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The Evolutionary Principles of the Attractiveness of Symmetry and Their Possible Sustainability in the Context of Research Ambiguities

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Abstract: *Symmetry belongs to one of the basic principles of the beauty of human and non-human objects since antiquity. Even though its significance has been verified by numerous theories and research studies, there is a number of papers suggesting that this principle may be false. The study identifies five major evolutionary principles, in the context of new approaches and research ambiguities based mainly on neuroscience and evolutionary psychology, that support the thesis that highlights the significance of symmetry in the perception and assessment of attractiveness: 1. symmetry as an honest signal of various health characteristics; 2. symmetry as proof of developmental stability; 3. effectiveness; 4. comprehensibility; 5. predictability. In the context of the mechanisms described above it also seeks possible explanations for the existence of contradictory research results related to the attractiveness of symmetry. The outcome of the study is the postulation of three hypotheses: 1. the naturalness hypothesis (symmetry is only attractive to the same degree that it naturally occurs in the subject); 2. the accent hypothesis (minor asymmetries do not disprove the principles of symmetry, they make them more visible); 3. the ecology hypothesis (the attractiveness of symmetry is conditioned by the situation and depends on the type of subject assessed) that allow us to integrate both past and contemporary (and putatively contradictory) research findings. The paper also provides proposals for the verification of the postulated hypotheses.*

Keywords: *attractiveness; symmetry; beauty; evolution; neuroscience; cognition.*

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1. Symmetry as a Major Element of Attractiveness

Symmetry has been known as a feature of beautiful objects since ancient times. Even Aristotle suggested that "the chief forms of beauty are order and symmetry" (Aristotle, 1998, p. 400), Cicero characterised a beautiful body as "a certain symmetrical shape of the limbs" (Cicero, 1971, p. 359), and Plotinus claimed that "a beautiful thing is essentially symmetrical" (Plotinus, 2014, p. 36). In general, artists have used symmetry to produce attractive works of art, including ornamental symmetry (e.g., the ornaments in the medieval palaces of Alhambra in Granada, Spain) and figural or facial symmetry in portraits (McManus, 2005). Symmetry is considered a "super-principle" of science and art even today (Voloshinov, 1996). Mathematicians appreciate symmetry expressed in the form of geometric (fractal geometry – Sandu, 2011) or arithmetic systems based on a rule or criterion; in the field of logics, symmetry represents the identical nature of properties (such as equivalence or mutual implication). In chemistry, symmetry is seen in the properties of the links and interactions between molecules and is the key to understanding dipole moments and spectroscopic transitions (Peng et al., 2019), or even the structure of crystals and, for instance, their optical properties. Symmetry is also highly praised in physics – the laws of physics may be understood as expressions of symmetry (e.g., the symmetry of forces or fields, the symmetry of time and space, various continuous symmetries, discrete symmetries, or even super-symmetries). In 2008, Yoichiro Nambu received the Nobel Prize for Physics for the discovery of the mechanism of spontaneous broken symmetry in subatomic physics (Schlagberger et al., 2016). In biology, bilateral symmetry correlates with health and high genetic quality (Foo et al., 2017). Symmetry is therefore considered to be aesthetically pleasing in several scholarly domains (Zaidel & Hessamian, 2010) and at the same time, it is one of the most significant factors in the attractiveness of the human face (Little et al., 2011), the human body (Tovée et al., 2000), or pieces of art (Jacobsen & Höfel, 2003; McManus, 2005).

2. Symmetry in the Context of Neuroscience

Over the last few decades, it has been proven, using different approaches, that a preference for specific features of objects (e.g., their symmetry, averageness...) is based on the internal arrangement of the brain (Chen et al., 2007; Shen et al., 2016; Yarosh, 2019). It is thus evident that many aspects of the process of perception are different in the case of objects that possess these specific features (Pramod & Arun, 2018). In terms of the presence of symmetry, this specifically includes areas of the visual cortex (mainly V3 extending across the extrastriate visual cortex) (Bertamini & Mankin, 2014; Mankin et al., 2015; Kohler et al., 2016). Moreover, the perception of symmetry tends to be associated with pleasant experiences and activates other regions of the brain (e.g., the amygdala, insula and limbic system (Pitcher et al., 2011) responsible for the production of emotional reactions and areas linked to the reward and punishment systems. Consequently, the perception of an object is not only limited to the identification of the characteristics of the perceived object, but it also includes the experience of beauty associated with positive emotions. This may lead us to wonder why the human psyche prefers these objects and why exposure to this perceptual experience was positively reinforced and fixed through a positive emotional experience. One of the possible frameworks that may provide an explanation is evolutionary psychology. From this perspective, the perception of symmetrical objects that involves the reward system and the regions of the brain responsible for emotions results from evolutionary processes that, in the process of phylogeny, rewarded those individuals who were able to identify and prefer symmetry. The preference for symmetry in the property of objects thus must have involved certain advantages in the context of evolutionary pressures (natural selection and the selection of a mate). These may be identified in two main areas – the reproductive (in the case of human objects) and cognitive (in the case of non-human objects).

