COMPARATIVE COGNITION

Dogs with a large vocabulary of object labels learn new labels by overhearing like 1.5-year-old infants

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Children as young as 18 months can acquire novel words by overhearing third-party interactions. Demonstrating similar learning processes in nonhuman species would indicate that the social-cognitive skills supporting this process are not exclusively human but may have evolved, or can develop, in other species, offering valuable insights into the origins of language-related cognition. In this study, we demonstrated that a small group of Gifted Word Learner dogs, which possess an extensive vocabulary of object labels, can learn new labels by overhearing their owners' interactions. Moreover, we show that these dogs can acquire novel object-label mappings even when the labels and objects are not presented simultaneously. Taken together, these results suggest that Gifted Word Learner dogs possess sociocognitive skills functionally parallel to those of 18-month-old children.

At 18 months, infants can learn new object labels equally well when directly addressed or when overhearing an interaction between two experimenters [reviewed in (*1*)]. The ability to learn from overheard speech shows that infants can acquire information by passively observing triadic interactions, in which two people engage with an object. This requires a range of social skills, including following others' gaze and attentional state (*2*), taking another's perspective (*3*), monitoring conversations (*4*), understanding intentions (*5*), and segmenting target words (*6*).

In studies of label learning from overheard speech, triadic interactions between experimenters often resemble pedagogical child-directed interactions. These interactions include simple linguistic frames, embedding novel words in labeling contexts, and using child-directed speech (*1*, *7*). Verbal input is also accompanied by ostensive cues, such as label emphasis (*1*, *8*), gaze alternations between object and partner (*1*, *8*, *9*), emotional expressions such as smiling or gasping (*6*, *9*–*11*), and expressing enthusiasm (*1*, *8*). Placing the novel label at the end of a sentence further facilitates learning (*12*).

Although language is exclusively human, some cognitive skills underlying its evolution are shared with other species (*13*). If other species can use overheard speech to map labels onto objects, it would suggest that they possess social cognitive skills that are functionally similar to those used by infants observing triadic interactions. Object label learning from overheard speech has been documented in two enculturated bonobos (*Pan paniscus*) (*14*). Label learning from third-party interactions has also been documented in an African gray parrot (*Psittacus erithacus*) (*15*), although these interactions combined third-party demonstrations with direct teaching.

Dogs (*Canis familiaris*) evolved and develop in the human ecological niche, undergoing selection that makes them an exceptional model for studying "human-like" social cognition (*16*, *17*). Research shows that dogs display several behaviors analogous to those of young children [e.g., (*18*–*20*)], evident even in very young puppies (*21*). Listening to and learning from human verbal interactions may have given dogs an evolutionary advantage. A recent study found that family dogs recognized familiar action labels (e.g., "sit" and "down") embedded in neutrally intonated speech not directed at them (*22*). Although dogs readily learn action labels (*23*), to date, behavioral evidence of learning object labels were documented in only a small group of dogs (*24*). We previously defined this small group as Gifted Word Learner dogs (with the term "Word" narrowly referring to auditory labels of objects) (*24*, *25*). These dogs spontaneously acquire object labels without intentional training, during natural play interactions (*25*). Thus, Gifted Word Learner dogs may present social cognitive skills for learning object labels from overheard speech.

Studies on children's object label learning often introduce a single new object with a novel utterance and then test mapping by presenting it among unlabeled distractors [e.g., (*6*, *8*, *26*)]. This approach has been criticized because children may choose the novel object by exclusion without truly learning the mapping (*27*). Similarly, Gifted Word Learner dogs can use exclusion to select a novel object when hearing a novel label, without forming an object-label mapping (*28*). Thus, procedures should expose subjects to at least two novel object-label pairings. However, in the Gifted dogs, presenting several new labels in a short time often causes them to confuse between the new toys and labels (*25*). This may lead to apparent failures in learning owing to factors unrelated to the mechanism under investigation [e.g., (*29*)].

