks might be that they confront the perceiver with *semantical instability* on the one hand but also with opportunity for insight on the other hand. Indeed, not only *hidden images* but also

indeterminate Cubist artworks were appreciated more when they provided high detectability of objects (Muth et al., 2013a; see Core publication I). This is remarkable as—in contrast to *hidden images*—Cubist artworks never provide determinate identification (Gombrich, 1960/2002). It is interesting that the *solvability of ambiguity* in another set of visual artworks did not even have positive effects on liking, interest, and affect. Instead, the judged *strength of insights* gained during their elaboration predicted appreciation positively (Muth, Hesslinger, et al., 2015; see Core publication II). Here, the selected artworks evoked several kinds of *ambiguity* being *hidden*, *indeterminate*, or *multistable* images, sculptures, and objects. The *Aesthetic Aha* effect (Muth & Carbon, 2013) might thus be applicable to *semantical instability* in art in general. By utilizing a slider as assessment device, Core publication III (Muth, et al., 2015) took a close look at the changes in perception and appreciation during the elaboration of artistic movies in which Gestalt emerges, vanishes, and transmutes to new Gestalt. This specific combination of a dynamic stimulus material with the *Continuous Evaluation Procedure* (*CEP*) enabled the proposal of a preliminary model of dynamics in the perception and appreciation of *semantical instability* (see Figure 8). It states that a certain level of complexity in *semantically instable* artworks can induce an increase in interest along with an orienting reaction in the perceiver. If further elaboration results in an insight this has rewarding effects which increases the appeal of the artwork in terms of liking.

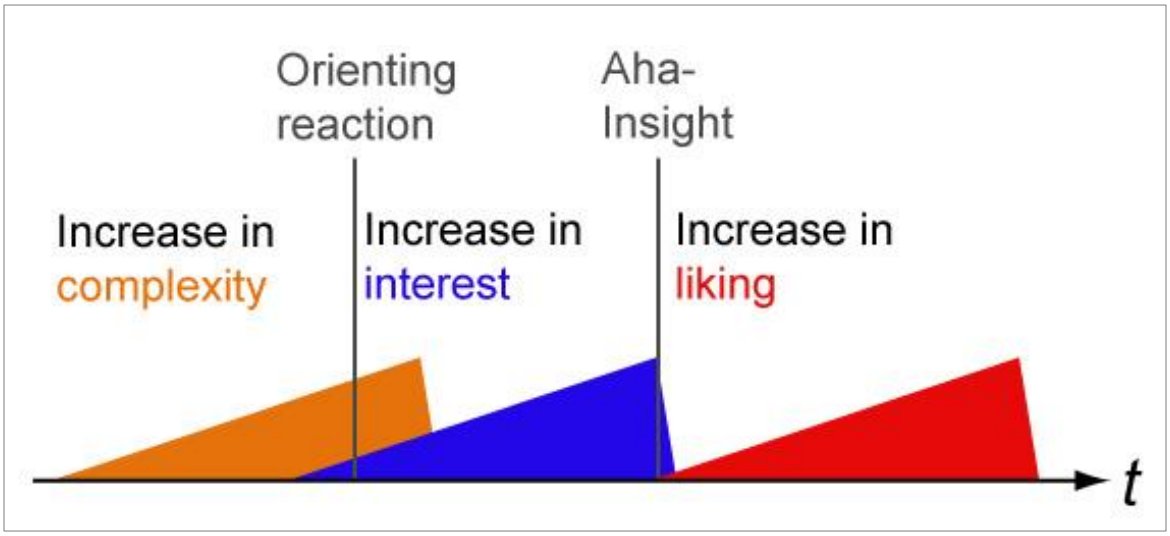


Figure 8. A preliminary model of dynamics in *semantical instability* and appreciation; adapted from Muth et al. (2015).

With regard to the main question of this thesis the comprised findings altogether implicate that *semantical instability* in art can indeed be appreciated and the experience of such artworks is marked by dynamics in perception and appreciation: it equals an insight-driven elaboration instead of a static evaluation or a linear progressive resolution of *semantical instability*. Positive affect can be gained not only by arriving at an insight but as well by anticipating it. This means that—also if artworks never provide a determinate meaning—they can arouse interest due to the induction of anticipations, association, or cues as well as they can induce reward and liking by (partial or peripheral) insights—even if they do not resolve ambiguity.