2.1. Developmental Stability

The most often mentioned fact relating to a preference for symmetry is its close link to developmental stability (Simmons et al., 2004). Diversions from symmetry result from the inability of the organism to cope with various adverse environmental (e.g., climate, pollution, malnutrition, parasites) or genetic (e.g., inbreeding, mutations) factors (Møller, 1997) during ontogeny. In this context, Juarez-Carreño et al. (2018) suggest three possible negative types of factors – environmental factors, genetic variants, and stochastic noise. The organism is subjected to negative influences throughout its whole life – it is proven that symmetry decreases as the age of the organism increases (Kobylianski & Livshits, 1989), which results in a decrease in the evaluation of the attractiveness of the organism. The inability of the organism to resist the negative effects of its environment is not only exhibited after birth – the organism may even exhibit these adverse effects during intra-uterine development. And the earlier the damage occurs during the development of the foetus, the greater the consequences (Gilbert-Barness, 2010). It has been suggested that only high-quality individuals can maintain symmetrical development (Little et al., 2011).

In this regard, the preference for these features has two positive effects – direct and indirect effects. On one hand, by choosing a more symmetrical partner, the individual is less likely to come into contact with an infected person, and so the individual protects their own health (direct effect), and on the other hand – if the individual's sexual partner is resilient to negative effects, it is highly likely that they will pass the fitness of their own organism to their offspring, who will inherit resistance to pathogens (indirect effect) (Waitt & Little, 2006). The distortion of symmetry is therefore a signal of the instability of the organism, and since these qualities may be hereditary, the preference for symmetry is favoured by natural selection (Penton-Voak et al., 2000).

2.2. Honest Signal

As a consequence of the greater developmental stability of symmetrical organisms, symmetry has become a crucial honest signal of various health characteristics. As early as in 1990s, several studies confirmed the parasite theory – a hypothesis related to the greater resilience of symmetrical organisms to microparasites (bacteria, viruses) and macroparasites (nematodes and protozoa) (Grammer & Thornhill, 1994; Agnew et al., 1997). Shackelford and Larsen (1997) conducted wider research and used daily diary reports and psychophysiological measures in order to explore the connection between actual health and facial symmetry. Their results clearly demonstrated a high degree of correlation between physical and mental health and the parameters of symmetry – women with asymmetrical faces exhibited lower resilience to physical stress, while asymmetrical men had a higher prevalence of depression and emotional instability (Shackelford & Larsen, 1997). The research continued with evidence of additional factors – asymmetry in men is significantly linked to lifelong health handicaps (Møller, 1990) or lower fertility (Manning et al., 1998). Furthermore, the symmetry of organisms correlates with growth rate and survivability (Livshits & Kobyliansky, 1984; Little et al., 2008), potential fertility (Jasienska et al., 2006) as well as real and age-independent fecundity (Møller et al., 1995) in women. The importance of symmetry in ensuring health has also been proven by other studies. In fact, it turns out that individuals who had a higher number of infections during childhood statistically significantly prefer symmetry, especially in the faces of the opposite sex (de Barra et al., 2013). Hence, it is in the interest of the organism to prefer partners with a higher level of symmetry in reproduction, and this preference is secured by the production of positive emotions associated with the perception of symmetry (the experience of attractiveness by the subject). The activation of specific regions of the brain associated with emotions (Demuth, 2019) retains this behaviour in the inventory of strategies of mating selection. The preference for symmetry may be, in addition to the positives for reproductive behaviour, explained by cognitive biases that also allow us to interpret the attractiveness of symmetry outside of mating selection and can also be applied to non-human objects.

