SeIns: Semantic Instability in Art

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Abstract

Many artworks defy determinacy of meaning by inducing a variety of potential meanings. We aim to describe different kinds of such semantic instability (which we call "*SeIns*") by comparing related concepts as well as specific phenomena in order to arrive at concise definitions. These analyses will be positioned in the framework of Predictive Coding. Furthermore, this article fathoms the specifics of semantic instability in art and presents psycho-aesthetic accounts on the appeal of semantic instability in art. We propose that one factor for the appeal of semantic instability might be that it offers the opportunity of rewarding insight. Furthermore, we suggest that positive affect can be gained not only by arriving at an insight but also by anticipating it—a crucial point with regard to those kinds of semantic instability which are not "resolvable" into semantic stability. Current challenges within this field of research include the necessity of an empirical approach to classes of semantic instability, the lack of a specification of psycho-aesthetic theories on the appeal of each class, as well as the need for an integration of context- and person-related facets of the experience of art.

Keywords: empirical aesthetics, art & science, ambiguity, indeterminacy, collative variables, experience of art, predictive coding, semantic instability

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1. Prelude

Many if not all artworks defy determinacy of meaning by inducing a variety of potential meanings. People explore the aesthetic qualities of an everyday object being exhibited in an art context (like Duchamp's "fountain", see below and Fig. 8); they praise the way in which impressionist painters capture fleeting moments with applications of paint, they struggle for centuries with the enigmatic smile of Mona Lisa and meanwhile—mostly unnoticed—cope with the coexistence of the painting being frame, canvas, color, a composition of color and a depiction of a woman all at the same time. This general quality of art perception is often referred to in the literature with the term "ambiguity", but actually comprises a variety of very different—sometimes even contradictory—phenomena. Therefore we will refer to it more broadly as "semantic instability", which we will call *SeIns* [saɪns] throughout this article.

2. Agenda

In the present paper we will first provide a theoretical framework guiding the exploration of different concepts associated with *SeIns*. Furthermore, we will discuss specific phenomena of *SeIns* in detail in order to arrive at more concise definitions and describe several ways in which art induces *SeIns*. A confrontation of theories from the field of psycho-aesthetics explores explanations for the appeal of *SeIns* in art—from approaches promoting the pleasure of processing fluency or moderate arousal to those taking the dynamic character of *SeIns* into account by promoting reward via predictive progress or insight. Finally, we will point to several current challenges within the field of psycho-aesthetics with regard to a missing consideration of the phenomenal variety of *SeIns* and the integration of object-, person-, and context-related facets of according experiences.

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3. *SeIns* as repeated Formation of Prediction Errors and Prediction Matches

Referring to Gregory's (1980) theoretical framework of "perceptions as hypotheses" it can be stated on a very general level that phenomena of *SeIns* are marked by the lack of a stable hypothesis about an object or event; instead they imply the competition of multiple hypotheses. Before we have a look at different phenomena of *SeIns*, this section will introduce in greater depth a basic theoretical framework on perception and particularly on *SeIns* which will be referred to repeatedly in the following sections.

We will make use of the theory of Predictive Coding, which is a promising approach in the cognitive sciences (for a review see Clark, 2013). It is based on the concept of perception as inference by Herrmann von Helmholtz (1866) and claims that perception is not a passive reception of information but is guided by expectations and knowledge. More specifically, it states that we constantly make predictions, form hypotheses about the world, and match them to current sensory inputs. This way, higher level models of structures in the world (hypotheses) predict lower level inputs. The mismatch between prediction (or predicted processing noise) and the actual cues provided by perception—the so called prediction error—demands the adaptation of hypotheses and potentially also the induction of actions for new input-selection (Clark, 2013) or re-interpretation—what we might basically term learning and exploration. The part of the sensation which matches predictions is "explained away" (Clark, 2013, p. 7), meaning that if predictions were to be fully met, there would be no perceptual activity at all. Higher levels deal only with the mismatches between their predictions and actual lower level input—the unpredicted residuals—and update predictions continuously (Barto et al., 2013). Hence, such a

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mechanism is marked by a very economic use of processing resources. In a nutshell, Predictive Coding underlines that the perceptual and cognitive system seeks semantic stability by adapting itself (its models of the world as well as its interactions with the world) and thus by minimizing surprise (see also the principle of minimizing free energy by Friston, 2005). In the case of *SeIns*, such an attempt is especially challenging. Consider the classical example of a bistable picture offering mutually exclusive interpretations in Fig. 1. As Clark (2013) and Hohwy et al. (2008) described in the case of binocular rivalry (when two eyes are presented simultaneously with incompatible stimuli) the perceptual system will activate the best-fitting hypothesis about the cause of the stimulation (for instance, either two faces or a vase in the case of the Rubin-Vase, see Fig. 1). The part of the stimulation which matches the prediction is explained by this hypothesis, while the prediction error—the remaining mismatching data—drives the perceiving system to adapt its model of the causes of the experience to create a more accurate prediction. In the case of bistability, there is always an alternative prediction structure which is suitable to explain the cause of the stimulation and this repeated prediction error "renders perceptual inference unstable" (Hohwy et al., 2008, p. 691). If you first perceived the vase, you will switch then to the prediction of two faces. Again, this top-down activation causes a match between the sensation and the prediction of faces but a mismatch to the former prediction of a vase-structure: "To explain them [the prediction errors] away the overall interpretation must switch. This pattern repeats, yielding the distinctive alternations experienced during dichoptic viewing of inconsistent stimuli" (Clark, 2013, p. 5). Within this framework, *SeIns* is thus the repeated formation of matches and errors with regard to predictions. As will be shown in the next section by descriptions of different phenomenal variations of *SeIns*, it is important to consider the multiplicity of levels on which we form predictions: not only do we compare our experiences to

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predictions on the level of Gestalt detection as exemplified above, but we also do so with regard to "more complex compounds of items at the higher levels" (Barto et al., 2013, p. 5); be it the interpretation of a facial expression depicted in a painting or the expectation of prediction errors themselves given a certain context, like when we enter an exhibition of modern art and expect our perceptual habits to get challenged.

(Fig. 1 about here)

4. Variations of *SeIns*

While being rather clearly definable within the provided framework as a dynamic pattern of matches and mismatches to predictions, the phenomena subsumed under *SeIns* are quite distinct. Part of the conceptual challenge rests within the inherent interdisciplinarity of the construct. In the domain of art theory, Krieger (2010) subsumed phenomena like ambivalence, openness, multistability, indeterminacy, or vagueness (among others) under the concept of ambiguity while at the same time providing a differentiated analysis. In the field of psychologically- and neuroscientifically-oriented aesthetics, e.g., Zeki (2004) contrasts this view by explicitly dissociating ambiguity from phenomena like uncertainty and indeterminacy. But even within one discipline, phenomenal differences of *SeIns* are not thoroughly marked. This section aims at providing a first step towards greater conceptual clarity. In the following sections we will describe four broad variations of *SeIns* with regard to phenomenal qualities and suggest specific underlying processes for each of them before we point to the relevance of context and interaction in the induction of *SeIns*.

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4.1 Phenomena of SeIns

In this section, we describe variations of *SeIns* with regard to phenomenal qualities, refer them to specifics in the dynamics of perceptual and cognitive processes drawing on general mechanisms of Predictive Coding and examine open questions. The suggested variations of *SeIns* are neither to be understood as complete or exclusive with respect to each other nor as distinct; but rather as dynamically bound, as will be exemplified repeatedly. As broad as they might seem at this stage, describing these differences seems crucial for the field of research because a narrow view on ambiguity as the switch between determinate interpretations might reduce the variety of experiences of *SeIns* to a subset. Such a wider focus might be especially important for the field of psychological aesthetics, as these phenomena are characterized to different degrees by dimensions from the range of "collative variables" like conflict, instability, or complexity as suggested by Berlyne (1971). Very much compatible with the framework of Predictive Coding, collative variables specify a certain collation between perceived, remembered, or anticipated elements. For our understanding of the concept of *SeIns*, as well as for empirical approaches examining its effect on appreciation, it is thus crucial to specify the kind and dynamics of the collation between the perceiver's hypotheses and sensations. To avoid the merge of phenomenal and process-oriented levels of description and to provide the reader with a clear overview we present a structured summary on the suggested variations of *SeIns* in Table 1. It mirrors the structure of the following sections by separating phenomenal quality from specific processes and open questions. We have added an additional column to provide a preliminary characterization of the varieties of *SeIns* with regard to three main dimensions which seem crucial for a differentiation: exclusivity of interpretations, flexibility of semantic stabilities, and number of most relevant levels of predictions involved.

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(Table 1 about here)

4.1.1 Multistability: Switches between several mutually exclusive Semantic Stabilities

In Zeki's (2004) sense, ambiguity describes instability between determinate solutions; in fact several 'certainties'. Again, Fig. 1 may illustrate this sharp definition: a depiction of a Rubin-Vase provides at least two discrete and determinate solutions, a vase or two faces—we might even consider the interpretation of the display as an abstract pattern to be a third option (the picture is rather more multistable than bistable in this regard). Importantly, these multiple solutions, which can be perceived with a more or less equal likelihood, mutually suppress each other: only one specific solution is available at a time—a mechanism which is called the principle of exclusivity (see Leopold and Logothetis, 1999). The concept of multistability can be easily incorporated in the framework of Predictive Coding (e.g., Hohwy et al., 2008), provided above as a switch of matches and mismatches with predictive structures. The exclusivity of the matches is explainable from the perspective of Predictive Coding as follows (here with regard to a binocular rivalry of face and house):

> the brain has learnt that there can be only one cause of sensory input at the same place and time. This generic prior constraint (a ''hyperprior") reflects the way we sample the visual world; binocular vision, in primates, rests upon both eyes foveating the same part of visual space. […] In other words, the prior probability of both a house and face being co-localised in time and space is extremely small, to the extent it is almost impossible for us to support this representation or percept (Hohwy et al., 2008, p. 691).

Still, a switch between interpretations does not have to be clear-cut but temporarily involves partial changes in the visual field (Hohwy et al., 2008). A strongly debated question is: do we

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always have to switch between semantical stabilities, or can matches between sensations and incongruent predictions coexist? And analogously with regard to experience: can we be simultaneously aware of contradictory interpretations? Note that these two questions are not equitable as the first might not necessarily lead to the second, and simultaneity in awareness might not necessarily imply simultaneity in neural activations of incompatible predictive structures.

Multistability is marked by the strict exclusivity of Gestalts and characterized by a moderate flexibility of stabilities (at least two). It is mostly evoked solely on the level of Gestalt formation and thus primarily associated with stabilities on one level of predictions which is about object identification (see also Table 1).

4.1.2 Dichotomy: Coexistence of incongruent Semantic Stabilities

The relevance of the question about whether matches to incongruent predictions can coexist becomes obvious if we look at a concrete example: neurobiologist Semir Zeki (2004) applied his definition of ambiguity as a switch between determinate interpretations not only for bistable figures but also for features of artworks, e.g., the facial expression of the girl depicted in Johannes Vermeer's "Girl with a pearl Earring" [Dutch: *Meisje met de parel*] from the year 1665. The rationale is that—analogous to the detection of a vase versus two faces in Fig. 1—her facial expression offers different interpretations: "at once inviting, yet distant, erotically charged but chaste, resentful and yet pleased" (Zeki, 2004, p. 189). According to Zeki (2004), ambiguity lies within the oscillation between these interpretations or certainties respectively. It can be assumed, though, that they eventually build up new categories integrating the inconsistencies within one object. Consider for instance the androgynous fashion style of Berlin women in the

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1920s. Despite once having been incompatible with perceptual habits and the semantic connotation of stylistic elements, it is a rather determinate pattern of style from today's perspective. Furthermore, a differentiation of *SeIns* 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 of patterns of familiar facial expressions and as *incongruent* due to conflicts between elements associated with different, partially mutually exclusive meanings. The expression of the face might even be *instable* as it does not resemble a typical pattern (it does not provide Prägnanz; see Berlyne's concept of instability, 1971). Another insightful account of how conflicting elements and interpretations can relate to each other is provided by Kaplan and Kris (1948 with regard to ambiguity in language). While they might term multistability as a kind of *disjunctive* ambiguity in which mutually exclusive interpretations are induced, they consider that there can also be overlaps between interpretations (*additive* ambiguity) and several meanings can contribute jointly to an interpretation, for instance in irony and humor (*conjunctive* ambiguity). When several meanings are divergent but build one complex meaning together—as might be the case with the girl's facial expression in the famous Vermeer painting—Kaplan and Kris (1948) speak of *integrative* ambiguity. It can however be assumed from studies in binocular rivalry that such an integrative percept is possible only when elements are highly consistent, "if the blended hypothesis happens to have a high prior"—higher than the competing hypotheses alone (as when a mouth-less face is combined with a mouth, see Hohwy et al., 2008, p. 691). Similarly, as stated above, we can assume that contradictory expressions of a face can form an integrative meaning given we are able to adapt our predictive structures by repeated exposure—as might have been the case with the androgynous style of clothing in the 1920s. Furthermore, other predictive

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structures might play a role here as well; for instance the knowledge about facial expressions being dynamic while bound to the person doing the expressing. Drawing on the literature on Predictive Coding however, it seems to be an open question how the several levels of predictive structures work together: how is "consistency" between contradictory hypotheses realized at a level as high as the identification of facial expressions?

