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Research report

There is more to the picture than meets the rat: A study on rodent geometric shape and proportion preferences

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HIGHLIGHTS

- We examined exploration in tripartite metal objects with 1.2; 1.618 and 1.8 ratios in adult rats.
- Rats preferred 1.2 object ratio composition, independently of the maze object location.
- Rats did not disclose any preference for novelty when metal spheres were presented before cylinders.
- Rats preferred metal spheres more than cylinders when both were presented at the same time.
- The main rat external body ratios were more related to 1.2 ratio than to 1.6 or 1.8 ratios.

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ABSTRACT

In rodents, the novel object preference test has been used as a behavioral parameter for evaluation of neotic exploratory behavior, and also for memory consolidation tasks. Geometric patterns of this preference are poorly understood, and may vary among species. We evaluated in Wistar rats (*Rattus norvergicus*) a possible exploration preference considering aluminum tripartite rounded and cylindrical objects of different proportions: 1.2; 1.618; 1.8. At the first day, animals were exposed to 1.2; 1.6 and 1.8 rounded objects. At 24 h after, these animals were exposed to the same objects, together with three new steel cylindrical objects (same proportions). ANOVA and T tests were used to quantify object exploration for each animal ($p < 0.05$). Data analysis pointed to a longer exploration time of the object 1.2 at the three different protocols indicating a preference pattern on the first day exposition. On the second day the exploration was similar in both familiar and unfamiliar objects, revealing no novel object preference for cylinders. However, we found an object preference related to the 1.2 proportion (balls plus cylinders), in two of three position protocols. In addition, on a single exposition with both cylinders and rounded objects, rats revealed a rounded object preference. The 1.2 preference disclosed by rats also reflected the proportion of their body. From nine main measures of body ratios, seven were close to 1.2 ratio. The correspondence between body ratios and object preference may be explained by habituation learning and by sexual selection, and highlight innate factors regarding aesthetic preferences among species.

1. Introduction

Thinkers, artists and philosophers have examined the issue of beauty and aesthetics for years. One of the major discussions of aesthetics concerns the nature of aesthetic experience [1]. The search for the source of beauty, of whether it resides in the object apprehended or in the perceiving subject, has exercised the speculation of philosophers and writers throughout the ages [2].

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Regarding tri- and two-dimensional aspects of object appraisal, preference of certain ratios has been studied in humans. The golden ratio (1.618) is often attributed to the limit of the ratio between two successive numbers in the Fibonacci sequence, and is considered since antiquity as a golden beauty parameter [3]. This is considered, since antiquity, a ratio connected to beauty and aesthetics, and was repeatedly used in art and architecture [4]. This theory led to various studies, which also observed the golden ratio in nature. Some occurrences were found in various contiguous human body segments [5], in ramifications of Purkinje neurons [6], the bronchi ramifications in human lung [7] and the spiral arrangements of leaves and petals of plants [5].

The craving for novelty is believed to be one important aspect of art appreciation, and was based on well-known psychological principles of habituation [8]. So, novelty seeking may be "the single force that has pushed art always in a consistent direction ever since the first work of art was made" [9].

Charles Darwin was one of the first scientists to study about human beauty standards from a biological point of view [10]. Darwin took the notion of beauty away from its formerly anthropocentric location, redefining it as a part of the acting forces of the biological world.

Also for Semir Zeki group [11,12], art has a biological basis. According to his studies, an specific part of the brain, the medial orbito-frontal cortex, was active during the experience of musical and visual beauty, regardless of the extent to which the work can be classified as a work of art or not. Additionally, another related study demonstrated a differential activation of brain limbic system areas via insula when human subjects are exposed to golden ratio, but not to software modified other ratios, in Classical sculptures and Renaissance [13]. This last study clarifies an association of golden ratio preference in aesthetic objects (renaissance body representations), and the natural occurrence of this proportion in human body.