In addition to the possibility that symmetry indicates the quality of the signaller, it is possible that sensitivity to symmetry may have arisen through evolution as a by-product of the general properties of biological recognition systems (Enquist & Johnstone, 1997). Humans, as well as many other moving organisms (Troje & Bülthoff, 1998), receive most of their information about the external environment through paired sense organs. As a result of these paired sensors working together, the maximal ability for these receptors (eye, ear...) to distinguish something happens at the overlap of the sensory field of the paired sensors. In general, impulses that stimulate our sensory apparatus to the greatest degree are those that are well perceived in all possible positions and orientations (Enquist & Arak, 1994), which is especially true for symmetrical objects. The fact that the cognitive apparatus prefers symmetrical patterns (Bertamini et al., 2019) leads to an aesthetic preference for symmetrical objects (Jacobsen & Höfel, 2003; McManus, 2005), which may be observed from an early age (Huang et al., 2020). The reasons for the preference of symmetrical objects (also aesthetically) can be seen in the effectiveness of the cognitive processing of this kind of impulse, its comprehensibility and predictability.

2.3. Effectiveness

In the context of evolutionary psychology, effectiveness is a principle that explains why certain behavioural models are retained in the inventory of reactions that an organism has to impulses from its environment. At the same time, effectiveness is a variable that depends on the amount of energy expended for a given type of reaction and the resultant benefits. This means that only the most energy-efficient solutions are used in nature – for instance, bees build a honeycomb in perfectly symmetrical shapes – connected hexagons, since this is the only shape that ensures an absence of gaps and at the same time, has the smallest circumference (energy spent) with the largest internal volume (benefit) (Hales et al., 2001; Lightman, 2013).

The perception of complex and complicated objects requires a lot of time and attention, which is a great disadvantage in the context of evolution. In a competitive and dangerous environment, when the organism faces the dangers around it, a need to concentrate and spend time observing an object is an apparent disadvantage. From this perspective, symmetrical objects are highly preferable for perception and cognition. With single-axis symmetry, only half the time is required to capture the whole object, with dual-axis symmetry, only a quarter of the time is needed and so on. Thus, the perception of symmetrical objects is highly efficient, which is why it is preferred by the cognitive apparatus (Little, 2014). A need to make perception more efficient (faster) produced such a strong evolutionary pressure that a tendency to look for and find symmetry in places where it is not 100 % present (i.e. in objects where it is slightly distorted) was confirmed by experimental studies as distortion towards symmetry (Freyd & Tversky, 1984). It is apparent that profiting from generalisations (omitting inaccuracies in symmetry) that will accelerate and facilitate perception is more advantageous from an evolutionary perspective, even if we accept the consequences of these inaccuracies and simplifications in the results of the cognitive processes. It may therefore be assumed that in the process of evolution, these circumstances have led to a preference for symmetrical objects, which may even be supported by further findings. The presence of symmetry in perceived objects is identified extremely quickly (in several milliseconds) (Niimi et al., 2005), which makes the processes of perception easier, faster, and thus more efficient (Martinovic et al., 2018). Furthermore, a preference for symmetrical objects is fostered by the presence of positive emotional reactions in the experience of attractiveness.

2.4. Comprehensibility

Perception is the process we use to obtain information. Data obtained through our senses and processed by our cognitive apparatus is usable if the percipient understands it and is able to extract information from it. Incomprehensible data is a burden – the individual spends too much time processing it and even then, its usability is questionable. Symmetrical objects are typically able to clearly communicate the presence of the basic principle on which they are based (the identical distance of all points on the opposite sides of a plane, line, or point). Symmetry as the presence of the regularity of the perceived object is clearly identifiable by our cognitive apparatus because it is clear, visible, and simple. Complex rules related to the form of objects, or objects with irregular principles of construction (logic, congruency etc.) require longer processing times in order for us to understand them and our cognitive apparatus needs to expend more energy to identify them (especially in the amount of attention paid to them) (Mudrik et al., 2011). Hence, the quick and easy detection of the rules that the object is based upon not only allows rapid (and thus efficient) perception (Demuth et al., 2019), but also provides the percipient with other important information – it communicates the principles of construction and the arrangement of the object, which ultimately makes it comprehensible.

