Title: Perception of animacy in dogs and humans

Authors

Judit Abdai[1*], Bence Ferdinandy[2,3], Cristina Baño Terencio[1,4], Ákos Pogány[1], Ádám Miklósi[1,2]

Affiliations

[1]Department of Ethology, Eötvös Loránd University, Hungary

[2]MTA-ELTE Comparative Ethology Research Group, Hungary

[3]Department of Biological Physics, Eötvös Loránd University, Hungary

[4]University of Valencia, Spain

*Corresponding author: abdai.judit@gmail.com

Abstract

Humans have a tendency to perceive inanimate objects as animate based on simple motion cues. Although animacy is considered as a complex cognitive property, this recognition seems to be spontaneous. Researchers have found that young human infants discriminate between dependent and independent movement patterns. However, quick visual perception of animate

entities may be crucial to non-human species as well. Based on general mammalian homology dogs may possess similar skills as humans. Here we investigated whether dogs and humans discriminate similarly between dependent and independent motion patterns performed by geometric shapes. We projected a side-by-side video display of the two patterns and measured looking times at each side, in two trials. We found that in Trial 1, both dogs and humans were equally interested in the two patterns, but in Trial 2 of both species, looking times at the dependent pattern decreased, whereas they increased at the independent pattern. We argue that dogs and humans spontaneously recognized the specific pattern and habituated to it rapidly, but continued to show interest in the "puzzling" pattern. This suggests that both species tend to recognize inanimate agents as animate relying solely on their motions.

Background

Previous studies suggest that certain motion patterns can trigger the impression of animacy even in the absence of an animal-like embodiment [e.g. 1-3]. Observers' tendency to recognize inanimate objects as animate based on simple motion cues has been referred to as perceptual animacy [e.g. 3-6]. This perception can be evoked even by a single moving geometric shape that changes its direction and speed simultaneously without visible external cause [3]. Humans also tend to attribute personality traits, emotions and intentions to moving geometric figures, which seems to be induced by the temporal contiguity and spatial proximity among them [1,2]. The perception appears to rely on low-level visual processing and does not involve complex mental processes, like categorisation [e.g. 7]; however, some studies suggest that detection of some motion patterns have capacity limitations [8].

In humans, researchers have mostly tested the perception of animacy with a dependent (chasing-like) motion pattern performed by geometric shapes that were presented by video and interactive displays [e.g. 5,9,10]. Chasing involves motion characteristics that have been described to facilitate the recognition of an agent as animate, for example, self-propelledness, sudden changes in velocity, and goal-directed movement [e.g. 7,10]. Previous studies revealed that 3-month-old human infants discriminate between movement patterns and look longer at the chasing than at the independent pattern performed by two agents respectively in a side-by-side video display [9]. In contrast, 5-month-old infants and adults look longer at the independent movement, possibly due to a faster recognition of the chasing pattern and increased attention to the more unfamiliar pattern [9]. In a series of studies [e.g., 5,10; see also 2], Gao and his colleagues found that human adults rapidly perceive a chaser agent based simply on its motion. The recognition seemed to be affected by spatiotemporal contingencies between the agents and the characteristics of their movement.

Only a few studies investigated this phenomenon in non-human species by applying video displays [e.g. 11,12]. In two of them researchers used training as part of the procedure (go/no-go discrimination) [11,12]. Goto et al. [11] did not find evidence that pigeons (*Columba livia*) discriminate between two displays based on the presence of goal-directed motion. Atsumi and Nagasaka [12] also did not find univocal evidence that squirrel monkeys (*Saimiri sciureus*) are able to perceive a chasing pattern. We argue that prior training in perception research can confound the experiments (i.e. monitoring spontaneous behaviour vs. learning during training), leading to false conclusions.

Based on its biological significance, we suggest that perceptual animacy could be a common phenomenon in a wide range of non-human animals. Considering the general mammalian homology, and that in canids chasing plays a key role in acquiring food, we hypothesized that dogs spontaneously recognize animacy, similarly as humans.

Here, we experimentally tested whether dogs (*Canis familiaris*) are able to discriminate between dependent and independent movement patterns in a similar setup used by Rochat et al. [9]. For a cross-species comparison, we also tested human adults using the same setup. We expected rapid habituation to the dependent pattern over time both in humans and in dogs, so that they decrease their attention toward the chasing pattern, whereas show increasing interest in the independently moving geometric figures.

Methods

Subjects

We tested 40 dogs and 31 university students; of them 30 dogs (different breeds; 14 males; mean±SD age: 6.1±3.4 years) and 30 students (11 men; mean±SD age: 21.9±2.2 years) remained in the final analysis (for exclusion criteria, see supplementary material).