In our study, we first developed an exposure protocol to test whether Gifted dogs could learn the labels of two objects presented within a short time under naturalistic conditions, when addressed by their owners (Experiment 1a). We then modified this protocol to examine our main aim: whether Gifted Word Learner dogs can also learn labels from overheard speech (Experiment 1b), and, following a reviewer's suggestion, we also tested how typical family dogs, without a vocabulary of object labels, will perform with this protocol (Experiment 2). In both addressed and overheard conditions, labels and objects were presented simultaneously. Statistical regularities strongly influence language development in 18-month-old infants (*30*). Yet infants can also use a speaker's communicative cues to learn new labels even when the object is out of view (*26*). Therefore, as a follow-up (Experiment 3), we tested whether Gifted dogs can learn object-label mappings when objects are labeled out of sight, creating a temporal discontinuity between the presentation of the two stimuli.

All experiments followed the same exposure schedule, manipulating only how the labels were introduced (see Fig. 1). Because dogs are neophilic (*31*) and often get excited by new toys, we gave them ample opportunities to interact with the toys without hearing their labels. Each session included three steps. It began with 1 min of labeling (e.g., "This is 'Toy A'"), was followed by 3 min of play with the toy without mentioning the label, and ended with free exploration time, in which the dog could engage with the toy alone (for up to 20 min). This procedure was repeated twice daily for 4 nonconsecutive days and was also applied to a second toy ("Toy B"). The presentation of the toys was interleaved and included rest days (see Fig. 1). In total, each dog received 8 min of exposure to each label (for details, see supplementary materials).

In Experiment 1a, we investigated whether the Gifted dogs ($n = 10$) could learn the labels of two new toys using the exposure protocol described above. The key manipulation was that, during the 1-min labeling, owners directly addressed their dogs ("Addressed" condition) and played with them as they normally would when introducing a new object and its label. After the dogs were exposed to two toy labels as described above and received an additional rest day, a label comprehension test was conducted on day 12. The two new toys and nine familiar toys were placed on the floor in a room out of the owner's view. The owner asked the dog to retrieve first a familiar toy, and then

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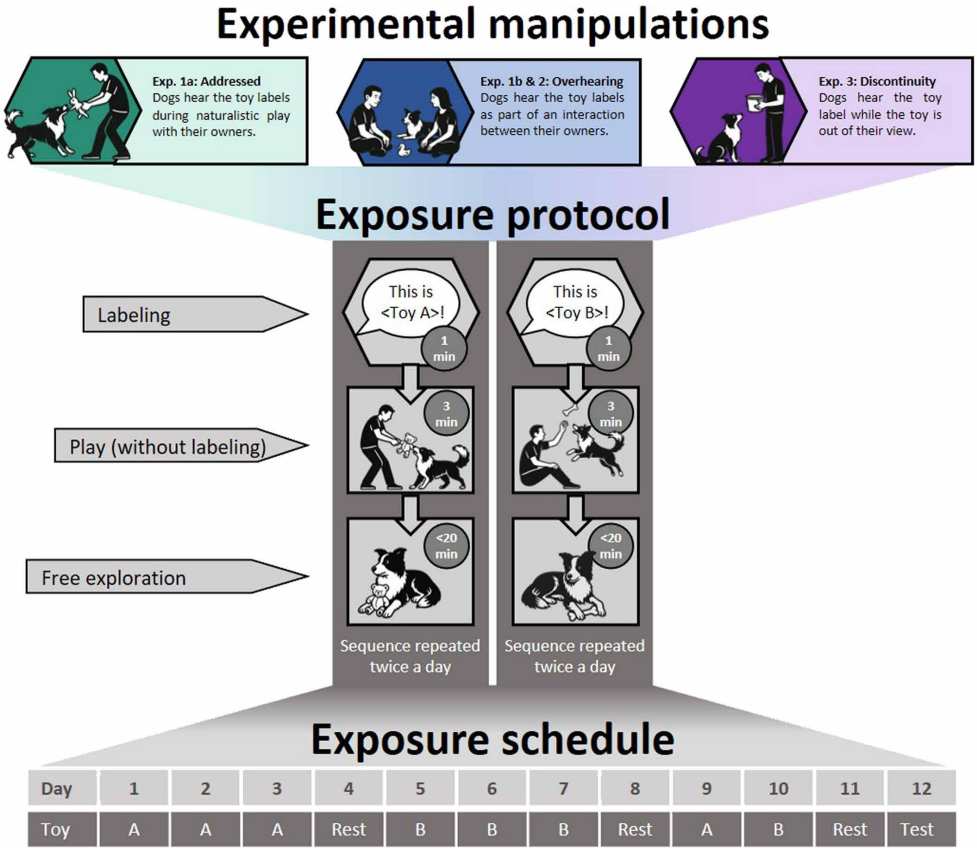