Comprehensibility is crucial in terms of perception – understanding what we see is a prerequisite for successful perception. The importance and preference for comprehensible objects, in terms of perception, has been confirmed by several studies – meaningful stimuli dominate over the abstract (Yu & Blake, 1992); well-ordered structures are greatly preferred in visual processing (Mühlenbeck et al., 2016). On the other hand, the identification of incomprehensible or incongruent objects requires longer processing times and is less accurate (Davenport & Potter, 2004; Underwood, 2005). Symmetry as a principle greatly facilitates the comprehensibility of objects – the identification of a symmetrical object, by the percipient, from different points of view is far simpler than the identification of other patterns (Enquist & Arak, 1994); symmetry also greatly facilitates the segmentation of the perceived object (Machilsen et al., 2009). The evolutionary preference for symmetry, i.e. the ease with which we process objects, is reinforced by the positive emotions that accompany this perception – the more easily (the more quickly, more efficiently) an object is processed, the more intense the aesthetic response (Reber et al., 2004). For this reason, symmetry is considered to be a stronger rule in perception when compared to other principles (Machilsen et al., 2009).

2.5. Predictability

The ability to anticipate the occurrence of phenomena or the behaviour of objects in the area surrounding an individual represents a great evolutionary advantage – it allows the subject to prepare and adequately react, in advance, to events in the surrounding area. The ability to predict is fundamental for all living systems (Budaev et al., 2019). In order for an individual to predict the behaviour of the surrounding objects or people, they have to understand these objects and their functional mechanisms. Therefore, to be able to make a prediction, it is first necessary to thoroughly observe the phenomena or object and formulate an explanation based on an understanding of their nature. This natural algorithm of exploration has also been adopted by the behavioural sciences (especially psychology) that have postulated the sequence of steps for scientific investigation, starting from a fundamental description of the observed phenomena (e.g. behaviour), through an effort to understand their mechanism (explanation), to the anticipation of their likely occurrence (prediction) (Greenwood, 1989). Prediction (with the subsequent modification of behaviour based on the results of the estimation) is the peak of investigation.

Evolutionary psychology describes, in detail, the behavioural strategies that have evolved in an effort to maximize the fitness of an organism but has paid less attention to how these strategies were formed. It is prediction that is the key element in this process. It allows an organism to predict the consequences of potential events and choose the best alternative (Budaev et al., 2019). In this regard, symmetrical objects are highly predictable from both current and long-term perspectives. Current predictability is based on the fact that if symmetry is present, we may be able to predict what the rest of the object will look like, even with a relatively small amount of information. The theory that there is a lower energy demand in the perception of predictable objects was confirmed by Wang et al. (2010), who discovered that the duration of fixation, within visual perception, decreased with higher predictability. Moreover, in the case of symmetrical objects, shapes and patterns present in one half also occur smoothly and without distortion on the other half. Potential missing (or so far not perceived) details are easily substituted through good predictability – it is not a coincidence that the Gestalt law of symmetry is one of the key rules of perception (Katkov et al., 2015). Therefore, symmetry allows a high degree of fluency of perception (Reber, 2002) and many studies have repeatedly confirmed that fluent perceptual processing results in positive hedonic feelings (Makin et al., 2012; Bertamini & Makin, 2014). The long-term predictability of symmetrical objects is based on the fact that the presence of symmetry is a signal of developmental stability over time. Thus, it is reasonable to predict that symmetrical objects also retain their stability in the future, and we are more likely to correctly predict their appearance and behaviour than we would in the case of asymmetrical objects. Our preference for and the production of positive aesthetic reactions to predictable symmetrical objects is not only true for inanimate objects – it appears to be clear that the predictability of the behaviour of living organisms, especially in the context of evolutionary significant interactions (such as mating), is considered to be a major factor in perceived attractiveness in animals (Scherer et al., 2018) and also humans (Sheldon, 2009).