This last point seems especially crucial to our understanding of the perception and appreciation of art in particular: how can insights contribute to a heightened pleasure by and appeal of artworks which leave us with unresolved mystery? A recent examination of the *Aesthetic Aha* effect (Muth & Carbon, 2013) and of the link between object-detectability and liking of Cubist artworks (Muth et al., 2013a) by Consoli (2015) might bring more light to this question. He proposed two phases of aesthetic pleasure during the perception of unsolvable *semantical instability*: perceptual insights would evoke an *early aesthetic pleasure* which motivates further exploration by signaling "that there is more, that other processes of integration are available" inducing "a complex network of cues, associations, and meanings" (para. 7). Such further integrations during elaboration have the potential to induce a *late aesthetic pleasure*. This idea underlines that insights are not only rewarding per se but also influence the perceiver's predictions as well as the further course of elaboration. As mentioned above especially interest benefits from such anticipation of further insights. Also, an anticipatory quality of *early aesthetic pleasure* might explain the evidence of positive affect by incomplete or fragmentary interpretation of *indeterminate* artworks (see, e.g., Core publication I; Muth et al., 2013a):

> Even if the process of interpretation is still open and he [the viewer] has to face other challenges, we might expect that he begins to have a positive mood, determined by the previous series of insights and rewards. Enhancing this diffuse and enduring positive affect, great artworks can support and stimulate viewers' further explorations even when the degree of discrepancy is significantly high or discrepancy remains temporarily unsolved (Consoli, 2015, para. 9).

It might even be the case that we aspire towards a challenge of perceptual habits to arrive at an increased *late aesthetic pleasure* with elaboration. Similarly, Van de Cruys and Wagemans (2011) suggested: "The immediate motivation of seeking *prediction errors* may, in our view, be obtaining a larger reward (by contrast) later" (p. 1057). At the same time it is reasonable to assume that to induce deep elaboration—potentially leading to such an increased *late aesthetic pleasure—early aesthetic pleasure* might be needed. As described in chapter 1.3.3 the initial *level* of challenge or discrepancy from expectations should therefore be neither too high nor too low. Such optimal levels were for instance discussed with regard to *ambiguity* (moderate level, e.g., Jakesch & Leder, 2009), novelty/typicality (combination, e.g., Hekkert, 2006), or arousal (moderate level, Berlyne, 1971). An alternative idea would draw on the proposed model in Figure 8 as well as on Consoli's (2015) suggestion by stating that the likelihood of deep elaboration (and *late aesthetic pleasure*) is influenced by the degree to which an artwork allows for (early and anticipated) insights on various levels of understanding. Instead of a stable intensity of challenge assigned to the artwork, this idea includes dynamics by highlighting the relevance of the promise of rewarding experiences. It can be furthermore speculated that it might need both early (peripheral or partial) insights as well as an ongoing challenge to enable a *late aesthetic pleasure*. Also with regard to the pleasure of narratives a dynamic perspective on challenging as well as insightful moments is fruitful. Douglas and Hargadon (2000) for instance suggested:

> Just as immersion is satisfying as long as local details infuse the schema with unique or unpredictable elements, so engagement remains pleasurable only when it displaces or subverts one schema while offering readers suitable alternatives (Douglas & Hargadon, 2000, p. 155).

In an even wider context, the idea of insight-driven elaboration might qualify processes like exploration and learning in general: being confronted with a challenge together with a promise of rewarding insights might induce increased arousal along with an orienting reaction and increased interest. These effects might be crucial for the induction of curiosity—the motivation to gain new knowledge. Fost (1999) accordingly claimed that theorizing itself might be rewarding due to limbic reinforcement of neural binding processes. Similarly, Ramachandran and Hirstein (1999) mentioned the possibility that

> a limbic 'reinforcement' signal is not only fed back to early vision once an object has been completely identified, but is evoked at each and every stage in processing as soon as a partial 'consistency' and binding is achieved (…), at *every* stage in processing there is generated a 'Look here, there is a clue to something potentially object-like' signal that produces limbic activation and draws your attention to that region (or feature), thereby facilitating the processing of those regions or features at earlier stages (Ramachandran & Hirstein, 1999, pp. 22-23).