The coexistence of matches to incongruent hypotheses was recently expressed with the concept of 'dichotomy' (Pepperell, 2015). We are, for instance, able to analyze and praise the way in which an artist depicts a semantic scene; do we hereby fuse the mutually exclusive levels of material (e.g., canvas, paint and color), composition (arrangement of material), and content (e.g., the depicted scene)? Concerning the question of which processes might underlie this variation of *SeIns* we would like to suggest that in contrast to multistability, the according predictions of this example are formed and compared on a multitude of different levels. In fact all our visual experiences are accompanied by context and thus by many different kinds of predictions shaped by experience. For instance, in art perception a variety of different levels of prediction are involved from knowledge of style to social conventions and categorization (e.g., as an artwork this object was deliberately produced and I might gain an insight by elaborating it). And after having seen many multistable displays like the one in Fig. 1, we form predictive structures about the specifics associated with their experience; e.g., we expect further switches in interpretation after the first switch. These levels—e.g., predictions of Gestalt vs. broader predictions about the dynamics of experiential switches—are nevertheless not always mutually exclusive. In dichotomy, the case is slightly different as it concerns the simultaneity of matches to incongruent predictions concerning one visual event at different levels. If we look at the photograph in Fig. 2, we will experience a coexistence of incongruent semantic stabilities: we

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perceive paper and print but a man's back as well. In this case, their intertwined nature is underlined by the artist's manipulation which concerns both levels of observation at the same time, content and material: the illusion that the depicted man tears the paper apart is a consequence of the dichotomy between the depicting material and the depicted. Dichotomy might in general be the result of such simultaneous matches to predictions at different levels. Whereas some of these might be incompatible (material vs. content), others might include or imply this incompatibility: for instance, the (meta-)prediction that representations are necessarily dichotomous or predictions associated to the art context in general (e.g., as an artwork this object is likely to induce *SeIns*). As one such "hyperprior", Kesner accordingly suggests the "capacity of seeing in/as, (…) to see 'through' the depiction to its referent and at the same time to the nature of the relation between representation and referent" (Kesner, 2014, p. 10). While being universal, such knowledge would be strongly influenced by specifics and changes of pictorial culture (e.g., the invention and omnipresence of photography). In sum, the question remains why we can accept semantic conflicts in some situations (e.g., dichotomy) whereas our perceptual system is forced to switch between them in others (e.g., multistability).

(Fig. 2 about here)

Dichotomy is marked by incongruent predictions on different levels of perception. In contrast to multistability, the phenomenon questions the principle of exclusivity in the sense that it evokes the experience of simultaneity of mutually exclusive interpretations. It is characterized by a moderate flexibility of stabilities (at least two) and a multitude of involved levels of

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observation like the focus on Gestalt, composition, material, and categories of objects (see also Table 1).

4.1.3 Visual Indeterminacy / Semantic Potentiality: the Lack but Promise of Semantic Stability

Potential (Gamboni, 2002) or visually indeterminate (Pepperell, 2006) pictures, respectively, promise to contain identifiable patterns but never provide determinacy. This is for instance the case in Cubist artworks, being evocative of recognizable patterns but hindering Gestalt recognition. In the provided example in Fig. 3 we are able to recognize the silhouette of a hat, text which might belong to a newspaper, fragments of a beer glass and parts of a wooden table. The arrangement of these elements however does not conform to a unified Gestalt of what would represent the title's content "Man in café". Art historian Ernst Gombrich encapsulated it: "each hypothesis we assume will be knocked out by a contradiction elsewhere" (Gombrich, 1960/2002, p. 240). Expectation thus plays a major role in indeterminate/potential images: the name of the painting "Paradox 1" (Fig. 4), for instance, already indicates certain incongruence between our expectation of finding bodies within the images and the actual lack of determinacy. Visual indeterminacy might be linked to the collative variable of *complexity* as defined by Berlyne (1971) due to the high number of potential elements and to the collative variable of *instability* as it never entirely fits into one interpretation of Gestalt alone. Such a struggle of unfulfilled hypotheses could be integrated within the provided framework of Predictive Coding as the highly changing and distributed activation of (parts of) predictive structures driven by an enduring irresolvable prediction error. Here, the set of predictions, structures of our model of the world, cannot be adapted so as to provide error-free predictability. One question regarding this is

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how ‘promise’ or ‘potentiality’ is signaled in these cases: we can imagine partial matches to predictive structures as well as competition between a great number of them (bridging visual indeterminacy to multistability) to be involved—a clear answer from the field of Predictive Coding is yet missing. The question of plurality and fragmentation of predictive matches/mismatches gets even more interesting if we ask again whether there can be stability in rather abstract predictive structures (“This is an artwork”, “This is a Cubist artwork”, “This looks like a Picasso based on the distinctive stylistic features”) while image-internal identification processes are highly instable: how do these various levels of perception work together? Furthermore, the differentiation between multistability and visual indeterminacy/potentiality becomes rather 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., Kubovy, 1994), and visual indeterminacy or potentiality as an infinite number of potential stabilities without a single interpretation which would minimize the prediction error on all levels of processing.

(Fig. 3 about here)

It cannot be clearly stated if visual indeterminacy or semantic potentiality, respectively, is marked by exclusivity of predictions as here visual cues guide all kinds of associations to a variety of predictions without choice. In contrast to multistability, these predictions might be exclusive once confirmed but never reach this status as they are potential only. They are characterized by either no stability or an infinite flexibility of stabilities and mainly refer to the levels of object identification and expectation (see also Table 1).

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(Fig. 4 about here)

4.1.4 Experience of Hidden Images: the Emergence of Semantic Stability

To furthermore highlight the difficulty of a differentiated conceptualization, we can note that the phenomena of visual indeterminacy as well as of visual determinacy can both qualify the perception of a hidden image. These images—like those used by Muth and Carbon (2013, see Fig. 5)—conceal hardly identifiable objects (Gamboni, 2002). Here, they allow one to find a Gestalt: a face within a black-and-white pattern.

(Fig. 5 about here)

One example of hidden images in motion is the stop-motion-movie “Konstrukte” (07:18 min.) by Claudia Muth from the year 2009. By taking photographs at several thousand stages during the development of a drawing (charcoal and acrylic paint) the artist documented the evolution and metamorphosis of Gestalt within the ongoing drawing process (see Fig. 6 and supplementary material). When watching the movie we can retrace various stages of visual indeterminacy/potentiality within the drawing and experience the joyful transition between indeterminacy and determinacy when a Gestalt emerges (‘Aesthetic Aha’, Muth and Carbon, 2013). Hidden images reveal general perceptual mechanisms as every process of recognition can be understood as the minimization of a prediction error: it always involves an inference of causes of a sensation (Friston, 2005). This active contribution of the perceptual system becomes apparent by being inhibited or slowed down in the case of hidden images.

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(Fig. 6 about here)

In some hidden images the promise of matching predictions might play a big role in the investment of attentional resources to initially indeterminate material, while in other cases Gestalt might just "pop out". Though multistability lacks the prolonged indeterminate phase there is a potential link to the experience of hidden images: we can compare the sudden appearance of a stable interpretation in a hidden image to the phenomenal quality of the 'Aha!'–insight when changing from one interpretation (e.g., clouds) to another (e.g., sheep) in multistability. Whereas in multistability we are able to return to the former interpretation (from vase to faces and vice versa), in the case of hidden images we mostly stick to the identified Gestalt as is famously demonstrated by Dallenbach's (1951) concealment of a cow (see Fig. 7 for an adapted version): as soon as you detect the cow, it is difficult to return to the visual experience of a seemingly random composition of dots. The difference between the experience of hidden images and the one of visual indeterminacy/potentiality is that in a hidden image, a considerable prediction error minimization finally occurs through Gestalt recognition so that semantic stability can be established (at least temporarily in the case of the movies). With regard to their influence on collative variables (Berlyne, 1971), hidden images might induce *surprise* via a conflict between the prediction of indeterminacy (random pattern) and the sudden perception of determinacy (e.g., a cow in Fig. 7) especially if they are accidental images (Gamboni, 2002) unintentionally forming Gestalt. These phenomenal qualities are again very much compatible with the definition of *SeIns* as formation and resolution of prediction errors.

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(Fig. 7 about here)

As clear as this case might appear, it is important to make a distinction between *accidental* hidden images (e.g., sheep within clouds) and those hidden images which we explore while knowing about the potential to find a Gestalt or even to find a very specific Gestalt (e.g., "Wally" in "Finding Wally" games); referred to as *expected* hidden images in the following. Concerning the latter case, several levels of prediction are involved: the perceiver builds up an expectation when perceiving the image which causes the formation of a prediction error during the indeterminate phase, as no Gestalt is actually recognized ("something must be hidden in this display but it is hard to recognize"). This prediction error consequently concerns the unfulfilled prediction of recognizable Gestalt and its resolution is a *confirmation* of expectation. On the other hand, the Aha-insight characteristic of both accidental and expected hidden images, the surprise induced by sudden recognition, is a *violation* of expectation; we are not able to anticipate the distinct Gestalt of the cow within the hidden image in Fig. 7 before it is actually perceived. This seemingly paradoxical coexistence of confirmation and violation of predictions is linked again to the multilevel quality of predictions. We can speak of predictions on the level of expectations about forthcoming experiences ("I will probably detect a Gestalt in the hidden image") vs. predictions on the level of object identification ("the actual sensation is caused by a pattern of black and white dots" or "the actual sensation is caused by a cow"). A similar differentiation is found in the discussion about the differences between surprise and novelty. Novelty refers to previously un-experienced instances but is not always an effect of a violated expectation because we can expect novelty (see Berlyne, 1971): we can expect the emergence of a new Gestalt in Fig. 7. On the other hand "[s]omething can be unanticipated without being un-

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experienced" (Barto et al., 2013, para 2): you are familiar with the features of a cow and you would even expect to experience it were I to tell you that it is hidden in the display in Fig. 7; nevertheless the experience of seeing the Gestalt elicits a surprising 'Aha!' because the quality of the Gestalt itself is unanticipated. We thus suggest that the experience of both accidental and expected hidden images evokes a prediction error as soon as Gestalt is detected—we are surprised if the Gestalt "pops out", because our prediction that the actual experience is caused by a random pattern of black and white dots does not match the new experience. The recognition of Gestalt, however, is of course a match to an alternative prediction (e.g., cow in Fig. 7). In contrast to multistability, this interpretation is determinate after recognition; in most cases no prediction errors are formed of the level of Gestalt formation anymore. If it is an expected hidden image an additional level of prediction is relevant: here, Gestalt detection is a sudden resolution of the mismatch between expecting Gestalt vs. experiencing no Gestalt.

The experience of hidden images is marked by exclusivity of predictions once the random composition is resolved into a determinate semantical stability. It is then characterized by a low flexibility as well, as in most cases it is impossible to switch back to the original state of visual indeterminacy. The phenomenon mainly refers to two levels of observation: object identification and expectation (see also Table 1).