Fig. 1. An overview of the methods tested for teaching the dogs the names of toy labels. All experiments followed the same exposure protocol but manipulated how the dogs were exposed to the toy labels. The protocol included 1 min of labeling, followed by 3 min of play with the owner (without labeling) and then free exploration time (up to 20 min). In each experiment, the experimental manipulation was carried out with a set of two completely new toys. The order in which the two toys were introduced is presented in the exposure schedule at the bottom of the figure. In Experiments 3a and 3b, the test was divided across 2 days (day 12 and 13), thus the protocol was 1 day longer.

a new toy, by saying its label (e.g., "Can you bring the <label>?"). After every two trials, the toys that the dog retrieved were randomly placed back on the floor. Therefore, when the dogs were asked to retrieve a new toy, they could always choose between the two new toys. Each new toy was requested six times. Overall, the test included 12 trials for the new toys and 12 trials for the old toys.

In Experiment 1b, we exposed the same 10 Gifted dogs to an "Overhearing" condition, which was devised from studies investigating the ability of young children to learn from overheard speech [e.g., (*1*, *6*)]. The schedule of the exposure was the same as in Experiment 1a. The key manipulation in Experiment 1b was that, during the 1-min labeling, the dogs observed while their primary caretaker (C) and an additional family member (F) sat across from each other. C addressed F by saying the name of the toy embedded within sentences (e.g., "This is <label>.", and "Do you want <label>?") and passed it to F, who passed it back to C. Similarly to the studies with children mentioned above, C used simplistic linguistic frames [e.g., (*1*)] and ostensive communicative cues, such as gaze alternations between the object and the partner (*1*, *8*, *9*) and expressions of enthusiasm (*1*, *8*). Neither of the owners looked at or communicated with the dog in any way during the labeling phase of the protocol. The test phase that followed used the same procedure as in Experiment 1a.

For statistical analysis, we set the chance level of the Gifted dogs retrieving the correct new toy conservatively at 0.5, taking into account only the presence of the two new toys. This was done because whenever the dogs retrieved an incorrect toy, they most often chose the other new toy (mean ± SD = 0.80 ± 0.30 of the cases; see supplementary materials). The proportion of correct choices of the new toys in the Addressed condition was median = 0.92 and interquartile range (IQR) = 0.71 to 0.98. In the Overhearing condition, the proportion was median = 0.83 and IQR = 0.77 to 1.00. At the group level, the Gifted dogs performed significantly above chance with the new toys in both conditions (Wilcoxon signed-rank test: group performance versus chance level set at 0.5, Addressed: $W = 45$, $P = 0.004$, Overhearing: $W = 54$, $P = 0.004$; Fig. 2A), with no significant difference between their performance in the two conditions (Wilcoxon signed-rank test; Addressed versus Overhearing: $W = 14$, $P = 0.622$). In both the conditions, 7 out of 10 dogs retrieved the correct new toys at significantly above chance level (binomial tests, chance level = 0.5; successful dogs: all P values <0.020, unsuccessful dogs: all P values >0.073; see supplementary materials for individual results). Within each condition, the dogs performed equally well with both the new and old toys (Wilcoxon signed-rank tests; Addressed new versus old: $W = 28$, $P = 1$; Overhearing new versus old: $W = 16.5$, $P = 0.246$; Fig. 2). Additionally, to rule out learning during the test itself, we analyzed only the first trial for each new toy (two trials per dog). The group-level accuracy was 0.8 (16/20 trials) in the Addressed conditions and 1 (20/20 trials) in the Overhearing condition. Both ratios were significantly higher than chance (binomial test, chance level = 0.5, both P values <0.006). These results confirm that dogs had learned the toy labels before the test began.

