*1. Title of Dataset:* Data from: High pitch sounds small to domestic dogs – Abstract crossmodal correspondences between auditory pitch and visual size

*2. Author information:*

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<https://doi:10.5061/dryad.6q573n60g>

DATA AND FILE OVERVIEW:

*1. Description of dataset*

These data were generated to investigate whether domestic dogs, like humans, show abstract pitch-size associations (also known as crossmodal correspondences). We first trained dogs to approach and touch an object after hearing a sound emanating from it. Subsequently, we repeated the task but presented dogs with *two* objects differing in size, only one of which was playing a sound. The sound was either high- or low-pitched, thereby creating trials that were either congruent (high-pitch from small object; low-pitch from large objects) or incongruent (the reverse). We found that dogs reacted faster on congruent versus incongruent trials. Moreover, their accuracy was at chance on incongruent trials, but significantly above chance for congruent trials. Our results suggest that non-human animals show abstract pitch-sound correspondences, indicating these correspondences may not be uniquely human but rather a sensory processing feature shared by other species.

*2. File list*

High pitch sounds small\_dataset.xlsx

*3. Methods*

Participants

Fifty domestic dogs of unrestricted breeds aged between 6 and 132 months (M=56.1, SD=36.6) who had previously received some basic training (e.g., basic commands such as “sit” and “stay”) were recruited. After exclusions we were left with 133 trials from 30 dogs.

Materials

The training stimulus consisted of a plastic-coated 3-dimensional frustum-shaped object, painted blue. The frustum had a base-diameter of 29cm and a volume of approximately 9000 cm3. A JBL Flip 4 Bluetooth speaker was inserted via a small hole in the side of the object and the remaining cavity filled with insulating rockwool (Knauf Earthwool) to reduce any resonances from the speaker. The sound stimulus for training was a 2-second-long 430Hz (9.33 erb) pure tone created in PRAAT. The sound was played at 86dB (approximately 65dB measured at the dog’s position) which was controlled from a Motorola Razor phone connected to the speaker via Bluetooth. The dogs’ behaviour was recorded using 3 cameras: a Go Pro Hero 7 camera positioned on the right side of the dog; a GoPro Max camera positioned to the front of the dog, and a Sony Handycam camera positioned to the right (or left, depending on the position of the experimenter) and behind the dog. Additionally, there was a Sony Handycam camera, positioned in front of the dog, to the right or left of a partition screen which was hiding the experimenter. This was connected to an Acer LED 21.5” Monitor (KA220HQ) where the experimenter could watch the behaviour of the dog while out of sight.

The testing stimuli were identical to training stimuli in all ways other than the following: There were now *two* objects per trial, one big and one small (approximately 23000cm3 and 2300cm3 respectively). To ensure that our findings would hold across multiple shapes, we created three sets of objects: a pair of cylinders, a pair of cones, and a pair of cuboids ensuring each dog saw one set only (e.g., a big and small cuboid). There were now also two sound stimuli, one low pitch (150Hz, 4.26 erb) and one high pitch (900Hz, 14.4 erb). All other aspects of stimuli and recordings were as in the training phase.

Remaining materials were a partition screen, button-clicker, reward-tube, and rewards. The experimenter trained the dogs to touch the object using a button clicker and commercially available dog treats (see below). Treats were delivered via the plastic reward-tube attached to the partition screen, whose position and orientation is described below.

Procedure

Training

Dogs were brought into the testing room at the University of Sussex by their owners and given approximately 5 minutes to acclimatise, while owners signed the consent form and completed a questionnaire about their dogs (stating their breed, age, sex, neuter status, and weight). In order to avoid any potential bias resulting from their expectations, the owners were not informed about the purpose of the study or the hypothesis until testing was completed, at which point they were debriefed. Then the owners were asked to sit in a chair facing a partition screen which had a reward-tube attached to it. Each dog was put into a “sit” position directly in front of the owner to prevent the owner from accidentally cueing the dog, and owners were asked not to interact with their dogs during the experiment. The dog was positioned directly in front of the object at the start of training. The training object, a mid-sized blue frustum, was positioned between the dog and the screen, 90 cm away from the screen.