4.2 Sources of SeIns

Besides these theoretical suggestions, empirical approaches to a categorization of *SeIns* in art are rare (e.g., Muth and Carbon, 2012) but seem highly important with regard to the fuzziness of the applied concepts as well as the overlap of according phenomena. Another challenge for a clear definition of according phenomena concerns sensitivity to context: Gaver et al. (2003) gave a

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theoretical account of three sources of ambiguity in design. They stated that not only can object-based information be ambiguous—determinate information can become ambiguous in certain contexts. So called Ready-Mades are, for instance, everyday life objects often industrially produced, which are notwithstanding exhibited in an artistic context and thus make explicit use of such a kind of context-dependent *SeIns*. Again, Predictive Coding incorporates this contextual induction of *SeIns* because the same features of a situation might relate to different sets of predictions depending on our actual state of experience and expectations concerning its context. When Marcel Duchamp exhibited Ready Mades such as the urinal entitled "fountain" (see Fig. 8) in the beginning of the 20th century, this might have caused strong mismatches to predictions being closely linked to the context of an art exhibition. Such predictions might for instance have concerned the experiencing of objects which are unique instead of industrially produced, and thus linked to authenticity and authorship. Nowadays many perceivers might form other predictions concerning artworks, having had different experiences and thus forming different sets of predictions which might be more compatible with Ready Mades than at the time of their first exhibition. Such artworks reveal the relevance of context for every experience: the context of an experience determines if and how prediction errors are formed. They also show that even a familiar item like a urinal can engender surprise, if it is unpredicted. This is the case if it is encountered in a context which does not evoke cues predicting its appearance. And as Barto et al. (2013) intensely discuss, it can be even unfamiliarity as such which is predicted: people might not have expected a familiar object like a Ready Made in the context of art exhibitions. It is thus important to keep in mind that semantic stability as well as *SeIns* is very much context dependent. This can be exemplified as well via a discussion about the so called "dark room problem": the drive to minimize prediction errors and thus reduce surprise does not imply that

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the system seeks an avoidance of stimulation. In contrast, a "darkroom" is surprising in the context of the prediction that environments are stimulating: "Agents that predict rich stimulating environments will find the 'darkroom' surprising and will leave at the earliest opportunity. This would be a bit like arriving at the football match and finding the ground empty" (Friston, Thornton, and Clark, 2012, p. 3).

As a third option, *SeIns* "arises from the viewer's personal relationship with the piece" (Gaver et al., 2003, p. 237). In particular, this seems highly relevant for product design but also for the contemporary art direction of *Relational art* (Bourriaud, 1998) which includes the participation of the audience; for instance via Swarm-Happenings evoking discussions on the usability of public space. People's interactions make up the artwork in the first place, so they gain a double function in this regard. Pretend play is yet another example of the relevance of the relationship between object and perceiver as a source of *SeIns*. Here, an object changes its meaning due to a new way of interacting, a re-enaction of meaning (Di Paolo et al., 2007)—using a hairbrush as a microphone, for instance. Not unlike play, art makes use of perceptual habits or sets of predictions respectively, and often violates them.

(Fig. 8 about here)

4.3 Summary and open questions

The term *SeIns* comprises various characteristics of objects that defy a determinate interpretation. More specifically it can refer to multistability if several meaningful patterns can be established, to dichotomy if incongruent semantic stabilities coexist, to visual indeterminacy or semantic potentiality, respectively, if objects are evocative of an identifiable pattern but never

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provide determinate identification, and to the experience of hidden images if objects conceal identifiable patterns. The review of the varieties of *SeIns* revealed that they differ along the dimensions of exclusivity, flexibility of stabilities, and the multitude of levels of predictions as much as they differ in the dynamics of the relations between perceived elements, predictions, and expectations. The characteristics of some of these relationships are of great importance for the empirical investigation of effects of *SeIns* in art: a hidden image such as the one in Fig. 5, for instance, allows for comparing the effects of visual indeterminacy (random elements) on appreciation with those of determinacy (for instance, recognition of a face; see Muth and Carbon, 2013). Indeterminate or potential pictures—in contrast—provide the opportunity to see how an ongoing disappointment of expectations affects the perceiver. The dynamics of expectation play a crucial role not only for the induction of ambiguity but—as will be shown later—for the induction of interest as well.

As is evident from the descriptions of varieties of *SeIns*, there remain several open questions regarding the involved perceptual and cognitive processes. Especially if we consider examples from the field of art perception, the multilevel nature of predictions becomes apparent: whether we are challenged by detecting fragmentary cues for a concealed object within a Cubist painting but are unable to match it to a prediction, or we encounter an artwork by Jeff Koons which resembles a Kitsch object in an exhibition when having expected art objects to differ greatly from easy-on-the-mind objects. We often form matches and mismatches to predictions alike, for instance on conceptual and perceptual levels as well as about the temporal course of future events. An explanation of phenomena of *SeIns* can be mainly focused on one level of predictions alone in some cases (e.g., that of object identification in cases of multistability), but is always accompanied by a multitude of other levels as well. The coexistence of different levels might

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even be relevant to other varieties of *SeIns* (e.g., in cases of dichotomy). Not unrelated to this multilevel-quality of predictions, another question arises: prediction errors are signals of change and evocations of perceptual and cognitive activity which we continuously encounter. Though we might speak of *SeIns* in all of these cases, the described phenomena demand a perceiver's awareness to these instabilities and the question remains at which point prediction errors induce this awareness.

5. Specifics of *SeIns* in Art

SeIns is not an exclusive phenomenon reserved for cabinets of curiosities, produced by deliberate image manipulations for scientific or entertainment matters. We can claim the contrary that everyday perceptual processes are attempts to disambiguate semantically undefined data. A simple case often used to exemplify this in the visual domain is the formation of three-dimensional impressions out of two-dimensional retinal data (cf. Carbon, 2014). But as described above, instead of providing a copy of the outside world, the perceptual system constructs hypotheses and makes predictions about it (Clark, 2013; Gregory, 1980). Taking another perspective on the term "information", we might even state that meaningful information is never "taken up" but emerges from the interaction of an agent with the environment. Enactivists (e.g., O' Regan and Noë, 2001) consequently claim that regular patterns in the dynamic interplay between movements and sensual impressions (like characteristic shifts in a table's shape when we move around it) would form "sensorimotor contingencies" instead of static internal representations. The relationship between environment and perceiver is a mutually dependent one: the environment poses different "Umwelten" [subject-specific "environments" in von Uexküll's conception, 1909] for different living systems depending on their architecture and

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what their needs are: "the 'Umwelt' is itself only understandable from its relationships to the behaviors of the animal. The 'Umwelt' consists only of those questions which can be answered by the animal" (translated from von Uexküll, 1909, pp. 89-90). At the same time, the perceiver's perceptual and cognitive system organizes itself by encounters with its Umwelt. Varela et al. (1991) consequently compare a supposed predominance of either environment or perceptual system with that of the chicken and egg. Semantic stability might then be more a result of this interaction than a feature of an object. The fact that perception always deals with *SeIns*—even if we are not aware of this—becomes more or less pronounced in our daily life. Only in some cases does the omnipresence of *SeIns* and the activity of perception become apparent: identifying sheep within clouds (an accidental ambiguity), finding Wally in a crowd of similar people (an expected hidden image), repeating a word again and again until it seems strange to you (semantic satiation; James, 1962), finding out what your child intended to draw (in some cases it might induce a plurality of potential meanings that is close to visual indeterminacy), or seeing a new car design for the first time (inducing novelty, maybe even instability in the sense of Berlyne, 1971). Encounters with artworks are prominent examples among these situations when the *SeIns* of the world becomes apparent: the art theorist Majetschak (2003) for instance claimed that through art, perceivers are able to perceive themselves perceiving—he consequently described looking at an indeterminate painting by Cézanne as a "birthplace of visibility" [trans. by the authors] (p. 324) as it renders obvious the perceptual effort of constructing objects out of the coarse fields of color. The art theorist Konrad Fiedler (1887) claimed that art can provide a way to visualize viewpoints instead of representing objects by such an impairment of everyday automatized perception. Other philosophical accounts describe art as "self-aware enaction", putting us in a situation in which we "catch ourselves in the act of perceiving" as "a mode of

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active engagement with the world" (Noë, 2000, p. 128). And the art historian Dario Gamboni states that potential artworks can "make the beholder aware […] of the active, subjective nature of seeing" (Gamboni, 2002, p. 18). A chair-sculpture by Stefan Wewerka (Fig. 9) 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).

(Fig. 9 about here)

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 (p. 280; referring to artistic language).

In terms of the idea of hypothesis testing (Gregory, 1980) and Predictive Coding (see review by Clark, 2013) such *de-automatism* might be the result if no relatively stable state can be established on the basis of an existing set of predictions and its adaptation. An art object "resists being simply 'explained away.'" (Kesner, 2014, p.4; whereas the object might apply to a set of predictions on other levels, e.g., concerning its qualities as an art object, see Kesner, 2014). An awareness of *SeIns* may not be evoked by every artwork, although ambiguity is often claimed to be a particular characteristic of 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 and Leder, 2009; Van de Cruys and Wagemans, 2011; Zeki, 2004). Thinking about the omnipresent *SeIns* that our perceptual system faces; is there something

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specific about the *SeIns* of artworks? An overview of three main arguments shall be presented within this section before the text turns to psycho-aesthetic accounts of the appeal of *SeIns* in art.

One answer to the question of the specificity of *SeIns* in art is that *SeIns* is a cultivated, historical feature of art. The paradigmatic character of ambiguity as a quality feature has been applicable to art since at least the epoch of modernity associated with the 19th and 20th centuries. However, "several ways" to a de-automatization of perception—as intended by Shklovsky (1917/2002)—have already been previously undertaken. For instance it was assumed that Albrecht Dürer deliberately concealed faces in drawings of pillows in 1493 (see Gamboni, 2002) and his "Self-portrait in fur coat" (German: *Selbstbildnis im Pelzrock*) from the year 1500 creates *SeIns* by sharing features of earlier depictions of Jesus Christ (Hall, 2014). Indeed, at least from the 16th century on, deliberate acts of executing ambiguous manipulations of picture elements occurred quite frequently. Krieger (2010) claims that back then, art went beyond the religious context which had demanded the generation of symbolic motives that offered a determinate interpretation (e.g., a specific saint had to be identifiable as such). Popular examples of ambiguity in art within this era are Giuseppe Arcimboldo's visual compositions of vegetables, fruits and other objects which together suggest the emergence of human heads. It might be useful to look at an analysis of the beginning of modernity in art, especially in painting, to understand why modernity and *SeIns* are nevertheless often explicitly linked to each other. According to Gombrich (1950/2002) and Meinhardt (1997) the invention of photography and other techniques of reproduction in the mid-19th century induced a crisis in painting: a major function (and with it a source of income for many artists—the representation, e.g., of a person or a city) was overtaken by cheaper and later on relatively effortless but highly accurate photographs (at the same time, the accuracy of a photograph can be questioned again as it "translates" the scene via a limited

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range of tone, Gombrich, 1960/2002). This functional loss furthermore challenged the understanding of a painting being "an image", a depiction of content external to the material in use. Subsequent artistic approaches can, from an art-historical perspective, be understood as a response to this historical change; the consequence being that they focused less on the represented theme (*sujet*) but reflected for instance the process of perception itself (e.g., in impressionism) or the activity of painting (e.g., in expressionism, Meinhardt, 1997). Furthermore, Gombrich (1950/2002) points to the idea that spontaneous perspectives and the general freedom concerning composition in impressionism might have been especially appealing to its contemporaries due to their contrast to the highly static procedure of taking a photograph just before new techniques enabled snapshots. It can be stated that painting was shaken by another crisis in the beginning of the 20th century, induced by Marcel Duchamp's first Ready-Mades. The aesthetic experience of an artwork, its status as an artwork as well as the supposition of meaningfulness of an artwork had been exposed as social conventions bound to the context of an art 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 (Meinhardt, 1997). For instance, monochrome paintings by Alexander Rodtschenko from the 1920s deprived the image of a representation (the illusory layer) as they pointed to their own materiality by eliminating any form of composition. Another reference to dichotomy was made in the 1950s and 1960s by Lucio Fontana, who pointed to the materiality of a painting by cutting the canvas. Among the different manners of self-reflection, art movements like *Art Informel* (a word borrowed from the French word "informe", meaning unformed or formless) aimed at the deprivation of objects from associations and intentionality (Krieger, 2010). Here, *SeIns* refers to an intentional openness during the production of artworks. According to Umberto Eco (1989) an open artwork is

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"characterized by the invitation to make the work together with the author" (p. 21) and "is effectively open to a virtually unlimited range of possible readings" (p. 21). It is the 'beholder's share', the way in which a beholder perceives and elaborates it which makes up the artwork in the first place (Gombrich, 1960/2002) and determines how far such semantic openness reaches. Other modern as well as postmodern means of inducing *SeIns*—besides, e.g., the context shift inherent to Ready-Mades and the intentional openness in Art Informel—are for instance a more intense use of contradictions among style and content, contradictions by multiple perspectives and techniques like collage, or recourses in artworks (Krieger, 2010).