Several studies have found that the majority of family dogs do not present behavioral evidence of learning object labels when engaged in active learning procedures (*23*, *24*, *28*, *32*). In Experiment 2, we examined whether typical family dogs ($n = 10$ Border collies) without a preexisting vocabulary of object labels can acquire new labels with the same Overhearing condition implemented in Experiment 1b. To keep the testing conditions of the typical family dogs as similar as possible to those of the Gifted dogs, during the label comprehension test, the owners were asked to put the two new toys on the floor together with nine other old toys that they had at home. However, as these dogs had no prior label knowledge, they were asked to retrieve only the new toys during the test. Because in each trial the dogs could choose from a set of 11 toys (nine old plus two new), we started the analysis by setting the chance level at 0.09 and found that 6 out of 10 dogs retrieved the correct new toys at significantly above chance level (binomial tests, chance level = 0.09; successful dogs: all P values <0.018, unsuccessful dogs: all P values >0.677; see supplementary materials for individual results). However, when making mistakes, these dogs most often retrieved the other new toy (0.78 ± 0.20 of the cases). Therefore, we repeated their chance tests using the same chance level of 0.5 used for the Gifted dogs, which resulted in zero of the six dogs performing above chance (all P values <0.387). Thus,

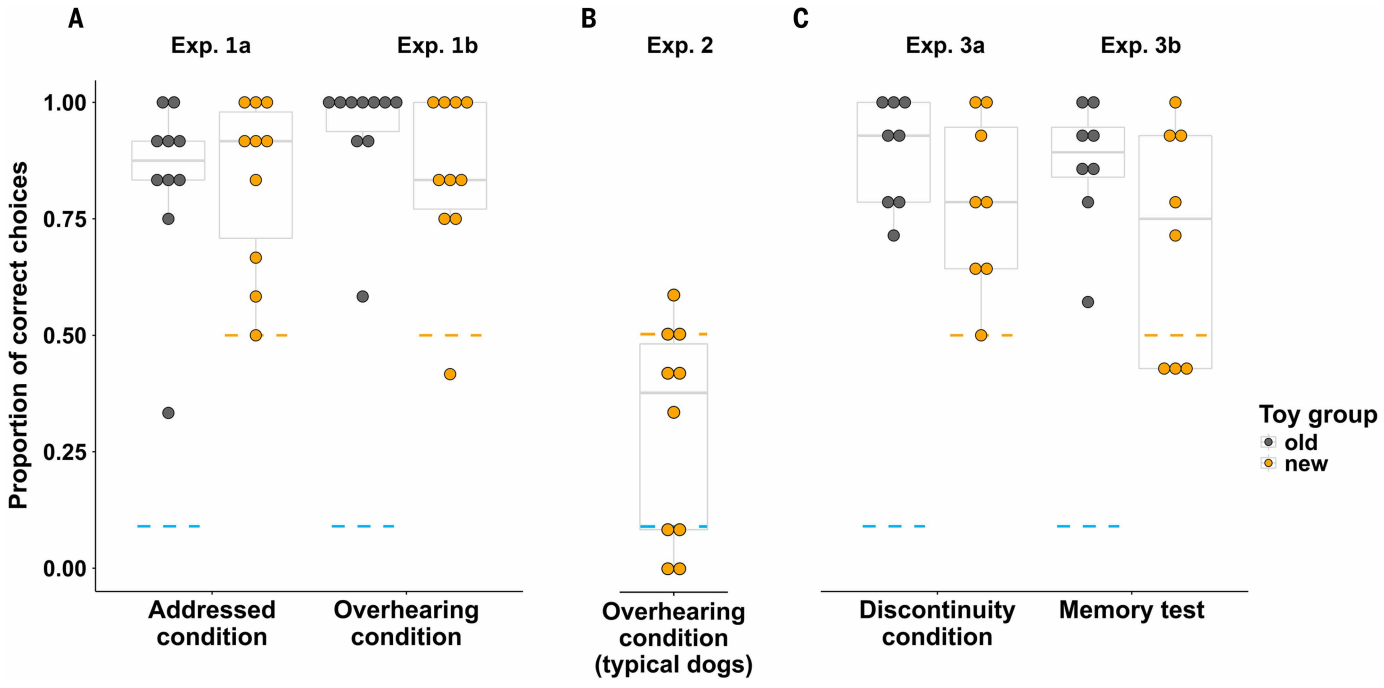

Fig. 2. The dogs' proportion of correct choices in each of the experiments. (**A**) Gifted Word Learner (GWL) dogs' performance with their old (gray) and new (orange) toys in the Addressed (Experiment 1a) and Overhearing condition (Experiment 1b). (**B**) Typical dogs' performance with their new (orange) toys in the Overhearing condition (Experiment 2). (**C**) GWL dogs' performance with their old (gray) and new (orange) toys in the Discontinuity condition (Experiment 3a) and the Memory test (Experiment 3b). Box plots indicate the median, 25th, and 75th percentiles (boxes), and the minimum and maximum (whiskers). Dots represent individual data points. Horizontal dashed lines represent the probability of choosing a toy completely by chance. The blue dashed lines indicate a chance level of 0.09 (considering all the toys available on the floor). The orange dashed lines indicate a chance level of 0.5 (considering only the two new toys).

the behavior of the typical dogs likely reflects their novelty preference and not the learning of object-label mappings.