Procedure

We used side-by-side displays of dependent ('chasing', henceforth) and independent movement patterns by two white dots over a plain black background on each side, separated by a white vertical line (see supplementary video). The chasing patterns were generated by a computer simulation based on previous findings [e.g. 5,10]. The independent patterns were compiled from two other chasing patterns selected randomly; from one of them, the program used the chaser, and from the other one, the chasee. Thus, the dynamics of the chasing and independent patterns were the same. The stimuli were projected on a screen (2 m x 2.1 m), and an audiovisual attention grabber was played before each stimulus. Subjects sat 2.8 m away from the screen on the ground. Owners sat behind the dog on a chair; we asked them to look down during the test in order to rule out the "Clever Hans effect" [13]. The room was darkened and the display was operated from outside. We repeated the 10 s long stimuli twice (Trial 1 and 2).

The sides of the chasing and independent patterns were counterbalanced between trials and subjects. We presented the same set of stimuli (30 videos) to dogs and humans, and each stimulus was presented to one dog and one human participant. For the details of the procedure and computer simulation, see the supplementary material.

Data analyses

We coded duration of looking at the two patterns based on eye movements of subjects. We then calculated looking time as proportion of trial time spent looking at each pattern, and used these (arcsine transformed) proportions as explained variables in statistical analyses.

We used Linear Mixed Models (LMMs) to analyse the effects of motion pattern, trial and species on looking time. Initial models included all two- and three-way interactions between explanatory variables. We also used LMMs to analyse within-trial looking times of dogs and humans, separately for Trial 1 and 2. Backwards model selection was based on AIC values, so that the model with the lowest AIC value was kept and we considered a model better whenever delta AIC was $\geq$ 2. For significant explanatory variables in the final models, we provide parameter estimates (B $\pm$ SE), whereas for non-significant variables we provide test statistics before exclusion from the model.

Inter-coder reliabilities were investigated on random subsamples of the recordings by an independent coder (TF) who coded 20% of dog and 20% of human subjects (average Cohen's kappas, dogs: 0.733; humans: 0.787; see supplementary material).

Results

The difference between looking times at the two patterns changed with trials, as reflected by a *Trial x Pattern* interaction in our analyses (LMM of looking time, *Trial x Pattern*: $F_{1,235}=13.590$, p<0.001). This interaction was driven by subjects looking longer to the

independent than to the chasing pattern in Trial 2 (Trial 2 vs Trial 1: Chasing $\rightarrow$ Independent: B±SE=0.199±0.54, p<0.001); the results further suggest that this change in behaviour was the same in dogs and humans (i.e. no three-way interaction: *Trial x Species x Pattern*: $F_{1,232}=0.050$, p=0.823). *Species x Pattern* ($F_{1,233}=0.336$, p=0.563) and *Species x Trial* ($F_{1,234}=0.712$, p=0.400) interactions were non-significant, and therefore excluded from the final model. Total looking times toward the screen were different between dogs and humans (*Species*: $F_{1,235}=13.590$, p<0.001), because dogs looked shorter to the screen than humans (Dogs vs Humans, B±SE=-0.191±0.027, p<0.001; for more details, see supplementary material).

Within-trial looking times were different between the two species (LMM, Trial 1: $F_{1,117}=28.981$, p<0.001, Dogs vs Humans, B±SE=-0.168±0.031, p<0.001; Trial 2: $F_{1,117}=23.337$, p<0.001; Dogs vs Humans, B±SE=-0.204±0.062, p=0.001), however, both dogs and humans reacted similarly to the patterns (LMM, Trial 1, *Species x Pattern*: $F_{1,116}=0.482$, p=0.489; Trial 2, *Species x Pattern*: $F_{1,116}=0.047$, p=0.829). Although in Trial 1 both species looked equally long relatively at the two patterns (*Pattern*: $F_{1,117}=0.216$, p=0.643), this changed for Trial 2 (*Pattern*: $F_{1,117}=17.530$, p<0.001) so that dogs and humans looked longer at the independent than at the chasing pattern (Trial 2, Independent vs Chasing: B±SE=0.184±0.044, p<0.001).

Discussion

We found that dogs and humans showed an initial interest in both patterns, but they favoured to watch the independent pattern later. Although overall humans looked longer at the projected video than dogs, we found that the two species allocated their attention similarly across the experiment.

We suggest that the decreased looking time at the chasing pattern across trials in both species was due to the spontaneous habituation to and/or recognition of the chasing pattern; this could

have shifted attention to the independent ("unrecognized") pattern. These results are in line with those reported for 5-month-old infants and adults by Rochat et al [9], who argued that sensitivity to social causality may explain such a shift in attention.