When training began, the dog underwent a shaping phase with the aid of a clicker to train the dogs to target the training object with their nose or paw. This technique involves waiting for the desired behaviour and quickly marking and rewarding when it occurs. The primary reinforcer (food treat) was delivered through a reward-tube attached to the screen positioned behind the object (facing the dog). After a correct response was established (i.e., dog consistently targeting the object and touching with nose or paw), a sound playing from the speaker within the object was now introduced. If the dog moved too soon (before the sound was played) the experimenter prevented the dog from touching the object, by blocking it with her hand or lifting the object up. After each repetition of the behaviour, the dog was returned to the “sit” position in front of the owner and another trial was initiated.

As the training progressed, the owner and the dog were slowly moved backwards to increase the distance the dog had to travel to touch the object, and the experimenter started to gradually retreat behind the room-dividing screen which was necessary in order to avoid influencing the dogs’ behaviour during testing. Training continued until the owner’s chair was in position by the wall opposite the screen (350cm away from the screen) *and* the dog was able to sit and wait in an appropriate position for the next sound to be played by the experimenter (now hidden out of view behind the screen). The appropriate position for the dog was to be seated in front of the owner but behind an orange line drawn on the floor. A final 6 trials (object to the left of the dog x2, object to the right of the dog x2, object in the middle x2) had to be completed with 100% accuracy before training ended and the experiment moved on to the testing phase. If this failed, another block of 6 training trials was completed.

Testing

Testing took place immediately after successful training was complete, and the dog and owner remained in the position they had reached at the end of training. All elements of testing were identical to training except now two objects were used, again placed in front of the screen, one to the left and one to the right, equidistant from the reward delivery tube, 90cm in front of the screen, 124 cm away from each other, and 150cm away from the dog. The shape of the objects was randomly assigned to each dog (i.e., a pair of cylinders or cones or cuboids). Only one of the objects played a sound on each trial. This crossing effectively means every trial presented two objects (big and small) one of which was playing a sound (high or low pitched), with objects switching on the left or right of the space (e.g., Trial 1 big-on-left; Trial 2 big-on-right). As with training, each trial began with the experimenter positioning the stimuli (i.e., moving the small/big objects left/right, according to the trial type) and setting the dog up in a sitting position in front of (and facing away from) its owner. The experimenter then retreated behind the screen, from where she could manipulate the sound media. She then activated the sound, which was the signal for the dog to approach and touch the sound-making object. When the dog touched the object, the experimenter marked the behaviour with a click from the clicker and deposited a small treat via the tube as a reward for the dog. The dog was then repositioned by the experimenter in preparation for the next trial. If the dog did not respond at all within 40s from start of the sound stimulus, the sound was repeated. If the dog continued to not respond, the trial was recorded as “no response”, and the next trial began. If the dog moved out of position, but made no choice (e.g., went to investigate an area of the testing room where there was no object) this was also recorded as “no response”. If the dog showed signs of stress such as excessive panting, pacing, comfort-seeking from owner, excessive whimpering, or avoidance of the experimenter, the experiment was terminated.

Video coding

Video recordings of dog behaviour were edited in iMovie (Apple Inc.) to replace the sound stimulus for each trial with a ringing tone to allow the behaviour of the dogs to be coded blind. Subsequently, the recordings were analysed using SportsCode Gamebreaker version 10 by ATK, and 25% of trials by HRG.

Design

Of each dog’s eight trials, four were congruent (small object playing high pitch sound; or big object playing low pitch sound; once with small object on the left and once with small object on the right). The remaining four trials were incongruent (i.e., small/low on left and right, and big/high on left and right). The combination of trials was pseudo-randomly assigned to each dog, to avoid any ordering effect.

DATA SPECIFIC INFORMATION FOR: High pitch sounds small\_dataset.xlxs

*1. Number of variables:*  27 altogether, in the model: 3 dependent variables, a random effect (DOG ID) and 1 independent variable

**Sheet 1:** Main data set

*2. Number of trials/rows:* 133

*3. Variable list:*

dog\_ID: Dog name included as a random effect

dog\_age\_months: dog’s age in months

age\_cat: dog’s age categorised into puppy, adolescent, young adult, adult, senior

dog\_weight\_kg: dog’s weight in kilograms

dog\_size: dogs categorised into sizes small, medium, large or giant

ear\_type: dog’s ear type (floppy or pricked)

dog\_breed:dog’s breed

playlist\_no: the playlist in which the order of the auditory stimuli and set up of the visual stimuli was specified

trial\_no: the trial number as specified by the playlist (1-8)

sound\_freq: the fundamental frequency (pitch) of the auditory stimulus (150 or 900Hz)