While Ramachandran and Hirstein (1999) refer to reward by "partial consistency"—which might apply for instance to *indeterminate* stages of elaboration—Biederman and Vessel (2006) refer to reward by multiple associations which might "lead to more neural activity in the association areas and hence to a greater release of endomorphins and increased stimulation of mu-opioid receptors" (p. 251) being associated with pleasure. The according mechanism is understood as a gain of pleasure by a gain of information—similarly to Fost's (1999) idea of rewarded theorizing. With reference to the findings reported within this thesis one could complement these ideas of *reward by sense making* by the point that the motivation for exploration and engagement might neither require processing fluency nor a constant progression towards a determinate solution—although both factors might be effective on pleasure and appreciation as well.

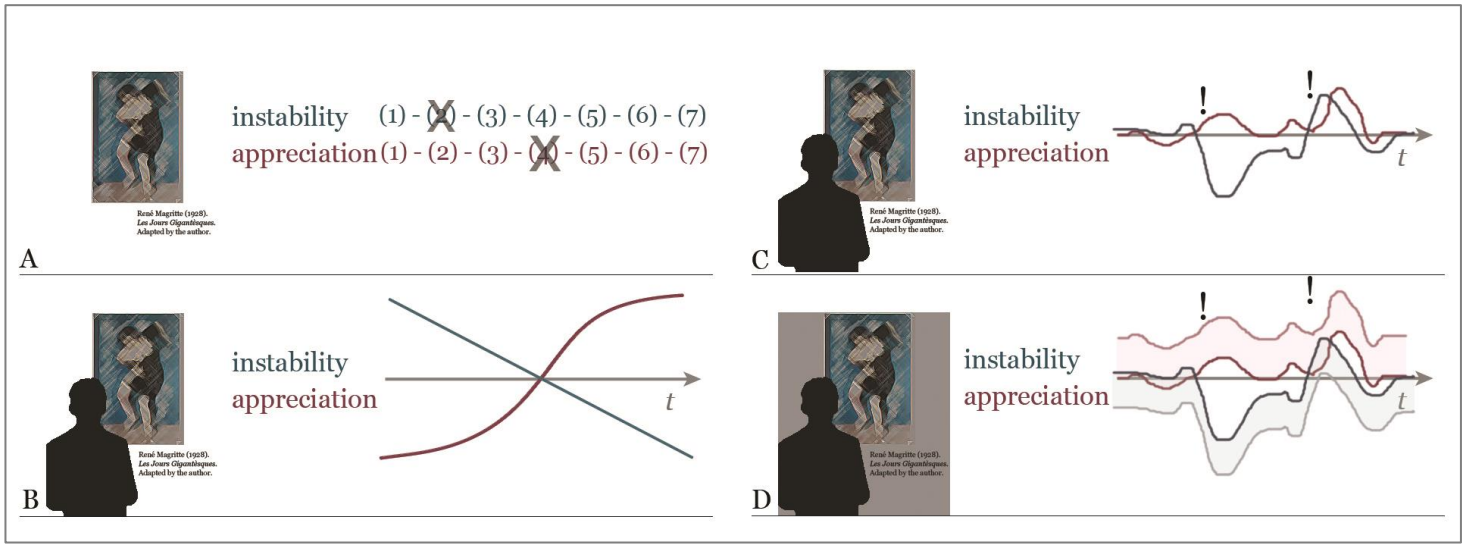
As mentioned in the introduction, a crucial critique on the simple concept of "aesthetic experience as art experience" is that not each encounter with an artwork leads to aesthetic experiences in terms of sensual delight, "aesthetic awe", "being moved", or by experiencing "thrills" (for an according differentiation of aesthetic affect see Konečni, 2005, p. 27). Still, we were able to determine with some level of detail which facets of appreciation were affected by moments of insight when elaborating an artwork. Nevertheless, intense work is required to get to the core of what differentiates these supposedly aesthetic experiences from solving a riddle or from general successes in learning and exploration. It is plausible that the reported research projects crystallized a crucial factor influencing aesthetic experience of *semantical instability* in art; but as described above this factor might be relevant in the context of everyday perception, cognition, and affect as well. It is a tough debate in art theory if aesthetic experiences are fundamentally different from everyday experiences with regard to exclusive perceptual processes and mechanisms. Accordingly, Graham (1997/2000) asks if the kinds of pleasure induced by artworks equal "amusements", "entertainments", or—in contrast—