Several social and nonsocial factors may have contributed to the observed success in Gifted dogs' label learning. One of the nonsocial factors may be the temporal contiguity between the labeling action and presentation of the objects. In Experiment 3a, we explored how temporal discontinuity affects label learning in Gifted dogs ($n = 8$) by applying a label-exposure procedure inspired by studies investigating the same phenomenon in children (*26*) ("Discontinuity" condition). The procedure mirrored the schedule of the exposure phases of Experiment 1 (labeling, play without labeling, and exploration phases) but with a critical modification. During the 1-min labeling session, the owner showed the dog a new toy (e.g., "Toy A"), placed it in a bucket, allowed the dog to take the toy out of the bucket, and then placed it back in the bucket and lifted the bucket, so that the dog could not see its content. Once the toy was out of the dog's view, the owner said the object label embedded within sentences (e.g., "This is <label>.", and "Do you want <label>?"), while alternating their gaze between the content of the bucket and the dog. We controlled for odor cues by using buckets with false bottoms (see supplementary materials). The test phase was similar to the one conducted in Experiment 1, but to enable larger variability in the data, each new toy was asked for seven times (14 trials in total). To explore whether the dogs formed long-lasting object-label mappings, the test was repeated after 2 weeks (Experiment 3b; "Memory" test).

In Experiment 3a, the group-level proportion of correct choices for the new toys was median = 0.79, IQR = 0.64 to 0.95 (see Fig. 2C) and was significantly above chance (Wilcoxon signed-rank test: group performance versus chance level set at 0.5, $W = 28$, $P = 0.011$). At the individual level, five out of eight dogs retrieved the new toys at significantly above chance level (binomial tests, chance level = 0.5; successful dogs: all P values <0.029, unsuccessful dogs: all P values >0.211; see supplementary materials). There was a nonsignificant trend toward a better performance with the old toys as compared with the new toys (Wilcoxon signed-rank test; $W = 15$, $P = 0.059$; old toys = median = 0.93, IQR = 0.79 to 1.00). The group-level accuracy at the first trials with the new toys was 0.81 (13/16 trials) and was significantly above chance level (binomial test, chance level = 0.5, $P = 0.011$), confirming that the dogs had learned the toy labels before the test began. In Experiment 3b—the Memory test conducted 2 weeks after the label comprehension test—the dogs performed equally well (Wilcoxon signed-rank test, $W = 22$, $P = 0.203$; see supplementary materials), suggesting that the dogs' object-label mappings were consolidated.