correct\_side: the side (left or right) on which the object containing the speaker was positioned

speaker\_in\_size: the size of the object (large or small) that contained the active speaker during the trial

trial\_cong\_y\_n: Type of trial (congruent or incongruent)

cong\_size: the size (large or small) that was congruent with the sound during the trial

side\_approached: the side (left or right) the dog approached

size\_approached: the size (large or small) the dog approached

prev\_trial\_side\_clicked: the side (left or right) which was rewarded in the previous trial

prev\_trial\_size\_clicked: the size (large or small) which was rewarded in the previous trial

choice\_congruent\_y\_n: the choice the dog made (Yes = congruent object chosen e.g. large object when the sound was low pitched, small object when the sound was high pitched; No = incongruent object chosen e.g. large object picked when the sound was high pitched)

choice\_correct\_y\_n: Whether the dog’s choice was correct or incorrect (Yes= correct choice, the dog chose an object that made a sound; No= incorrect choice, the dog chose an object that had an inactive speaker inside)

speed\_approach: In seconds, a measure of how quickly the dog travelled from starting position to the object

latency\_to\_approach: In seconds, a measure of how quickly from the start of a sound stimulus the dog started reacting

shape: the shape of the object the dog was presented with (cuboid, cone or cylinder)

experimenter\_l\_r: the side (left or right) on which the experimenter was positioned

side\_last\_touched: the side the experimenter touched last after positioning the objects

size\_last\_touched: the size the experimenter last touched after positioning the objects

*4. Missing data:*

D47-D50; D71-D76; D86-D92 – dog’s weight missing

V21 – speed of approach measure missing

W2-3, W24, W60, W62, W77, W103, W105, W106, W110, W120, W133 – latency measure missing

R2, R21, R25, R31, R42, R47, R51, R60, R65, R71, R93, R99, R103, R110, R115, R122 – no data as there was no previous trial (this was trial 1 for the dogs)

S2, S21, S25, S31, S42, S47, S51, S60, S65, S71, S93, S99, S103, S110, S115, S122 – no data as there was no previous trial (this was trial 1 for the dogs)

All coded as NA

*5. Abbreviations:* Y= Yes, N= No

**Sheet 2:** This data was used for exploratory analysis of first trials only and was not used in any of the analysis reported in the paper

*1. Number of variables:* 22

*2. Number of trials/ rows:* 17

*3. Variable list:*

dog\_ID: dog’s name

dog\_age\_months: dog’s age in months

age\_cat: dog’s age as a category (puppy, adolescent, young adult, adult, senior)

dog\_weight: dog’s weight in kilograms

dog\_size: dog’s size categorised as small, medium, large, or giant

ear\_type: dog’s ear type (floppy or pricked)

dog\_breed: dog’s breed

playlist\_no: the playlist in which the order of the auditory stimuli and set up of the visual stimuli was specified

trial\_no: the trial number as specified by the playlist (here only 1st trials)

sound\_freq: the fundamental frequency (pitch) of the auditory stimulus (150 or 900Hz)

speaker\_in\_size: the size of the object (large or small) that contained the active speaker during the trial

trial\_cong\_y\_n: Type of trial (congruent or incongruent)

cong\_size: the size (large or small) that was congruent with the sound during the trial

cong\_side: the side (left or right) on which the congruent object was positioned (e.g large object when the sound played was low pitched)

side\_approached: the side (left or right) the dog approached

size\_approached: the size (large or small) the dog approached

choice\_congruent\_y\_n: the choice the dog made (Yes = congruent object chosen e.g. large object when the sound was low pitched, small object when the sound was high pitched; No = incongruent object chosen e.g. large object picked when the sound was high pitched)

choice\_correct\_y\_n: Whether the dog’s choice was correct or incorrect (Yes= correct choice, the dog chose an object that made a sound; No= incorrect choice, the dog chose an object that had an inactive speaker inside)

speed\_approach: In seconds, a measure of how quickly the dog travelled from starting position to the object

latency\_to\_approach: In seconds, a measure of how quickly from the start of a sound stimulus the dog started reacting

shape: the shape of the object the dog was presented with (cuboid, cone or cylinder)

experimenter\_l\_r: the side (left or right) on which the experimenter was positioned

*4. Missing data:*

D7, D11, D12 – dog’s weight information missing

S3 – speed of approach measure missing

T2, T9, T15, T16 – latency measure missing

All coded as NA

*5. Abbreviations:*

Y = Yes

N = No