A second argument for the specificity of *SeIns* in art might come from a sociological perspective: the level of *SeIns* might not stem from the artwork's features alone but might be bound to historical changes in reception relevant to the perception of cultural objects in general (Bourdieu, 1984). 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. Furthermore, perception and production of *SeIns* in art is culturally shaped: perception scientist Pascal Mamassian (2008) accordingly describes ambiguities in art as "conventions" with regard to composition, spatial scale, illumination and color, three-dimensional layout, shape, and movement and describes how they are applied by artists and rooted in general perceptual constraints. We thus have to consider not only context but the (culturally influenced) mindset of the perceivers when discussing sources of *SeIns*. In his discussion of the 'culturality of vision' Kesner points to three variables that qualify such a mindset and influence which predictions a perceiver will form in response to art: "personality traits/affective style" (how perceivers respond to emotional/affective aspects of a work),

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"culture-cognitive capital" (skills in and knowledge about art perception), and "momentary psychosomatic state" (Kesner, 2014, p. 8). Also, beyond its aesthetic impact, ambiguity in art fulfills the function of social distinction as Bourdieu (1984) thoroughly worked out. This point clarifies that a work of art is a historical artifact—produced and perceived within a specific social context—and an aesthetic object at the same time; thus its reception is different at different periods in history.

A third answer to the question is that representational paintings are dichotomous (Pepperell, 2015) per se: they always entail simultaneity of a material layer—canvas and color—and an illusory layer—the depicted content (e.g., Gombrich, 1960/2002); Gregory (1970) even claimed in this regard that "[p]ictures have a double reality"; they are paradoxical (p. 32). Kesner for instance states with regard to the observation of a painting: "the viewer's perception of the virtual pictorial space as some sort of non-descript enclosed space, delineated by the ground and the wall, easily shifts to an awareness of the picture plane and markings, which seem to deny any claim to mimetic optical veracity" (Kesner, 2014, p. 5). 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 as material and image—even if we might not be aware of this—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 of the experience of form versus the

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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 also seems true when singing into a hairbrush).

As discussed above, the question of whether we can be conscious of various interpretations of an object at the same time lies at the very core of the theoretical conception of *SeIns* as well as that of its appeal. Furthermore, it is a fundamental discussion in the field of art perception. As stated before, from a classical psychological view, the principle of exclusivity prevents simultaneity of states or meanings and thus explains sudden switches between interpretations during multistable perception (Leopold and 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, philosopher of aesthetics 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, much like we are able to fuse phoneme and meaning in lyric poetry. Still, as described by 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 whether we oscillate analogously between microphone and hairbrush or if we instead

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use the microphone as represented by the hairbrush (to roughly refer to aesthetic philosopher Richard Wollheim's seeing-in account). 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 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 predictions and this signifies that there might be a simultaneity or collation between perceptual hypotheses or between hypotheses and actual perceptual cues. *SeIns* might be marked by such an ongoing mismatch in the case of visual indeterminacy or potentiality. The question of simultaneity 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 elliptical 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 dichotomy between the two layers of content and form: Pepperell (2015), for instance, described how "the materiality of the surface 'interferes' with our recognition of the forms" in Turner's "Rain, Steam, Speed" from the year 1844 in which the application of the paint underlines its quality as a material but also "functions […] as sky, brick, steam, metal, water, clouds, and fields"; this dichotomy would disappear only if "we focus too closely on a single patch of paint" (para 3). He furthermore suggested that such a dichotomy might be more pronounced in works of art than in other representational objects partially because representational artworks clearly point

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to the dichotomy between material and content—the way in which content is represented and the multiplicity of induced associations play a major role here. Psychologist Lev Vygotsky (1976) also pointed to the fact that material and content are never independent of each other; the same figure made of either paper or bronze will have a completely different appearance and effect on the perceiver. This dependence would become 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 content of the words is represented—might affect our appreciation of the poem to a great extent. A crucial point for Vygotski which is also proclaimed by Pepperell is that some aesthetic effects in art seem to require a corresponding dichotomy between content and form.

This section discussed three arguments for the specific link between *SeIns* and art: first, *SeIns* is a cultivated, historical feature of art. Second, the reception and appreciation of ambiguity in art is dynamic and linked to conventions; nowadays *SeIns* is a normative quality characteristic. Third, representational art always entails dichotomy through a conflict between the material layer and the layer of the represented content. The question of whether this conflict equals a simultaneous incongruence is strongly debated and underlies the theoretical conception of *SeIns* as well as the examination of its effects on perception in general. With an analysis of phenomena and art-specific aspects of *SeIns* at hand, the next section turns to theoretical accounts of psycho-aesthetics.

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6. The Appeal of *SeIns*

We do not presuppose that artworks always induce or aim at inducing a positive affect of pleasantness in perceivers, instead we can think of a variety of evoked affective reactions ranging from exhilaration to irritation, surprise and aversion. Still, a basic question is why we produce, expose ourselves to, and even make huge financial investments for objects which defy an easy consumption; this is the question of appeal of *SeIns* in art. The psychological examination of art perception is a major topic in the wide field of psycho-aesthetics. Corresponding research and theory provides at least four different but connected theoretical models which are highly relevant to the investigation of the appeal of *SeIns*: 1) appeal by fluency of processing, 2) appeal by moderate increases of arousal potential or decreases of high arousal, 3) appeal by predictive progress, and 4) appeal by pleasurable (anticipation of) insight. We will discuss them in further detail as follows.

6.1 Appeal by Fluency of Processing

Low-complex, familiar, symmetrical, or prototypical objects can be processed more fluently than their counterparts. In terms of Predictive Coding, we might state that they are more easily matched to existent predictions. According to the Hedonic Fluency Model (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). Evidence for the relationship between fluency and liking

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is provided, e.g., by the Mere Exposure Effect (originally reported by Zajonc, 1968 and transferred to the haptic domain by Jakesch & Carbon, 2012). Here, liking increases with the number of unreinforced presentations of a stimulus—and thus supposedly by an increase in the fluency of processing via familiarity. Nevertheless, in some cases conceptual fluency (e.g., suggesting a certain interpretation) is high whereas 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).

Although this idea reflects what we referred to before as the multilevel-quality of predictions—the simultaneity of matches and mismatches at different levels of prediction (here perceptual and conceptual)—the appeal of *SeIns* might also be explainable by including dynamics of prediction error minimization: positive effects of fluency could be gained 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). A related focus was meanwhile drawn to 'Aha!' experiences by Topolinski and Reber (2010) who described them as sudden increases in processing fluency. With regard to hidden images, as used in the stop-motion movie discussed above (see Fig. 6), it was indeed shown by Muth, Raab, and Carbon (2015) that the sudden recognition of Gestalt increases liking temporarily. All in all, aesthetic pleasure is definitely multifaceted (see Faerber et al., 2010, for an overview on multiple variables of aesthetic appreciation) and we want to underline again that not every artwork induces (or even aims at inducing) positive affect in the sense of a mild pleasure or prettiness which is assessable by liking evaluations (Armstrong and Detweiler-Bedell, 2008). Thus, *SeIns* or low fluency might

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affect liking in a different manner from how it affects another facet, 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 positive valence—if it can be more easily processed than its counterparts? Or does fluency instead amplify the evaluation in the respective direction with objects of negative valence being actually disliked to a greater extent the more fluently they are processed (see Fluency Amplification Model by Albrecht and Carbon, 2014)?

6.2 Appeal by moderate Increases of Arousal Potential or Decreases of high Arousal

Liking does not always increase with familiarity; their positive link is limited by boredom (Bornstein, 1989). We might relate this effect to Predictive Coding; boredom being a lack of opportunity for prediction error minimization on a perceptual level and at the same time being a mismatch with the prediction of "rich stimulation environments" which we hence attempt to resolve by the drive for exploration (see counter argument to 'darkroom' problem by Friston, Thornton, and Clark, 2012, p. 3, as discussed above). 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 above). 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 *SeIns*

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inevitably leads to 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" (Carbon, 2014); we perceive a flat world but know that the earth is round (Carbon, 2010), and we accept that a photograph is an illusory image on the one hand and paper and color on the other. Still, Jakesch and Leder (2009) found that moderately ambiguous stimuli are indeed preferred over those of low and high ambiguity. Ambiguity was defined by Jakesch and Leder as incompatibility between an artwork and additional auditory statements. This idea implies that if we encounter an easy, familiar object, arousal might be too low to be appealing; if we encounter a difficult or novel object, arousal might be too high to be appealing. Berlyne (1971) suggests that reluctance toward highly arousing stimuli might stem from the association with dangerous—highly arousing—situations to which we should react with aversion. In contrast, Wittmann et al. (2007) report positive links between novelty and activation of the reward system and Belke et al. (2015) report preferences for challenging portraits. So in contrast to the avoidance of arousal, 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). From Berlyne's perspective, 'difficult objects' can indeed 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 is 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

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becomes too low and boredom sets in. It is plausible therefore that simple and familiar stimuli lead to boredom more quickly than difficult ones (see Carbon and Leder, 2005):

> 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 for non-art domains:

> 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).

With regard to the elaboration of a Cubist artwork, as exemplified in Fig. 3, this means that indeterminacy might increase the arousal level of an observer, but with time he or she might be able to detect fragmentary familiar cues in it. Furthermore, we can imagine objects which are new and typical at the same time—in other words being "Most Advanced, Yet Acceptable" (MAYA, a design principle set up by the influential designer Raymond Loewy and tested in psychological studies by Blijlevens et al., 2012; Hekkert, 2006). This fruitful combination inspired Hekkert (2006) to 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).

6.3 Appeal by Predictive Progress

To induce surprise in their participants, Ludden et al. (2012) presented objects which looked very similar but differed in tactile characteristics. The level of surprise can be defined here by the

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level of visual-tactile incongruity: if the prediction based on visual cues (e.g., “this looks soft”) is disappointed (e.g., “this feels hard”), people are surprised (see also Carbon and Jakesch, 2013). In the rationale of Predictive Coding, such prediction errors would lead to negative affect as the predictions prove to be wrong, and would induce an attempt to minimize the error (Van de Cruys and Wagemans, 2011). Berlyne (1971) similarly stated that in cases 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 (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 predictions , thus potentially leading to their higher accuracy. On the other hand, it might be relevant that the object provides an opportunity for novel predictions. Accordingly, a limitation of the Mere Exposure Effect by boredom, as reported above, might also play a role for Predictive Coding according to Chetverikov (2013) who stated 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, an 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 and Wagemans, 2011, p. 1038) or, to put it differently, because the novel instance is not in accord with the beholder’s (visual) habits (Carbon and Leder, 2005). Following this, our perceptual system

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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 and Wagemans, 2011) such a process of predictive progress increases positive affect again. Indeed, 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 and Leder, 2005). Challenging artworks might also 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 be even greater than it would be without an encounter of incongruence in the first place if a prediction error precedes uncertainty reduction because it allows for a greater reward by reduction of prediction errors. Indeed, Dörner and Vehrs (1975) showed that patterns are most appreciated if the perceiver initially experiences difficulties in finding order in them, but ultimately succeeds in doing so. Such a contrast effect on appreciation (being repelled at first by the challenge and then rewarded by its solution) is compatible with Berlyne's (1971) idea that the combination of an increase in arousal with a subsequent reduction of arousal is effective with the reward system as well as with Van de Cruys and Wagemans' idea of reward by predictive progress.