Although dogs and humans divided their attention similarly between the two patterns, we found a difference in their overall looking time at the screen, and there are further, subtle differences between the two species (e.g. within-trial dynamics of looking times; see supplementary material). We suggest that these differences do not necessarily reflect different mental processing of the stimuli. Considering, that many dogs are not used to watching screens (e.g. computer, TV), the differences between the two species are likely not due to dogs' lack of interest in the stimuli, but in projections in general.

Behavioural evidence suggests that reduced interobject spacing is an important cue in guiding the attention of adults and children older than a year toward objects [e.g. 6,14]. In the present study neither dogs nor humans looked more at the chasing pattern in either of the trials; although in humans we measured a slight gradual increase in looking time at the chasing pattern in Trial 1 (see supplementary material). Considering the overall high proximity of dots in the chasing pattern, we cannot be sure whether increased looking times at the chasing pattern (at least in Trial 1) were due to the specific interaction or reduced interobject spacing. An important difference in experimental setups is that in both previous studies the objects moved with constant speed [6,14], whereas in our stimuli (in both patterns) the objects showed more dynamism with changing speeds. A further source of difference may come from the object's reactions to the changes of the other object's speed, in case of the chasing pattern.

When designing chasing stimuli, we followed the already established methodologies [e.g. 5,9]. Such motion patterns have been described by human observers as chasing interactions, however, we cannot exclude the possibility that dogs might have perceived these stimuli as other than chasing (a limitation of studies involving infants as well). However, it is important

to note that based on the motion dynamics of the dots alone, all of them could be perceived as animate.

In conclusion, our findings suggest that dogs, similarly to humans, tend to perceive geometric shapes as animate based simply on their movement patterns. Our study raises the question of how general trait animacy perception may be in animal species.

Ethics

Data accessibility

Measurement data of subjects are uploaded as supplementary material. The chasing algorithm is described in detail in the supplementary materials.

Competing interests

We have no competing interests.

Authors' contribution

JA conceived and designed the study, carried out the experiments, analysed the data, drafted the manuscript; BF designed the study, analysed the data, drafted the manuscript, created the ChasingDots program; CBT conceived and designed the study, carried out the experiments,

drafted the manuscript; ÁP analysed the data, drafted the manuscript; ÁM conceived and designed the study, drafted the manuscript. All authors gave final approval for publication. All authors agree to be held accountable for the work performed.

References

1. Heider F, Simmel M. 1944. An experimental study of apparent behavior. Am. J. Psychol. 57(2):243-259. doi:10.2307/1416950

2. Bassili JN. 1976. Temporal and spatial contingencies in the perception of social events. J. Pers. Soc. Psychol. 33(6): 680-685. doi:10.1037/0022-3514.33.6.680

3. Tremoulet PD, Feldman J. 2000. Perception of animacy from the motion of a single object. Perception. 29(8):943-951. doi:10.1037/a0020735

4. Scholl BJ, Tremoulet PD. 2000. Perceptual causality and animacy. Trends. Cogn. Sci. 4(8):299-309. doi:10.1016/S1364-6613(00)01506-0

5. Gao T, Newman GE, Scholl BJ. 2009. The psychophysics of chasing: A case study in the perception of animacy. Cogn. Psychol. 59(2):154-179. doi:10.1016/j.cogpsych.2009.03.001

6. Meyerhoff HS, Schwan S, Huff M. 2014. Interobject spacing explains the attentional bias toward interacting objects. Psychon. Bull. Rev. 21(2):412-417. doi:10.3758/s13423-013-0496-y

7. Scholl BJ, Gao T. 2013. Perceiving animacy and intentionality: Visual processing or higher-level judgment. In: Rutherford MD, Kuhlmeier VA, editors. Social perception: Detection and interpretation of animacy, agency, and intention. Cambridge, MA: MIT Press. p. [197-229].

8. Meyerhoff HS, Huff M, Schwan S. 2013. Linking perceptual animacy to attention: Evidence from the chasing detection paradigm. J Exp Psychol Hum Percept Perform. 39(4):1003-1015. doi:10.1037/a0030839

9. Rochat P, Morgan R, Carpenter M. 1997. Young infants' sensitivity to movement information specifying social causality. Cogn. Dev. 12(4):537-561. doi:10.1016/S0885-2014(97)90022-8

10. Gao T, Scholl BJ. 2011. Chasing vs. stalking: interrupting the perception of animacy. J. Exp. Psychol. Hum. Percept. Perform. 37(3):669-684. doi:10.1037/a0020735.