The findings of Experiment 1 demonstrate that Gifted Word Learner dogs can learn novel object labels by overhearing interactions, in a manner functionally similar to what has been described in young children overhearing triadic interactions [e.g., (*6*, *9*, *10*)]. Additionally, akin to what has been reported for young children during their initial developmental years (*6*, *10*), our study revealed that the Gifted dogs exhibited comparable proficiency in learning object labels whether they actively participated in an interaction or passively overheard it. The findings of Experiment 3a demonstrate that these dogs do not need to rely on temporal continuity to form object-label mappings. In all conditions, 8 min of exposure to the new labels (dispersed over 4 days) proved to be sufficient for learning. The Memory test in Experiment 3b suggests that the object-label mappings did not decay after 2 weeks. As we did not find evidence of learning in typical dogs [see also (*24*, *28*)], the findings presented in this study should not be extended to the general dog population.

It has been hypothesized that the ability of young children to adopt the perspective of others has a crucial influence on their ability to learn from third-party interactions (*3*, *33*). Notably, in 2-year-old toddlers,

the availability of joint attention cues enhanced label learning more than observing social scenes lacking jointness (*8*, *9*), possibly because the lack of jointness interfered with the perspective taking. Previous studies with typical family dogs have demonstrated that dogs are aware of their owner's attentional state and can engage in perspective taking (*17*, *34*). Future studies should examine the extent to which Gifted Word Learner dogs are influenced by the presence or absence of joint attentional cues, because this can shed light on how dogs perceive third-party interactions.

Although temporal continuity may be one of the mechanisms that facilitates object label learning in Gifted Word Learner dogs, the current findings demonstrate that they can learn new object-label mappings even when this mechanism is not available. Thus, during their learning process, these dogs may rely on a variety of learning mechanisms. As family dogs are known for their ability to interpret human directive cues in other contexts [reviewed in (*35*)], the Gifted dogs may use the speakers' communicative signals to support the formation of the object-label mappings. Future studies should examine to which extent other factors, such as the object's saliency and the dog's motivation, may influence label learning.

Children are equipped with a flexible "tool kit" to learn labels under varying conditions. We demonstrated that Gifted Word Learner dogs have flexible skills for learning object labels, some of which are functionally similar to those possessed by children in their first years of life. We cannot assume that these capacities in dogs reflect an evolutionary adaptation comparable to that of humans. It is still unclear how Gifted dogs developed their initial ability to learn object labels. As the phenomenon is very uncommon, we consider it likely that this ability results from idiosyncratic factors. Nevertheless, our findings show that the sociocognitive processes enabling learning from overheard speech are not exclusively human and can, under the right conditions, support label learning in a nonhuman species [see also (*14*, *15*)]. This suggests that in humans, the capacity to learn words from overhearing may build on more general sociocognitive mechanisms that predate language, which were later refined and specialized in our lineage. Future research should continue to examine what are the exact mechanisms that enable Gifted dogs to learn labels—and to what extent these differ from the mechanisms used by young children.