An introduction to the phenomenal variety of *SeIns* as well as the psycho-aesthetic accounts of its appeal show: to explain the appeal of *SeIns* in art we have to focus on the relationship between artwork and observer and we have to include temporal and semantic 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 Fig. 10A) we have to reveal how *SeIns* and appreciation evolve with elaboration. Figure 10B visualizes one exemplary and

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idealized model of such a relationship with regard to pleasure by the reduction of semantic instability.

(Fig. 10 about here)

6.4 Appeal by pleasurable (Anticipation of) Insight

Recent psycho-aesthetic studies revealed that ambiguity (Jakesch et al., 2013; Muth, Hesslinger, et al., 2015) and visual indeterminacy (Ishai et al., 2007) in art can be positively linked to appreciation—especially to interest and powerfulness of affect. This effect contrasts—at least at first sight—with predictions by the Hedonic Fluency Model (Winkielman et al., 2003) which links processing ease with high appreciation as well as approaches that link a moderate level of arousal (Berlyne, 1971) or ambiguity (Jakesch and Leder, 2009) with high appreciation. The previously discussed idea of appeal by predictive progress might actually be compatible with the appeal of *SeIns*, however: we gain reward by a decrease in uncertainty especially if the material is initially challenging (Dörner and Vehrs, 1975; Van de Cruys and Wagemans, 2011). We might actually be able to find compatibilities to fluency accounts in a similar way by including the dynamics of increases in fluency in our conception (as do Topolinski and Reber, 2010). Accordingly, a crucial quality of many ambiguous artworks might be that they confront the perceiver with *SeIns* on the one hand, but also with the opportunity for insight on the other. Indeed, not only hidden images but also indeterminate Cubist artworks were appreciated more when they provided a high detectability of objects (Muth et al., 2013). This is remarkable as—in contrast to hidden images—Cubist artworks never provide determinate identification (Gombrich, 1960/2002). Do we thus actually have to solve the "riddle" of an artwork, the induced prediction

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errors, to appreciate it? A corresponding—although speculative—idea states in this regard that the struggle to find meaning within artworks might itself be pleasurable (Ramachandran and Hirstein, 1999):

> 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).

"Partial consistency" might apply for instance to associations gained even if the material is indeterminate. Biederman and Vessel (2006) refer to reward by such 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. Similarly to Fost's (1999) idea that theorizing itself might be rewarding due to the limbic reinforcement of neural binding processes, here also a gain of pleasure is induced by a gain of information. We suggest that these ideas can be integrated with the idea of reward through predictive progress by stating 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 in uncertainty by such an Aha insight leads to a temporary increase in positive affect—an effect which we previously labeled as "Aesthetic Aha" (Muth & Carbon, 2013). Instead of a progressive increase in certainty, such Aha moments might happen several times during processing and sometimes even without a final resolution of *SeIns*. This account is an extension to the Tentative Prediction Error Account Of Visual Art (Van de Cruys and

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Wagemans, 2011) as these kinds of insight might actually be sudden resolutions of uncertainties like the detection of a facial Gestalt within a hidden image. In addition though, this account includes cases in which uncertainty is not entirely resolved—like the ones exemplified by the artworks in Figs 3 and 4. In fact, the kind of *SeIns* which offers complete resolution might rather be "banal, conventional or academic, and … gimmicky or kitsch" (Hyman, 2010, p. 256) than a real openness to meaning (Krieger, 2010 with regard to bistable effects in Dali's "The big Masturbator"). Adorno spoke of the enigmatic character of art which "survives the interpretation" (translated by the author, 1970/1973, p. 189). Such insolvability does not exclude the possibility of gaining insight though: when looking at Cubist art, for instance, we might not be able to arrive at a clear interpretation on the level of depiction but we might have the insight that "This is a Picasso" (which seems to be the most typical entry level of artworks, see Belke et al., 2010) based on distinctive stylistic features, or we might gain insight into our own perceptual mechanisms and their relation to affordance and context by looking at Stefan Wewerka's (1969) chair-sculpture (see Fig. 9). This way, multiple insights are possible concerning various features. Figure 10 clarifies these dynamics: Fig. 10A depicts a static link between object-features and levels of appreciation, Fig. 10B depicts how appeal would change with a progressive decrease in instability according to a strongly simplified fluency account (in case one determinate solution is provided), and Fig. 10C exemplifies the described pattern of changes in *SeIns* and appreciation suggested by the approach of appeal by insight.

Empirical support for the idea of rewarded insight was reported by Muth and Carbon (2013) based on increases in liking after the detection of faces within black-and-white patterns and by Chetverikov and Filippova (2014) based on increases in liking after a correct

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categorization of Gestalts of positive as well as negative valence. The fact that having an insight does not equal the resolution of *SeIns* was revealed inter alia via a set of visual modern and postmodern artworks: although the subjectively judged solvability of their ambiguity did not have positive effects on liking, interest, or affect, the judged strength of gained insights predicted appreciation positively (Muth, Hesslinger, et al., 2015). Here, the selected artworks evoked several varieties of *SeIns*; these being hidden, indeterminate, or multistable images, sculptures, and objects. And recently Muth, Raab, 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 (see above; Fig. 6 and supplementary material). This specific combination of dynamic stimulus material with the Continuous Evaluation Procedure (CEP, see Muth, Raab, et al., 2015) enabled the proposal of a preliminary model of dynamics in the perception and appreciation of *SeIns* (see Fig. 11). 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 a rewarding effect which increases the appeal of the artwork in terms of liking. In other words: positive affect can be gained not only by arriving at an insight but also by anticipating it. This additionally means that if visually indeterminate 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.

(Fig. 11 about here)

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Consoli (2015) furthermore proposed two phases of aesthetic pleasure during the perception of unsolvable *SeIns*: 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; note though that many perceivers might not elaborate an artwork any deeper after having been able to identify its pictorial content, see Kesner, 2014). We might link this back to the Tentative Prediction Error Account Of Visual Art (Van de Cruys and Wagemans, 2011) and state that not (only) might the minimization of prediction errors increase appreciation but that its anticipation might already motivate hypothesis testing and the adaptation of predictive structures. According to Consoli (2015), further integrations during elaboration have the potential to induce a late aesthetic pleasure. This idea emphasizes that insights are not only rewarding *per se* but that they also influence the perceiver's predictions as well as the further course of elaboration. As mentioned above, interest especially benefits from such an anticipation of further insights. Also, an anticipatory quality of early aesthetic pleasure might explain the evidence for positive affect by incomplete or fragmentary interpretation of indeterminate artworks. 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. Referring back to models of appeal by moderate increases of arousal potential, we can assume that 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

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with regard to ambiguity (moderate level, e.g., Jakesch and 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 Fig. 11 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.

6.5 Summary

The presented accounts provide explanations for the appeal of *SeIns* in art by focusing on different aspects and levels of involved processes. At the same time there exist deep connections which become apparent if we include dynamics as well as multiple levels of perceptual and cognitive processes in our analysis. Although these links are yet to be specified in more detail, it can be broadly stated that processing fluency effects (e.g., Reber et al., 2004) might be linked to the resolution of prediction errors, and Berlyne's (1971) idea of reward by decrease in arousal potential might be linked to Van de Cruys and Wagemans' (2011) account of reward by predictive progress. Our proposal of the major role of insights in the appeal of *SeIns* in art likewise connects strongly to processing fluency and predictive progress while highlighting dynamics and anticipation. For these specific aspects, the framework of Predictive Coding doesn't yet provide a clear description of according mechanisms. A very recent idea, however, is that interest in particular might be strongly influenced in a certain context by meta-predictions on

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the reducibility of errors, or by expected reductions of prediction errors, respectively (Sander Van de Cruys, personal conversation). We are therefore confident that an even closer integration of the presented approaches will be drawn in the future.

7. Current Challenges

This article attempts to provide an overview on different variations of *SeIns* in art and possible explanations for their appeal. Besides the need for some empirical support for the given classification of specific phenomena, the sketched psycho-aesthetic approaches have to be checked for consistency with these varieties. On which levels can prediction errors occur? How do they differ for multistability versus visual indeterminacy in art? Are insights induced exclusively by hidden images? Do indeterminate artworks primarily affect interest rather than liking? And to what degree does *SeIns* motivate deep elaboration?

Although the described approaches offer a variety of testable predictions, future research projects should additionally address the point that experiences are not qualified only by the experienced object or scene: an integration of object-, person-, and context-related facets of the experience of *SeIns* in art would be highly beneficial to an understanding of the relevant effects, mechanisms, and processes. Predictive Coding might be a very suitable framework to do this as predictions are always a consequence of these three main dimensions of experience. As discussed above, the phenomenon of *SeIns* in art is a cultivated, historical feature and furthermore its perception and appreciation is strongly influenced by conventions and historical changes. Although we should for instance be able to investigate mechanisms linked to the appeal

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of prediction violation or insight under controlled conditions in the laboratory, 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. Relevant factors for the experience of *SeIns* are, for instance, personality factors like (in)tolerance of ambiguity (e.g., Reis, 1996) which might influence the appreciation of ambiguity in art (see Muth, Hesslinger, et al., 2015). There is also the feeling of (non-)safety which influenced the appreciation of innovativeness in a study by Carbon et al. (2013). Within the scope of Predictive Coding the perceiver's previous experiences are fundamental determinants: it is the previous experience which determines whether a prediction error is encountered in the first place and whether hypothesis testing leads to alternative interpretations. The state of the perceiver as well as his or her expectations are of course also greatly determined by context (e.g., semantic context, Wolz and Carbon, 2014 or physical/socio-cultural context, Brieber, Nadal, Leder, & Rosenberg, 2014) which might influence, for example, the selection of an arousal-avoiding or an arousal-seeking mode (see Reversal Theory, Apter, 1989). Armstrong and Detweiler-Bedell (2008) provided an elaborate account on how beauty and interest are linked to so called 'promotion goals'. We could refer to these as the search for challenging prediction errors which nevertheless promise reducibility or insight (see the discussion on 'affective forecasting' above and in Muth, Raab, et al., 2015). Armstrong and Detweiler-Bedell (2008) mention an additional goal fulfilled by a more mundane prettiness, the so called 'prevention goals' linked to security and familiarity and probably rather to those objects which score low on *SeIns* and offer high fluency of processing (extreme cases might be those of Kitsch). Accordingly, we can state that the appeal of *SeIns* might depend on the mode of the perceiver and this mode is made changeable by different contexts, personality, and expertise. Figure 12B

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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 change the strength of *SeIns* and appreciation in the case of the model of appeal by the pleasurable (anticipation of) insight.

(Fig. 12 about here)

Although there has been theoretical and empirical progress with regard to the investigation of involved processes and criteria regarding the appeal of artworks, it is important not to forget the vast limitations of many approaches with regard to specifying the characteristics of aesthetic experiences. We might, for instance, even doubt whether every encounter with an artwork necessarily leads to positive affect. It is worth noting that dependent variables of aesthetic appreciation are often poorly defined in an aesthetic research context: for instance, we should separate effects of beauty from those of the sublime (Burke, 1757) as well as affective qualities of aesthetic peak experiences (see Aesthetic Trinity Theory; Konečni, 2005). With regard to the varieties of *SeIns* as well as the summarized accounts of their appeal, one crucial next step should be to differentiate between varieties of pleasure as well: is fluency of processing rather relevant to prettiness and liking whereas a 'free beauty' in Kant's conception requires irreducibility of *SeIns* and is pleasurable via the rewarding promise of insight (see Armstrong and Detweiler-Bedell, 2008 for a thorough analysis of the difference between prettiness and beauty; and Muth, Raab, et al., 2015 for a model on increases in interest by a promise of insight)? It seems we are far from a precise account of which affective states and experiential qualities are evoked by *SeIns* in art. The given description of varieties of *SeIns* along with their

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specifics in visual art and in psycho-aesthetic accounts of their appeal hopefully provides a first step in this important direction of aesthetic research.