3. Elements of Asymmetry and Attractiveness

Several contradictory findings been made throughout the history of the study of the attractiveness of symmetry. In addition to the above-mentioned studies that demonstrated the importance of symmetry in the perception of attractiveness, there are also those that fail to confirm symmetry as a factor that increases the degree of attractiveness (Zaidel & Hessamian, 2010; Jones & Jaeger, 2019; Kočnar et al., 2019; Kordsmeyer et al. 2020). It has been suggested that one of the reasons that some studies have not confirmed the importance of symmetry in attractiveness was due to the use of non-human objects. This claim has been based on the idea that the evolutionary principles of developmental stability and honest signals are mostly linked to reproductive behaviour and will therefore be most prominent when assessing the attractiveness of a potential partner (especially their face). This argument has been supported by studies that focused on the reproductive importance of symmetry, which have proved that a preference for symmetry is more significant in the perception of humans (as opposed to non-living or non-human) and at reproductive age (as opposed to pre-pubescent or post-menopausal) (Herbert et al., 2002). On the other hand, this argument still fails to explain these contradictions. In the case of non-human objects, it is possible to apply the principles of cognitive efficiency, comprehensibility, and predictability, which also have a strong evolutionary importance. Moreover, the importance of symmetry for attractiveness has even been rejected in scientific studies that assessed human faces (Jones & Jaeger, 2019). Different study methodologies, which have changed from a simple observance of the preference for symmetry in natural faces (Rhodes et al., 1998; Scheib et al., 1999; Rhodes et al., 2001) and real living objects (Cárdenas & Harris, 2006), through the study of preferences using digital facial composites (Little et al., 2011) or images (Machilsen et al., 2009), to the monitoring of brain activity during the perception and evaluation of the attractiveness and its dependence on symmetry (Chen et al., 2007), have also failed in accounting for ambiguities in the results of symmetry research. Even though none of these options has led to unambiguous conclusions, the individual results and findings of the research conducted allow us to postulate assumptions that may potentially unify the results obtained to date.

3.1. The Naturalness Hypothesis

It is apparent that symmetry is an element that makes a significant contribution to the perceived attractiveness of an object (Scheib et al., 1999; Little et al., 2007; Komori et el., 2009; Hatch et al., 2017). However, why have some studies (Zaidel & Deblieck, 2007; Choi, 2015) failed to confirm this tendency in cases where there is 100% (mirror) facial symmetry? These contradictory results may be explained by the "naturalness hypothesis". This hypothesis postulates that although symmetry is a significant evolutionary signal, the extent to which it is present must be natural. In the real world, no living organisms are 100 % symmetrical, all of them have a certain degree of fluctuating asymmetry but may still be considered to be highly attractive (Zaidel & Cohen, 2005; Kaipainen et al., 2016). So, a percipient views perfect symmetry to be unnatural (Bertamini et al., 2019). This hypothesis is confirmed by studies of human facial attractiveness and symmetry that have highlighted the importance of the natural appearance of a face (Swaddle & Cuthill, 1995; Muñoz-Reyes et al., 2015; Choi, 2015; Zheng et al., 2021) or scenery (Bertamini et al., 2019). This hypothesis needs verification, but it is also necessary to define a "critical threshold" of the degree of symmetry, a threshold, up to which increased symmetry increases facial attractiveness, and beyond which a face looks unnatural and is considered less attractive. We assume that this critical threshold will be slightly different for depictions of real faces, depictions of digital facial composites, non-human living objects, and non-living and artificial objects; the lowest acceptable degree of symmetry is to be expected in real human faces and the highest degree in artificial, non-living objects. These assumptions may be verified indirectly through a meta-analysis of study results focusing on the degree of symmetry present – if it is confirmed that a high level of symmetry failed to increase the assessed level of attractiveness, especially in natural faces (as opposed to facial composites) but was acceptable in non-living objects, it may be a viable assumption and could be the subject of a further systematic review.

3.2. The Accent Hypothesis

Studies of the attractiveness of symmetry have proposed several ideas that highlight the importance of a slight degree of asymmetry within an otherwise symmetrical object. This may be observed in early Renaissance art, where artists intentionally distorted the depicted symmetry. A perfect example of this approach is the piece by Giotto di Bondone, the Baroncelli Polyptych, from 1334 (Sebregondi, 2006), where the author painted a central scene with four side panels, two on the left and two on the right. The right-hand panels include fifty-one saints and ten angels who are turned to observe the central scene. The left-hand panels are a mirror image of the right-hand panels – they also include fifty-one saints and ten angels turned to observe the central scene (McManus, 2005), except for a single saint who is turned away from the centre and thus disturbs this very obvious and dominant symmetry. This principle may also be observed in the beautification of human faces – if a face is pretty and symmetrical, a tiny degree of asymmetry will increase its attractiveness. A classic example is the small mole (which fittingly is also called "a beauty spot") found on the faces of Cindy Crawford and Marylyn Monroe, who became symbols of beauty, and their moles were copied (Demuthova et al., 2019). However, these examples do not diminish the importance of symmetry for perceived attractiveness, quite the opposite; through their presence, they highlight it, make it more easily identifiable and emphasize it. According to Swaddle & Cuthill (1995), some small degree of asymmetry is not only acceptable but contributes to attractiveness. A tiny asymmetry that is present in an otherwise symmetrical object may, from an evolutionary perspective, be considered to be a variant of Zahavi's handicap hypothesis (Zahavi, 1975). Just as only high-quality individuals can maintain high levels of testosterone, which lowers overall immunity, only highly symmetrical objects can afford a small irregularity. Although these ideas suggest that the formulated hypothesis may be plausible, the importance and effect of a tiny asymmetry on the perception of symmetry in the context of attractiveness still needs to be verified through experimentation. It would be beneficial to observe what degree of minor asymmetry an object may support, depending on its overall level of symmetry, and still maintain its level of attractiveness, and whether the presence of a tiny irregularity will truly increase the level of attractiveness of an object by highlighting its degree of symmetry.