REFERENCES AND NOTES

1. L. A. Shneidman, J. S. Buresh, P. M. Shimpi, J. Knight-Schwarz, A. L. Woodward, *Lang. Learn. Dev.* **5**, 266–281 (2009).
2. R. Brooks, A. N. Meltzoff, *Dev. Sci.* **8**, 535–543 (2005).
3. K. H. Herold, N. Akhtar, *J. Exp. Child Psychol.* **101**, 114–123 (2008).
4. M. E. Barton, M. Tomasello, *Child Dev.* **62**, 517–529 (1991).
5. A. N. Meltzoff, *Dev. Psychol.* **31**, 838–850 (1995).
6. N. Akhtar, J. Jipson, M. A. Callanan, *Child Dev.* **72**, 416–430 (2001).
7. A. Gampe, K. Liebal, M. Tomasello, *First Lang.* **32**, 385–397 (2012).
8. A. Fitch, A. M. Lieberman, R. J. Luyster, S. Arunachalam, *J. Exp. Child Psychol.* **193**, 104793 (2020).
9. K. O'Doherty *et al.*, *Child Dev.* **82**, 902–915 (2011).
10. C. Martínez-Sussmann, N. Akhtar, G. Diesendruck, L. Markson, *J. Child Lang.* **38**, 273–296 (2011).
11. N. Akhtar, *Dev. Sci.* **8**, 199–209 (2005).
12. M. A. Callanan, N. Akhtar, L. Sussman, *First Lang.* **34**, 450–461 (2014).
13. M. D. Hauser, N. Chomsky, W. T. Fitch, *Science* **298**, 1569–1579 (2002).
14. H. Lyn, E. S. Savage-Rumbaugh, *Lang. Commun.* **20**, 255–273 (2000).
15. I. M. Pepperberg, *The Alex Studies* (Harvard Univ. Press, 1999).
16. Á. Miklósi, J. Topál, V. Csányi, *Anim. Behav.* **67**, 995–1004 (2004).
17. B. Hare, M. Tomasello, *Trends Cogn. Sci.* **9**, 439–444 (2005).
18. G. Lakatos, K. Soproni, A. Dóka, A. Miklósi, *Anim. Cogn.* **12**, 621–631 (2009).
19. J. Topál, G. Gergely, A. Erdöhegyi, G. Csibra, A. Miklósi, *Science* **325**, 1269–1272 (2009).
20. M. Gácsi, K. Maros, S. Sernkvist, T. Faragó, A. Miklósi, *PLOS ONE* **8**, e58475 (2013).
21. E. E. Bray *et al.*, *Curr. Biol.* **31**, 3132–3136.e5 (2021).
22. H. Root-Gutteridge, A. Korzeniowska, V. Ratcliffe, D. Reby, *Anim. Cogn.* **28**, 29 (2025).
23. D. Ramos, D. S. Mills, *J. Vet. Behav.* **31**, 92–99 (2019).
24. C. Fugazza, S. Dror, A. Sommese, A. Temesi, Á. Miklósi, *Sci. Rep.* **11**, 14070 (2021).
25. S. Dror, Á. Miklósi, A. Sommese, C. Fugazza, *Sci. Rep.* **13**, 21747 (2023).
26. M. Tomasello, R. Strosberg, N. Akhtar, *J. Child Lang.* **23**, 157–176 (1996).
27. E. L. Axelsson, J. S. Horst, *Acta Psychol. (Amst.)* **144**, 264–268 (2013).
28. C. Fugazza *et al.*, *Sci. Rep.* **11**, 2222 (2021).
29. S. Tempelmann, J. Kaminski, M. Tomasello, *PLOS ONE* **9**, e91014 (2014).
30. C. Yu, L. B. Smith, *Cognition* **125**, 244–262 (2012).
31. P. Kaulfuss, D. S. Mills, *Anim. Cogn.* **11**, 553–556 (2008).
32. D. Remon, thesis, Université Paul Sabatier - Toulouse III (2019).
33. C. Moore, in *Socioemotional Development in the Toddler Years: Transitions and Transformations*, C. A. Brownell, C. B. Kopp, Eds. (Guilford Press, 2007), pp. 43–65.
34. L. Huber, L. Lonardo, *Anim. Cogn.* **26**, 275–298 (2023).
35. J. Kaminski, M. Nitzschner, *Learn. Motiv.* **44**, 294–302 (2013).

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SUPPLEMENTARY MATERIALS

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Materials and Methods; Fig. S1; Tables S1 to S10; References (*36*–*39*);
MDAR Reproducibility Checklist; Data S1 to S5; Movie S1

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