11. Goto K, Lea SE, Dittrich WH. 2002. Discrimination of intentional and random motion paths by pigeons. Anim. Cogn. 5(3):119-127. doi:10.1007/s10071-002-0139-6

12. Atsumi T, Nagasaka Y. 2015. Perception of chasing in squirrel monkeys (*Saimiri sciureus*). Anim. Cogn. 18(6):1243-1253. doi: 10.1007/s10071-015-0893-x

13. Pfungst O. 1911. Clever Hans (the Horse of Mr. von Osten): A Contribution to Experimental, Animal, and Human Psychology. J. Philos. 8:663-666. doi:10.2307/2012691

14. Galazka M, Nyström P. 2016. Visual attention to dynamic spatial relations in infants and adults. Infancy. 21(1):90-103. doi: 10.1111/infa.12091
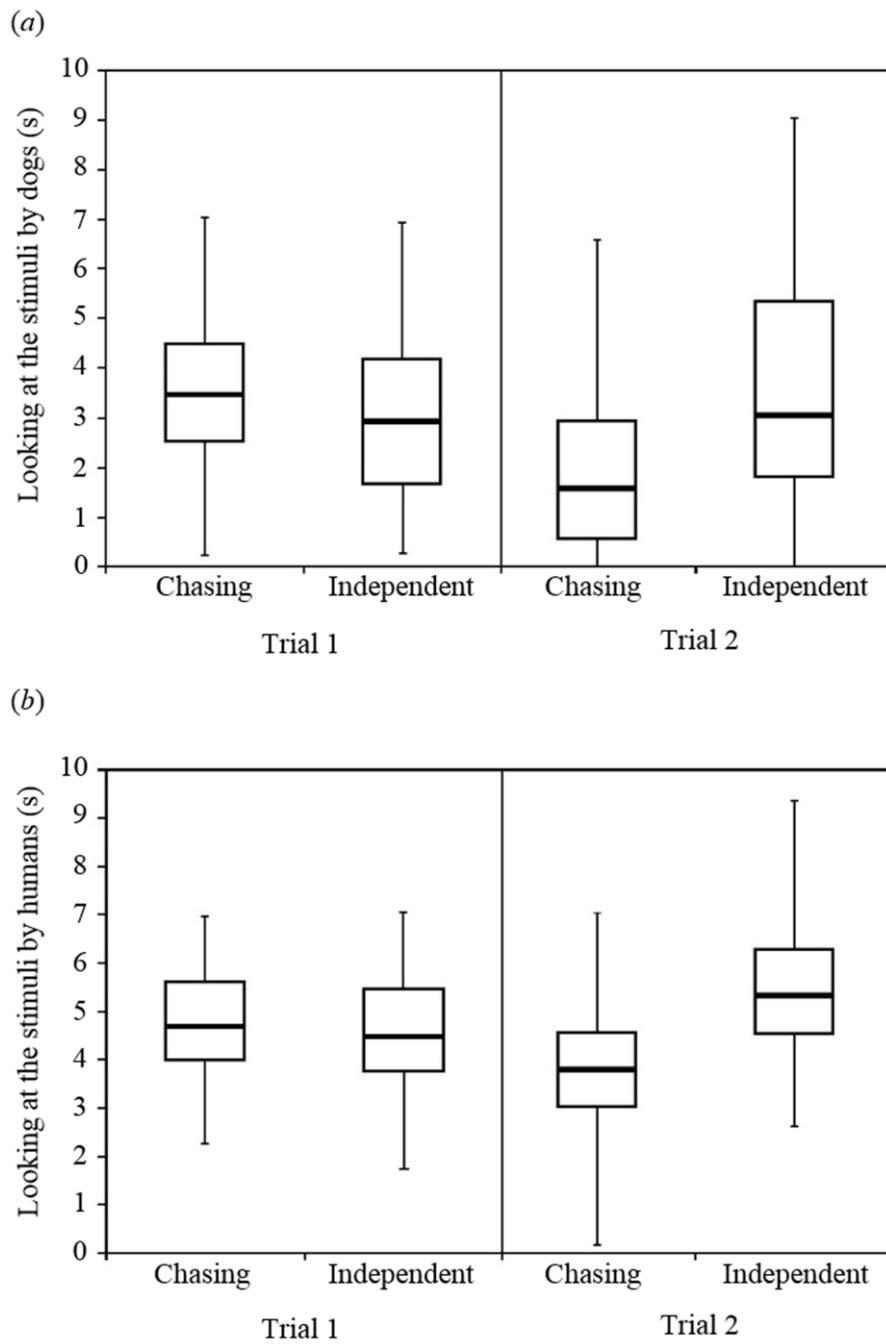
Figure legend

Figure 1 Duration of looking at the chasing and independent patterns in Trial 1 and 2 by (a) dogs and (b) human participants. The boxplots indicate the median, 25th and 75th percentiles (boxes), and the minimum and maximum (whiskers).