"distinctively aesthetic pleasures" (p. 22). Also it is unclear how the concept of insight as promoted within this thesis is related to various concepts and ideas in the art theoretical tradition: how does an aesthetic insight differ from a conceptual insight? The latter is actually rather mentioned as a contrast to the quality of aesthetic pleasure and delight. In Kant's (1790/1911) conception for instance *beauty* is marked by disinterest in determination "for, with it, no interest, whether of sense or reason, extorts approval" (p. 49). And also Fiedler (1913/1971) opposes the shallowness of conceptual approaches and identification to the rich experiences we can gain by artistic approaches. Phenomenological investigations might clarify—at least to a certain extend—how the various different experiences of insights during the perception of *ambiguous* artworks (as only briefly discussed in Core publication III; Muth et al., 2015) are related to or differ from such processes of identification. It should be noted in this context that the focus on rewarding effects of perceptual and cognitive insight disregards approaches to aesthetics addressing mainly the emotional impact of art (for an overview on according theories see Graham, 1997/2000).

Future research projects should also address the point that experiences are not only qualified by the experienced object or scene but as well by context and personality. An integration of object-, person-, and context-related facets of the experience of *semantical instability* in art is therefore crucial to an understanding of the relevant effects, mechanisms, and processes. As it was discussed in chapter 1.3.2 the phenomenon of *semantical instability* in art is a cultivated, historical feature and also its perception and appreciation is strongly influenced by conventions and historical changes (e.g., Krieger, 2010). We can ask accordingly in which situations and locations challenging artworks appeal and why they appeal in a different way to different persons as well as to one individual at different moments in time. Factors which might be especially relevant to the experience of *semantical instability* are for instance personality factors like *intolerance of ambiguity* (e.g., Frenkel-Brunswik, 1949; Reis, 1996) which proved to influence the appreciation of *ambiguity* in art (see Core publication II; Muth, Hesslinger, et al., 2015). Another person-related variable, the feeling of (non-)safety, influenced the appreciation of innovativeness in a study by Carbon et al. (2013; safety was manipulated here via dimensions on which the material

had to be elaborated). Other factors which are closely linked to the perceiver are experience, expertise, and mood. The perceiver's previous experiences are fundamental determinants with regard to the detection of ambiguities on the one hand and the gain of insights on the other hand. They also form the basis of expectations which—as described in detail above—are a crucial part of the aesthetic experience: it is the previous experience which determines if a *prediction error* is encountered in the first place and if hypothesis testing leads to alternative interpretations. The state of the perceiver as well as his or her expectations are of course also greatly influenced by context: Wolz and Carbon (2014) for instance manipulated semantic context by labelling artworks as "originals" or as "copies" and reported higher appreciation of the former. And also the *Aesthetic Aha* effect might as well be termed an effect of episodic context: the detection of a Gestalt is rewarding *in the context* of *ambiguous* stimulation (Muth & Carbon, 2013). There is also evidence for the influence of physical context on appreciation: stimuli being evaluated in a museum context were appreciated more than in the laboratory and *ambiguous* stimuli were examined longer in the museum but shorter in the laboratory (Brieber, Nadal, Leder, & Rosenberg, 2014). We recently found a similar effect of physical context on appreciation with regard to the movies which have been introduced in the first section of this thesis and utilized in Core publication III: in the gallery setting, the movies were consistently liked more than in the laboratory. Furthermore, determinacy was rated to be higher in the gallery setting. It is unclear to this point if this effect is determined by the context only or if differences in person-related factors play a role (Raab, Muth, & Carbon, 2014). The physical contexts in the two examples by Brieber et al. (2014) and Raab et al. (2014) are socio-cultural contexts as well: when persons with the same socialization as the according participants enter a gallery or a museum they might qualify the location as one in which their expectations will be challenged. Additionally, they might judge high *ambiguity* as a quality characteristic of great art (see Krieger, 2010) and perceive the situation as a rather playful, "safe" context. Such characteristics of a situation or context might influence the selection of an *arousal-avoiding* or an *arousal-seeking* mode. The so called *reversal theory* (Apter, 1989) suggests that we actually switch between these systems repeatedly; we can enjoy dangerous sports as well as a siesta despite their differences in arousal potential. Accordingly, we can state that the appeal of *semantical instability* might