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References

Adorno, T. W. (1970/1973). *Ästhetische Theorie*. Suhrkamp, Frankfurt am Main.

Albrecht, S. and Carbon, C. C. (2014). The Fluency Amplification Model: Fluent stimuli show more intense but not evidently more positive evaluations. *Acta Psychologica* **148**, 195-203. doi: 10.1016/j.actpsy.2014.02.002

Apter, M. J. (1989). Reversal theory: A new approach to motivation, emotion and personality. *Anuario de psycologia* **42**, 17-29.

Barto, A., Mirolli, M., and Baldassarre, G. (2013). Novelty or Surprise? *Frontiers in Psychology* **4**. doi: 10.3389/fpsyg.2013.00907

Belke, B., Leder, H., and Carbon, C. C. (2015). When challenging art gets liked: Evidences for a dual preference formation process for fluent and non-fluent portraits. *PLoS ONE* **10**, e0131796. doi: 10.1371/journal.pone.0138962

Belke, B., Leder, H., Harsanyi, G., and Carbon, C. C. (2010). When a Picasso is a "Picasso": The entry point in the identification of visual art. *Acta Psychologica* **133**, 191-202.

Berlyne, D. E. (1971). *Aesthetics and psychobiology*, Appleton-Century-Crofts, New York.

Biederman, I., and Vessel, E. A. (2006). Perceptual Pleasure and the Brain. *American Scientist* **94**, 249-255.

Blijlevens, J., Carbon, C. C., Mugge, R., and Schoormans, J. P. (2012). Aesthetic appraisal of product designs: Independent effects of typicality and arousal. *British Journal of Psychology* **103**, 44-57. doi: 10.1111/j.2044-8295.2011.02038.x

Bornstein, R. F. (1989). Exposure and affect: Overview and meta-analysis of research, 1968-1987. *Psychological Bulletin* **106**, 265-289. doi: 10.1037/0033-2909.106.2.265

this paper is "in press" (Art & Perception)

Bourdieu, P. (1984). *Distinction - A social critique of the judgement of taste*, Harvard University Press, Cambridge, MA.

Bourriaud, N. (1998). *Relational Aesthetics*, Les presses du réel, Dijon.

Brieber, D., Nadal, M., Leder, H., and Rosenberg, R. (2014). Art in time and space: Context modulates the relation between art experience and viewing time. *PLoS ONE* **9**, e99019. doi: 10.1371/journal.pone.0099019

Burke, E. (1757). *A philosophical enquiry into the origin of our ideas of the sublime and beautiful*, Dodsley, London.

Burwick, F. (1990). The grotesque: Illusion vs. delusion, in *Aesthetic illusion. Theoretical and historical approaches*, F. Burwick and W. Pape (Eds.), pp. 122-132, Walter de Gruyter, Berlin, New York.

Carbon, C. C. (2010). The earth is flat when personally significant experiences with the sphericity of the earth are absent. *Cognition* **116**, 130-135.

Carbon, C. C. (2014). Understanding human perception by human-made illusions. *Frontiers in Human Neuroscience* **8**, 1-6. doi: 10.3389/fnhum.2014.00566

Carbon, C. C., Faerber, S. J., Gerger, G., Forster, M., and Leder, H. (2013). Innovation is appreciated when we feel safe: On the situational dependence of the appreciation of innovation. *International Journal of Design* **7**, 43-51.

Carbon, C. C. and Jakesch, M. (2013). A model for haptic aesthetic processing and its implications for design. *Proceedings of the IEEE* **101**, 2123-2133. doi: 10.1109/jproc.2012.2219831

this paper is "in press" (Art & Perception)

Carbon, C. C. and Leder, H. (2005). The Repeated Evaluation Technique (RET): A method to capture dynamic effects of innovativeness and attractiveness. *Applied Cognitive Psychology* **19**, 587-601. doi: 10.1002/acp.1098

Chetverikov, A. (2013). Warmth of familiarity and chill of error: Affective consequences of recognition decisions. *Cognition and Emotion* **28**, 385-415. doi: 10.1080/02699931.2013.833085

Chetverikov, A. and Filippova, M. (2014). How to tell a wife from a hat: Affective feedback in perceptual categorization. *Acta Psychologica* **151**, 206-213. doi: 10.1016/j.actpsy.2014.06.012

Clark, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioral and Brain Sciences* **36**, 181-204. doi: 10.1017/S0140525X12000477

Consoli, G. (2015). Creativity and aesthetic evaluation. Two proposals to improve the model of aesthetic dis/fluency. *Frontiers in Psychology* **5**. doi: 10.3389/fpsyg.2014.01520

Dallenbach, K. M. (1951). A puzzle-picture with a new principle of concealment. *The American Journal of Psychology* **64**, 431-433. doi: 10.2307/1419008

Di Paolo, E., Rohde, M., and De Jaegher, H. (2007). Horizons for the enactive mind: values, social interaction and play, in *Enaction: towards a new paradigm for cognitive science*, J. Stewart, O. Gapenne and E. D. Paolo (Eds.), pp. 33-88, MIT, Cambridge, MA, US.

Dörner, D. and Vehrs, W. (1975). Aesthetical appreciation and reduction of uncertainty. *Psychological Research-Psychologische Forschung* **37**, 321-334. doi: 10.1007/BF00309726

Eco, U. (1989). *The open work*, Harvard University Press, Cambridge, Massachusetts.

this paper is in press" (Art & Perception)

Faerber, S. J., Leder, H., Gerger, G., and Carbon, C. C. (2010). Priming semantic concepts affects the dynamics of aesthetic appreciation. *Acta Psychologica* **135**, 191-200. doi: 10.1016/j.actpsy.2010.06.006

Fiedler, K. (1887). *Der Ursprung der künstlerischen Thätigkeit*. Retrieved from http://www.deutschestextarchiv.de/fiedler_kuenstlerische_1887/9.

Fost, J. W. (1999). Neural rhythmicity, feature binding, and serotonin. A hypothesis. *The Neuroscientist*, **5**, 79-85. doi: 10.1177/107385849900500212

Friston, K. (2005). A theory of cortical responses. *Philosophical transactions of the Royal Society* **360**, 815-836. doi: 10.1098/rstb.2005.1622

Friston, K., Thornton, C., and Clark, A. (2012). Free-energy minimization and the dark-room problem. *Frontiers in Psychology* **3**, doi: 10.3389/fpsyg.2012.00130

Gamboni, D. (2002). *Potential images: Ambiguity and indeterminacy in modern art*, Reaktion Books, London.

Gaver, W. W., Beaver, J., and Benford, S. (2003). Ambiguity as a resource for design, *Proc. SIGCHI Conference on Human Factors in Computing Systems*, Ft. Lauderdale, Florida, USA.

Gibson, J. J. (1986). *The ecological approach to visual perception*, Lawrence Erlbaum, Hillsdale.

Gombrich, E. H. (1950/2002). *Die Geschichte der Kunst*, Phaidon, Berlin.

Gombrich, E. H. (1960/2002). *Art and Illusion: A Study in the Psychology of Pictorial Representation* (5 ed.), Phaidon Press, Oxford.

Gregory, R. L. (1970). *The Intelligent Eye*, Weidenfeld & Nicolson, London.

this paper is "in press" (Art & Perception)

Gregory, R. L. (1980). Perceptions as hypotheses. *Philosophical Transactions of the Royal Society* **290**, 181-197. doi: 10.1098/rstb.1980.0090

Hall, J. (2014). *The Self-Portrait: A Cultural History*, Thames & Hudson, London.

Hekkert, P. (2006). Design aesthetics: principles of pleasure in design. *Psychological Science* **48**, 157-172.

Hohwy, J., Roepstorff, A., and Friston, K. (2008). Predictive coding explains binocular rivalry: An epistemological review. *Cognition* **108**, 687–701. doi: 10.1016/j.cognition.2008.05.010

Hyman, J. (2010). Art and Neuroscience, in *Beyond Mimesis and Convention,* R. Frigg & M. Hunter (Eds.), pp. 245-261, Springer, Dordrecht, Heidelberg, London, New York.

Ishai, A., Fairhall, S. L., and Pepperell, R. (2007). Perception, memory and aesthetics of indeterminate art. *Brain Research Bulletin* **73**, 319-324. doi: 10.1016/j.brainresbull.2007.04.009

Jakesch, M. and Carbon, C. C. (2012). The mere exposure effect in the domain of haptics. *PLoS ONE* **7**, e31215. doi: 10.1371/journal.pone.0031215

Jakesch, M. and Leder, H. (2009). Finding meaning in art: Preferred levels of ambiguity in art appreciation. *The Quarterly Journal of Experimental Psychology* **62**, 2105-2112. doi: 10.1080/17470210903038974

Jakesch, M., Leder, H., and Forster, M. (2013). Image ambiguity and fluency. *PLoS ONE* **8**, e74084. doi: 10.1371/journal.pone.0074084

James, L. J. (1962). *Effects of repeated stimulation on cognitive aspects of behaviour. Some experiments on the phenomenon of semantic satiation.* McGill University, Montreal.

this paper is "in press" (Art & Perception)

Kaplan, A. and Kris, E. (1948). Esthetic Ambiguity. *Philosophy and Phenomenological Research* **8**, 415-435. doi: 10.2307/2103211

Kesner, L. (2014). The predictive mind and the experience of visual art work. *Frontiers in Psychology* **5**, 1417. doi: 10.3389/fpsyg.2014.01417

Konečni, V. I. (2005). The aesthetic trinity: Awe, being moved, thrills. *Bulletin of Psychology and the Arts* **5**, 27-44.

Krieger, V. (2010). "At war with the obvious" – Kulturen der Ambiguität. Historische, psychologische und ästhetische Dimensionen des Mehrdeutigen, in *Ambiguität und Kunst - Typen und Funktionen eines ästhetischen Paradigmas*, V. Krieger and R. Mader (Eds.), pp. 13-50, Böhlau, Wien, Köln, Weimar.

Kubovy, M. (1994). The perceptual organization of dot lattices. *Psychonomic Bulletin & Review* **1**, 182-190.

Leopold, D. A. and Logothetis, N. K. (1999). Multistable phenomena: Changing views in perception. *Trends in Cognitive Sciences* **3**, 254-264. doi: 10.1016/s1364-6613(99)01332-7

Ludden, G. D. S., Schifferstein, H. N. J., and Hekkert, P. (2012). Beyond surprise: A longitudinal study on the experience of visual-tactual incongruities in products. *International Journal of Design* **6**, 1-10.

Majetschak, S. (2003). Die Modernisierung des Blicks. Über ein sehtheoretisches Motiv am Anfang der modernen Kunst, in *Die Kunst der Wahrnehmung. Beiträge zu einer Philosophie der sinnlichen Erkenntnis*, M. Hauskeller (Ed.), pp. 298-349, Die graue Edition, Kusterdingen.

this paper is "in press" (Art & Perception)

Mamassian, P. (2008). Ambiguities and conventions in the perception of visual art. *Vision Research* **48**, 2143-2153. doi: 10.1016/j.visres.2008.06.010

Meinhardt, J. (1997). *Ende der Malerei und Malerei nach dem Ende der Malerei*, Hatje Cantz, Ostfildern.

Muth, C. and Carbon, C. C. (2012). There's more than one way to irritation! An attempt to categorize ambiguity in art. *Perception* **41(Suppl.)**, 233.

Muth, C. and Carbon, C. C. (2013). The Aesthetic Aha: On the pleasure of having insights into Gestalt. *Acta Psychologica* **144**, 25-30. doi: 10.1016/j.actpsy.2013.05.001

Muth, C., Hesslinger, V., and Carbon, C. C. (2015). The appeal of challenge in the perception of art: How ambiguity, solvability of ambiguity and the opportunity for insight affect appreciation. *Psychology of Aesthetics, Creativity, and the Arts* **9**, 206-216.

Muth, C., Pepperell, R., and Carbon, C. C. (2013). Give me Gestalt! Preference for cubist artworks revealing high detectability of objects. *Leonardo* **46**, 488-489. doi: 10.1162/LEON_a_00649

Muth, C., Raab, M., 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**. doi: 10.3389/fpsyg.2015.00365

Noë, A. (2000). Experience and experiment in art. *Journal of Consciousness Studies* **7**, 123-136.