If there are patterns of human preference for certain object constructions, and considering that most human basic behaviors and neural pathways are also expressed in complex animals such as mammals, we believe that correspondent patterns could be also found in primate or in rodent models of object preference. If so, this preference would have also some evolutionary usefulness. According to our knowledge no such study has been done in any animal species. This paper aims to address these questions, through an adaptation of rodent based novelty preference test (NOPT) [14].

The novel object preference test [14,15] has been established as a memory consolidation task, in which rodents are presented to objects for free exploration in an habituation session and re-exposed in an evaluation session to both unfamiliar (new) and to already presented objects. In these approaches, however, the object geometric preference patterns in rodents and other animal species are poorly understood.

In the search of a better understanding of rodent geometric preference, this study analyze only the variations of object geometric form patterns and ratio construction, but conserve the general aspect and the same color or building material. NOPT was adopted for also measuring geometric preference in rats, using tripartite objects (both spherical and cylindrical) made with slight variations in their proportion. This approach is specially directed to the following assumptions: (1) there is really a natural preference of object exploration in rodents, and (2) if this exploration preference exists, there is probably an association with rat body segment ratios, as occurs with human preferences. We believe that addressing these questions we can contribute to clarify data regarding rodent object preferences and improve evolutionary theories regarding the aesthetic universals.

2. Methods

2.1. Animals

Animals were used in these series of experiments 65 adult male Wistar rats (3–5 months). Animals were housed in a controlled temperature ($22 \pm 1\,^{\circ}C$) room and 12 h light/dark cycle (lights on 06:30); with food and water ad libitum. Rats were handled in accordance with the guidelines of the Brazilian laws regarding the use of animals in research. All procedures were submitted and approved by the local university (UFRN) ethical committee.

2.2. Manufacture of objects

Specific objects were designed for these preference experiments. We used metallic objects, both rounded and cylindrical, consisting of tripartite components (stacked balls or cylinders) with slight variations of its proportions. We used ratios of 1.2, 1.62 and 1.8 for rounded and cylindrical objects (see Fig. 1A). In a detailed description, each rounded object had 3-stacked spheres. The basal sphere (at the bottom of the object) could have: 1.2; 1.62 or 1.8 times the diameter of the middle sphere, and the middle sphere could have 1.2; 1.62 or 1.8 times the diameter of the top sphere, depending on the object proportion. The same logic was applied to cylindrical ones. All objects were completely unknown by the animals at the first presentation session. Depending on the series of experiments, the round objects used in the first test had equivalent measures of its heights or bases. Thus, we define here equal bases and equal heights different approaches. We used this distinct approach in order to assure that a possible preference would be maintained for a given proportion independently of variation of heights or widths of round objects, aiming to avoid a possible bias related to object sizes. So, preference for spherical objects would not be directed to the height or to the width of a given object, but rather to the proportion among its divisions. Our working hypothesis was that most probably animals would choose the same proportion, in both cases of equal height or equal (base diameter) of objects. Cylindrical objects varied only in height (and not base) measures, since they were mainly used to measure learning at the second day of exposition.

2.3. Apparatus and object exploration measure

In this study it was used an open field arena (squared wood with 59 cm length) for analyzing differential exploration to each geometric pattern submitted and if memory consolidation occurred 24 h after the first trial. The animal was placed at the box center and the holding time for each object was quantified over a total period of 15 min. Exploration of an object was defined by head approximation of a circular area around the object which was measured according to the object of largest basis in exposition. The circular area around objects which defines exploration was drawn in Any maze software™, with a 2.2 times higher diameter (example: 9.9 cm) than the largest object basis (example: 4.5 cm), so the three areas occupied equivalent spaces. In all procedures, objects were equidistantly disposed at 5 cm from the maze walls, for allowing free passage of animals through the maze. The apparatus was cleaned with a 5% solution of alcohol after each session. The sessions were recorded by a digital camera and monitored through a computer screen. Any maze software™ was used to trace the exploration zones and quantify object exploration duration.

2.4. First exploration task: round object exposition

On the first day exploration we used three round objects, both with similar heights or similar bases (on two parallel approaches