depend on the mode of the perceiver and this mode is changeable by different contexts, personality, and expertise. Concerning the latter factor, Cupchik (1994) claimed that non-expert viewers would focus on immediate pleasure and moderate arousal while experienced viewers seek for challenging artworks. Figure 9D visualizes one strongly simplified example of how differences in context (e.g., museum versus lab) or person (e.g., high versus low *ambiguity* tolerance or expertise) might lead to variations in the strength of *semantical instability* and appreciation.



Figures 9. Models of a static (A) and three dynamic accounts of *semantical instability* and appreciation (B-D). In model B the pattern of changes represents a mechanism by which appreciation is negatively linked to *semantical instability*. Model C considers the positive effect of one or several *Aesthetic Ahas* (!) and Model D additionally integrates effects of context and person alluded by variations of strength of the dimensions (light colored areas).

One final aspect under which the presented findings shall be discussed is that they adopted one specific perspective on the phenomenon of *semantical instability* and its effect: a psychological—reception aesthetic—one. But *semantical instability* can be described in at least three different aspects which are not mutually exclusive: we can locate *ambiguity* in the artwork itself as it describes a structural feature of an object; for instance *multistability* (resembling a work aesthetic perspective). As discussed in

chapter 1.3.1 this endeavor is a challenge, partially due to the dynamics of according phenomena. We can thus locate *ambiguity* in the reception of art which can be instable not only due to structural features of the object but also due to knowledge and expectation of the observer or the context of the encounter as described above (resembling a reception aesthetic perspective). The concept of *multistability* can thus refer to perception itself as well. Also we can locate *ambiguity* in the production of art as for instance intentional openness of the artist during the creation of the artwork might not only lead to but also equal a *semantical instability* (resembling a production aesthetic perspective). Finally, we might even dare to locate it in the social context in which even a *Ready Made* is inspected with regard to meaningful content. The perceiver might activate a learned "script" which includes *semantical instability* by social convention. Especially the differentiation between object-centered versus reception-centered approaches in psycho-aesthetics is tough but should be included in next steps to an empirical classification of *ambiguity* (as started by Muth & Carbon, 2012). Also questions regarding *semantical instability* from a production aesthetic perspective would be highly interesting in future studies: do artists explicitly or implicitly take into account which perceptual habits they defy and how perceivers might form insights on the basis of their work?

Conclusions and outlook

The findings reported within this thesis reveal that *semantical instability* in art can be appreciated and the experience of such artworks equals an insight-driven elaboration (see Figure 9C) instead of a static evaluation (see Figure 9A) or a linear progressive resolution of *semantical instability* (see Figure 9B). From this perspective, art perception is not a kind of problem solving process in which *semantical instability* needs to be resolved for the artwork to appeal. Appreciation might instead benefit from rewarding insights into the instable.

These findings as well as the provided theoretical overview make evident that a further conceptual clarification is necessary with regard to *semantical instability* as well as with regard to insight. Also, future research should be invested in the assessment of

dynamics between *semantical instability* and aesthetic appreciation. Hereby, a focus on the role of expectation proved promising—especially with regard to variables like surprise, incongruity, and complexity on one hand and interest on the other hand. Also more complex affective responses like “aesthetic awe, being moved or touched, and thrills” (Konečni, 2005, p. 27) should be taken into account by future research projects to refine our understanding of the induced aesthetic experience. Furthermore, the reported effects have to be regarded from a multifold perspective on object-, person- and context-related factors (Figure 9D).

Supplementary material

The movie “Konstrukte” (2009) can be watched here: http://vimeo.com/46138003.

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