Noë, A. (2012). *Varieties of Presence*, Harvard University Press, Cambridge.

O' Regan and Noë, A. (2001). A sensorimotor account of vision and visual consciousness. *Behavioral and brain sciences* **24**, 939-1031.

Pepperell, R. (2006). Seeing without objects: Visual indeterminacy and art. *Leonardo* **39**, 394-400.

this paper is "in press" (Art & Perception)

Pepperell, R. (2015). Artworks as dichotomous objects: implications for the scientific study of aesthetic experience. *Frontiers in Human Neuroscience* **9**. doi: 10.3389/fnhum.2015.00295

Ramachandran, V. S. and Hirstein, W. (1999). The science of art: A neurological theory of aesthetic experience. *Journal of Consciousness Studies* **6**, 15-51. doi: 10.1.1.108.2599

Reber, R., Schwarz, N., and Winkielman, P. (2004). Processing fluency and aesthetic pleasure: Is beauty in the perceiver's processing experience? *Personality and Social Psychology Review* **8**, 364-382. doi: 10.1207/s15327957pspr0804_3

Reis, J. (1996). *Inventar zur Messung der Ambiguitätstoleranz*, Asanger, Heidelberg.

Shklovsky, V. (1917/2002). From 'art as technique', in *Art in theory 1900-2000: An Anthology of changing ideas*, C. Harrison and P. Wood (Eds.), pp. 277-281, Wiley-Blackwell, Cornwall.

Silvia, P. J. (2006). *Exploring the psychology of interest*, Oxford University Press, New York.

Topolinski, S., and Reber, R. (2010). Gaining insight into the “Aha” Experience. *Current Directions in Psychological Science* **19**, 402-405. doi: 10.1177/0963721410388803

Van de Cruys, S. and Wagemans, J. (2011). Putting reward in art: A tentative prediction error account of visual art. *i-Perception* **2**, 1035-1062. doi: 10.1068/i0466aap

Varela, F. J., Rosch, E., and Thompson, E. (1991). *The embodied mind: Cognitive science and human experience*, MIT Press, Cambridge, MA, US.

von Helmholtz, H. (1866). *Handbuch der physiologischen Optik: mit 213 in den Text eingedruckten Holzschnitten und 11 Tafeln*, Voss, Leipzig.

von Uexküll, J. (1909). *Umwelt und Innenwelt der Tiere*, J. Springer, Berlin.

Vygotsky, L. (1976). *Psychologie der Kunst*, VEB Verlag der Kunst, Dresden.

this paper is "in press" (Art & Perception)

Winkielman, P., Schwarz, N., Fazendeiro, T., and Reber, R. (2003). The hedonic marking of processing fluency: Implications for evaluative judgment, in *The Psychology of Evaluation: Affective Processes in Cognition and Emotion*, J. Musch and K. C. Klauer (Eds.), pp. 189-217, Lawrence Erlbaum Associates, Hillsdale.

Wittmann, B. C., Bunzeck, N., Dolan, R. J., and Düzel, E. (2007). Anticipation of novelty recruits reward system and hippocampus while promoting recollection. *NeuroImage* **38**, 194-202. doi: 10.1016/j.neuroimage.2007.06.038

Wollheim, R. (1982). *Objekte der Kunst*, Suhrkamp, Frankfurt.

Wolz, S. and Carbon, C. C. (2014). What's wrong with an art fake? Cognitive and emotional variables influenced by authenticity status of artworks. *Leonardo* **47**, 467-473.

Zajonc, R. B. (1968). Attitudinal effects of mere-exposure. *Journal of Personality and Social Psychology* **9**, 1-27. doi: 10.1037/h0025848

Zeki, S. (2004). The neurology of ambiguity. *Consciousness and Cognition* **13**, 173-196. doi: 10.1016/j.concog.2003.10.003

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Supplementary material

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

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Tables

	phenomenon	specific processes	open questions	dimensions
multistability	switches between semantic stabilities e.g., faces vs. vase	repeated formation of mutually exclusive matches and errors to predictions	possibility of simultaneous mutually exclusive stabilities	exclusivity: high flexibility: ≥2 stabilities levels: identification
dichotomy	coexistence of incongruent semantic stabilities e.g., paper and print vs. man's back	matches to predictions on various levels	possibility of simultaneous mutually exclusive stabilities simultaneity in awareness vs. in neural activations	exclusivity: unclear flexibility: ≥ 2 stabilities levels: ≥ 2 (e.g., content & material)
visual indeterminacy	lack but promise of semantic stability e.g., cues to hidden object in Cubist art	unsolvable prediction error induces enduring attempt to form matches to various predictions	mechanism explaining the 'promise' of a match (e.g., plurality of matches vs. fragmented matches)	exclusivity: not applicable flexibility: none or infinite levels: identification & expectation
experience of hidden images	sudden semantic stability; accidental or expected; surprising 'Aha!' e.g., face in random line composition	evocation of prediction error (Gestalt "pops out") additional if expected: sudden resolution of expectation violation	differentiation between accidental hidden images and expected hidden images	exclusivity: high once resolved flexibility: low once resolved levels: identification & expectation

Table 1. Summary of four varieties of *SeIns* with examples (for image references and bigger versions see Figures 1, 2, 3, and 5).

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Figures

Figure 1. A so-called Rubin-Vase displaying a vase or the facial profiles of two aesthetic researchers, depending on the respective interpretation.

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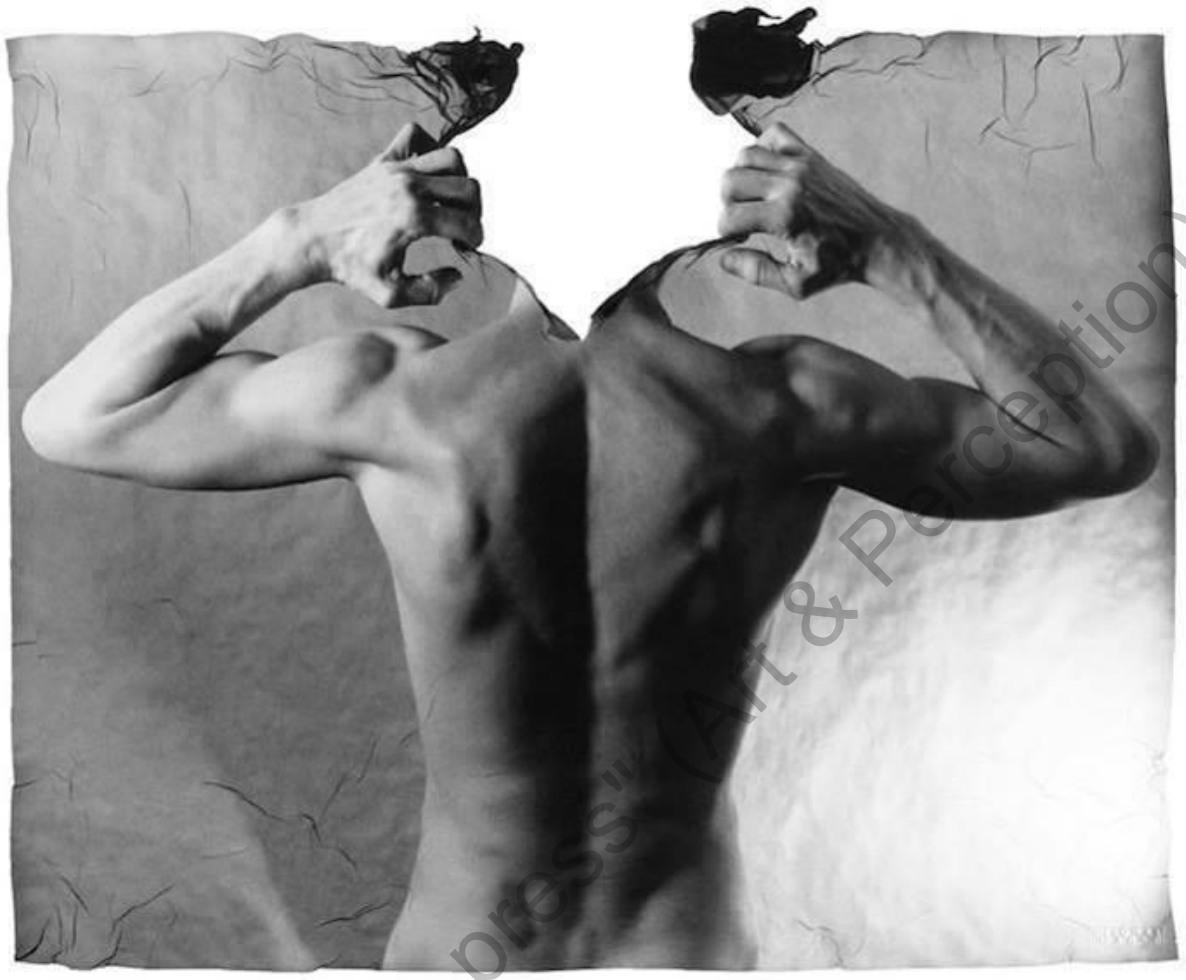

Figure 2. Macků, M. (1989). *Gellage No. 6* [photograph]. Retrieved from http://www.michal-macku.eu/image/122.

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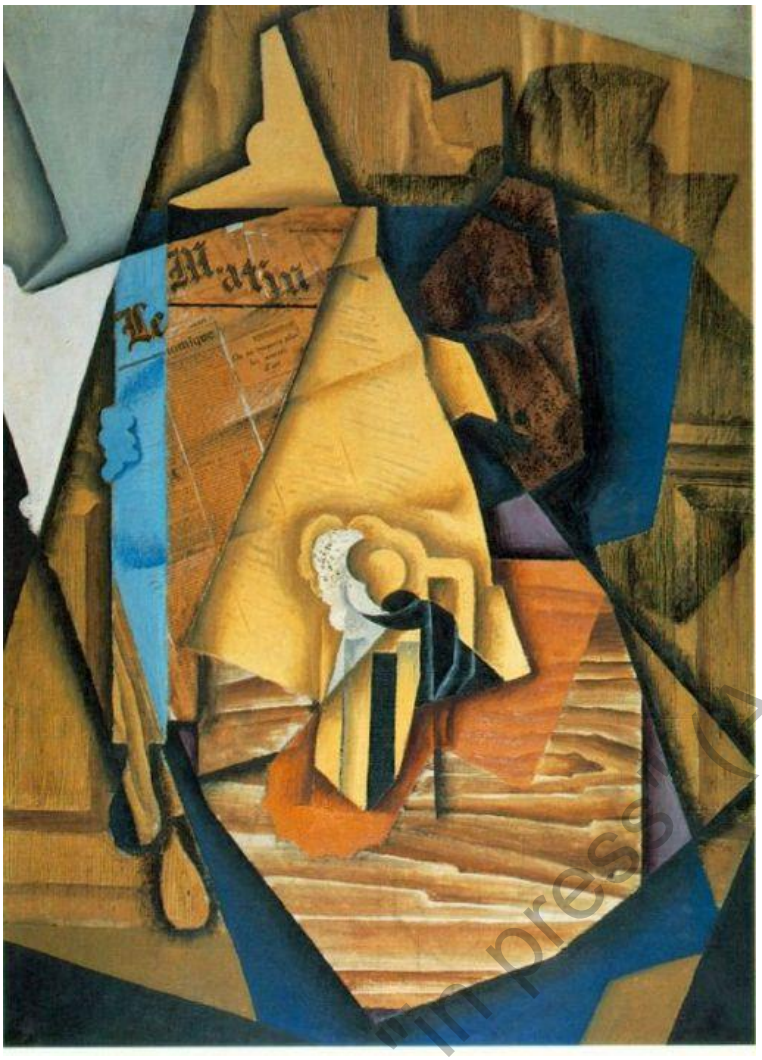

Figure 3. Cubist artwork by Juan Gris "Mann im Café [man in café]" from the year 1914.

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Figure 4. Indeterminate or potential image: Robert Pepperell's (2005) "Paradox 1" provides cues for potential detection but never reveals a determinate Gestalt. Image courtesy of Robert Pepperell.