3.3. The Ecology Hypothesis

The evolutionary principles that modify the degree of attractiveness based on the presence of symmetry mainly apply to those situations that are important from an evolutionary viewpoint. They are, in particular, situations of sexual and natural selection that result in a preference for one object over another. Two substantial facts follow from this. Firstly, when assessing the effect of symmetry on the perception and evaluation of attractiveness it is necessary to take the context into consideration. It may be expected that the effect of symmetry would be very strong in the assessment of the attractiveness of a potential sexual partner (e.g. their face), as a part of sexual selection. This is also true for critical situations when perception rate plays a major role, or the low energy demand of symmetrical objects (natural selection) is advantageous – the effect of symmetry is correctly identified. On the contrary, in situations which do not potentially affect the "survival" of an individual we can expect that symmetry will have a much lower impact on perceived attractiveness. For example, when we evaluate a work of art, or in situations when an individual seeks cognitive stimuli, entertainment or intellectual delight (Zahavi, 1975). In this context, perfect symmetry in art is considered boring (Hockenberry et al., 2018). It has also been found that as the degree of artistic expertise increases, so does the perceived degree of attractiveness of asymmetrical patterns (but – again – only to a certain degree) (Weichselbaum et al., 2018). The study by Weichselbaum (2018) also brought forth another interesting finding: asymmetrical patterns in art were only perceived as attractive in situations of explicit evaluation, this was not the case in implicit assessments. This again points to the evolutionary basis for the preference of symmetry in the evaluation of attractiveness which is more dominant within unconscious, quick and implicit processes (Kahneman´s fast System 1) (Kahneman, 2012). Breaking symmetry with an asymmetrical element increases the complexity of an object (Gartus & Leder, 2013) and therefore allows the involvement of a higher number of more complex intellectual processes, which leads to higher levels of aesthetic satisfaction (Hockenberry et al., 2018). Secondly, evolution also includes the aspect of selection, a choice between alternatives. Therefore, we can expect that the effect of a preference for symmetry in the evaluation of the attractiveness of objects is more dominant in situations where a decision must be made rather than those of a single evaluation. Therefore, the verification of whether evolutionary-important situations (compared to the unimportant) can really increase the effect of symmetry and to what degree this effect is regulated by the activation of individual information processing systems would be beneficial.

4. Conclusions

An ever-growing body of research has brought ambiguity into the problem of the impact of symmetry on the perception and evaluation of attractiveness. Neither new approaches nor sophisticated methods of research that have enabled better monitoring of possible intervening variables have yet managed to clarify the situation – some studies confirmed the validity of the evolutionary theories that support the presence of symmetry and its effect on the degree of attractiveness, while others have cast doubt on its role. Different methodologies, various stimuli and research subjects, along with many approaches and conditions for the measurement of reaction rates as well as the use of different methods for statistical analysis, that have differed from study to study, imply that different findings will also occur in the future. Thus, the key issue does not lie in whether evolutionary principles and their consequences affect the impact of symmetry on attractiveness, but under what conditions, and with what limitations, it is possible to assume that symmetry has an impact on attractiveness. Further research should therefore focus on the importance and prerequisites of the perception of attractiveness (ecology hypothesis), on the types of objects perceived in the context and form that they naturally occur (naturalness hypothesis) or on other significant elements that highlight the presence of symmetry and its impact on attractiveness (accent hypothesis).

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