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Figure 5. Hidden image: the indeterminate pattern becomes determinate as soon as we detect a face in it (highlighted in the right panel).

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Figure 6. Exemplary frames of the stop-motion movie “Konstrukte” by Claudia Muth from the year 2009.

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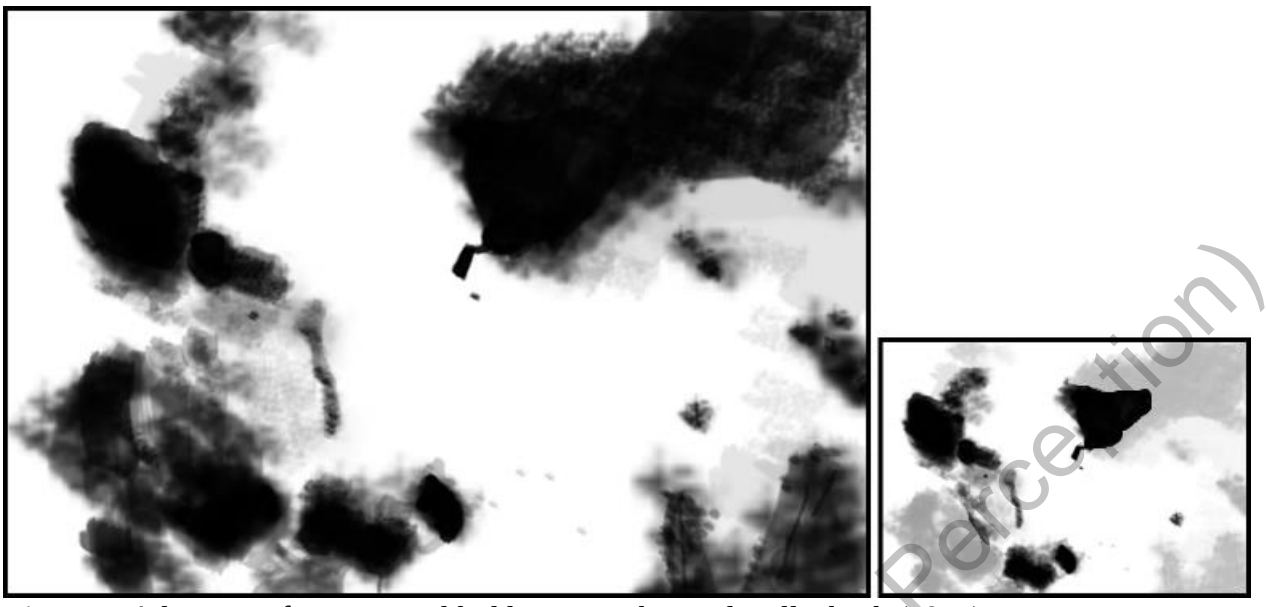

Figure 7. Adaptation from original hidden image by Karl Dallenbach (1951).

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Figure 8. Famous Ready-Made "Fountain" by Marcel Duchamp from the year 1917; photographed by Bart Everson in 2014, license via Creative-Commons.

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Figure 9. Stefan Wewerka (1969). *Untitled; chair-sculpture, corner chair.* Munich: Pinakothek der Moderne. Photograph by Claudia Muth.

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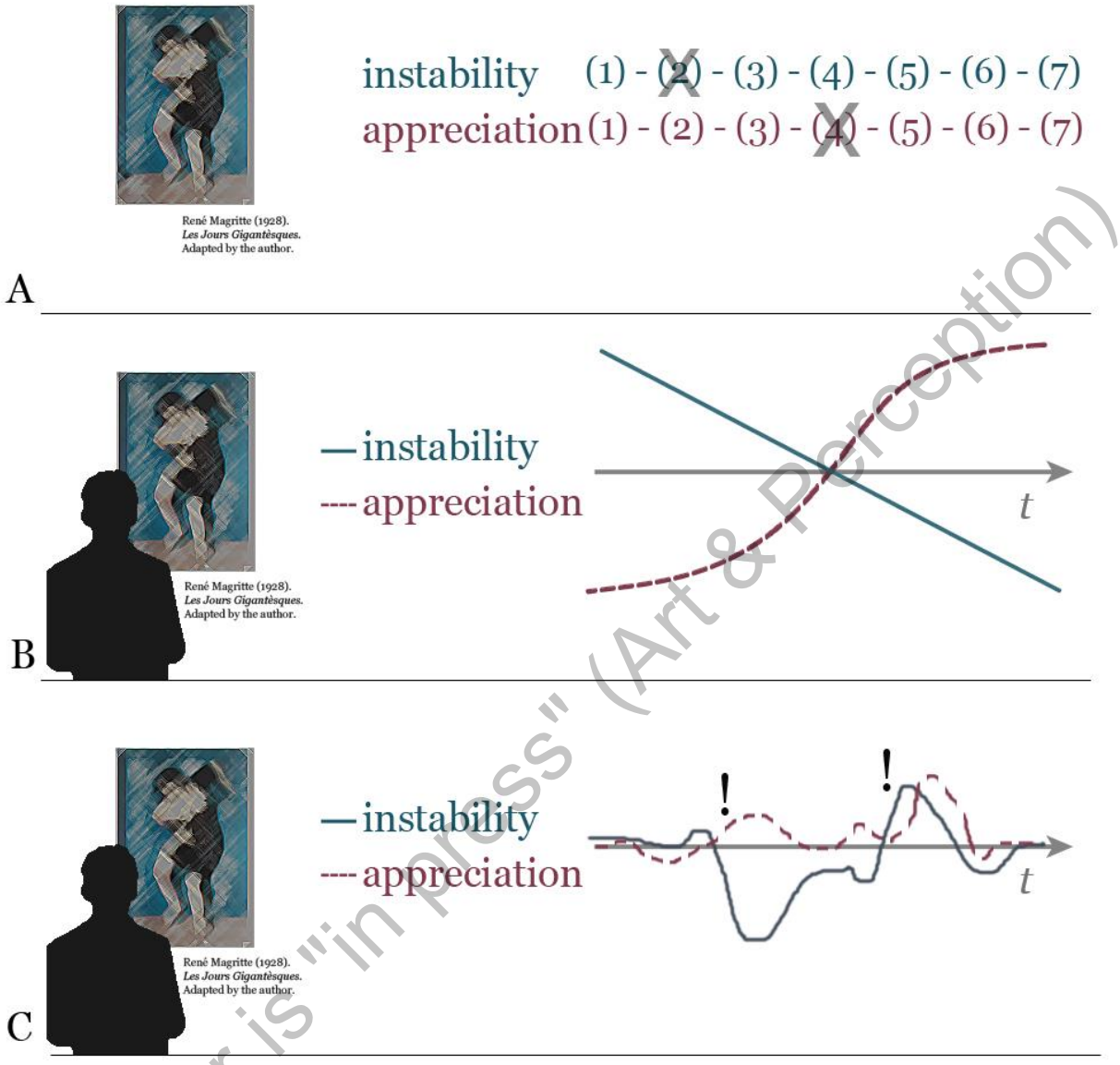

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Figure 10. Models of one static (A) and two dynamic accounts of semantic "instability" (*SeIns*) and "appreciation" (B+C). In Model B the pattern of changes represents a mechanism by which appreciation is negatively linked to *SeIns*. Model C considers the positive effect of one or several Aesthetic Ahas on appreciation; caused insights are indicated by exclamation marks ("!").

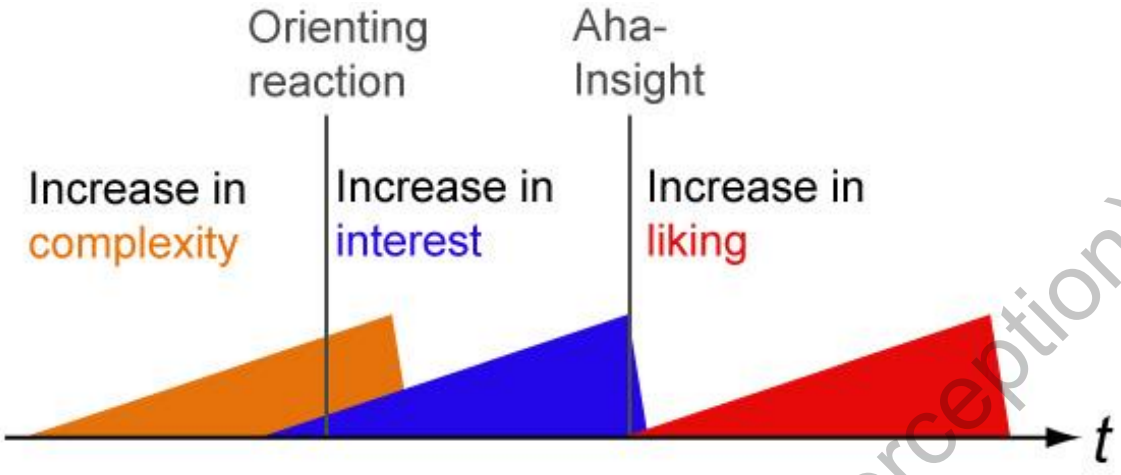

Figure 11. A preliminary model of dynamics in semantic instability and appreciation; adapted from Muth et al. (2015).

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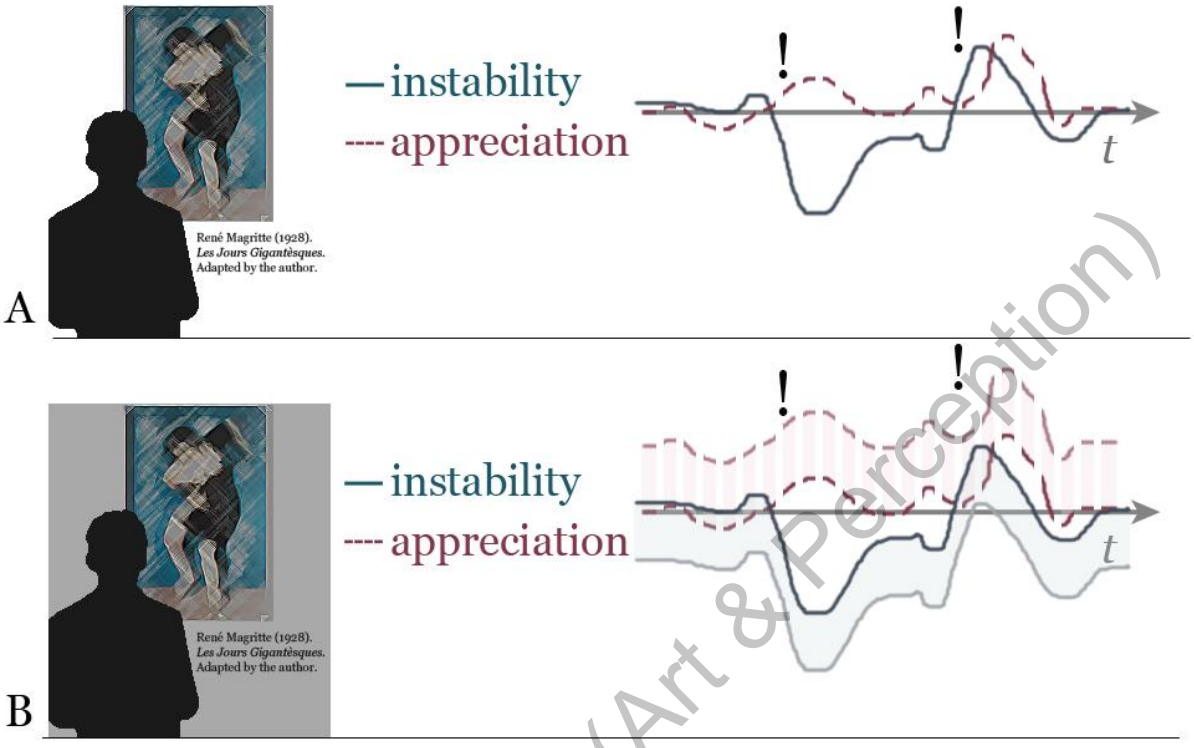

Figure 12. Model A considers the positive effect of one or several Aesthetic Ahas (!) on appreciation. Model B additionally integrates the effects of context and person alluded to by variations of the strength of the dimensions (light colored areas).

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