The Quarterly Journal of Experimental Psychology

ISSN: 1747-0218 (Print) 1747-0226 (Online) Journal homepage: http://www.tandfonline.com/loi/pqje20

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Publisher: Taylor & Francis & The Experimental Psychology Society

Journal: *The Quarterly Journal of Experimental Psychology*

DOI: 10.1080/17470218.2017.1322990

Carrying their own weight: Dogs perceive changing affordances for reaching

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Author Note: We thank Dawn McBride for helpful discussion

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Abstract

Choices about when to transition between two modes of behaviour are determined by the fit between action capabilities and environmental properties. However, such transitions typically occur not at the absolute limits of action capabilities but rather based on the relative stability of each mode. People transition from an arm-only to an arm-plus-torso-reach, not when object distance exceeds arm length but when the stability of reaching with the arm-plus-torso exceeds that of reaching with the arm only. To the extent that perception is supported by detection of invariant stimulation patterns, such a transition ought to reflect both the fit between action capabilities and environmental properties and the relative stability of modes regardless of species. We investigated the height at which dogs transitioned from reaching with the head-only to rearing when wearing a weighted backpack—a manipulation expected to decrease the stability of a head-only reach. As expected, the transition occurred at taller heights for tall than for short dogs but at the same ratio of treat-height-to-shoulder-height for both groups. This transition also occurred at shorter heights and smaller ratios of treat-height-to-shoulder-height when dogs wore a weighted backpack. The results suggest that stimulation patterns that support control of behaviour may be invariant across species.

Keywords: affordances, perception-action, animal perception and cognition, reaching

Word count: 2954

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Performing any behaviour requires perceiving whether and how that behaviour can be performed. Such possibilities for performing behaviours are known as affordances (J. Gibson, 2014/1979) and are determined by the task-specific fit between action capabilities and environmental properties. Perception of whether and how to perform a given behaviour reflects this fit (for a review, see Dotov, de Wit, & Nie, 2012). Specifically, choices about when to transition between two modes of performing a given behaviour are determined by this fit. Accordingly, when people are presented with objects at different distances, the boundary between distances perceived to be reachable with an arm-only reach and those perceived to be reachable with an arm-plus-torso reach occurs at a farther distance for long-armed than for short-armed people, but at the same ratio of object-distance-to-arm length for both groups (Carello, Grosofsky, Reichel, Solomon, & Turvey, 1989). That the boundary occurs at different distances but a constant ratio for people who differ in action capabilities is critical in establishing that perception reflects a task-specific relationship between action capabilities and environmental properties.

From the ecological approach to perception-action (J. Gibson, 2014/1979), perception of a given affordance is supported by detection of an invariant stimulation pattern that is informative about the task-specific fit between action capabilities and environmental properties.

This entails not only that such a stimulation pattern is invariant across instances of perceiving and across anatomical components but also that is invariant *across species.* Consequently, choices about when to transition between two different modes of performing a given behaviour ought to be determined by the task-specific fit between action capabilities and environmental properties *regardless of species*. Accordingly, when dogs are presented with food treats at different heights, the transition from reaching with the head only to rearing (a head-plus-torso reach) occurs at taller heights for tall dogs than for short dogs but at the same ratio of treat-height-to-shoulder-height for both groups (Wagman, Langley, & Farmer-Dougan, 2017).

Importantly, the choice to transition from one mode of behaviour to another typically occurs not at the absolute limits of a person's ability but rather based on the relative stability or efficiency (experienced as relative comfort) of each mode. For example, people choose to transition from an arm-only reach to an arm-plus-torso-reach not when object distance exceeds arm length but rather when subjective ratings of comfort of an arm-plus-torso exceed those of an arm only reach (Mark, Nemeth, Gardner, & Dainoff, 1997). We investigated whether relative stability (and hence, likely, experienced comfort) also influences the height at which dogs choose to transition from vertically reaching with the head only to rearing (see Figure 1). We reasoned that while performing a fully extended arm-only (or head-only) reach is somewhat unstable (and hence, likely to be somewhat uncomfortable), doing so while encumbered by carrying a load would likely be even more so. Consider, for example, the relative stability of reaching to a maximum distance with and without carrying an arm-load of groceries. Therefore, we investigated when dogs chose to transition from reaching with the head only to rearing while wearing a weighted or unweighted backpack.

We systematically presented food treats to dogs at various heights and determined the height at which each dog chose to transition from a head-only reach to rearing. Dogs performed this task while wearing a weighted or an unweighted backpack. We expected that choices about when to transition would reflect both the fit between action capabilities and environmental properties (determined by the shoulder height of the dog) and changes in the (relative) stability of performing a head only reach (brought on by the weighted backpack). Specifically, we expected that the transition from head-only to rearing would occur at taller heights for tall than for short dogs, but at the same ratio of treat-height-to-shoulder-height for both groups. Moreover, given the increased instability of performing a fully extended reach with the head- when wearing a weighted backpack, we expected that this transition would occur at *shorter* heights and *smaller* ratios of treat-height-to-shoulder-height when dogs wore a weighted than an unweighted backpack.

Method

Subjects. Twenty dogs (*Canis lupus familiaris)* were recruited from a local animal rescue facility, Illinois State student or faculty owners, and the Illinois State University Service Dog Organization (17 pets, 3 shelter dogs). One of the dogs was deaf. Sample size was based on previous research on perception of affordances for reaching by dogs (Wagman et al., 2017) and humans (cf. Carello et al., 1989; Rosenblum, Wuestefeld, Anderson, 1996) (see Table 1). Written informed consent was obtained from the owner/caretaker of each dog. The project was approved by the Illinois State University Institutional Animal Care and Use Committee.

Materials and Apparatus. A treat delivery apparatus (cf. Wagman et al., 2017) was mounted on the wall directly across from an entry door of a small room (1.5 m × 2.4 m). Each side of the apparatus consisted of a pair of parallel vertical copper pipes (1.27 cm wide × 152.4 cm long) placed one in front of the other (with a 2-cm gap between them) and connected with an elbow connector. The pairs of pipes were placed 50 cm apart, and each end of the apparatus was secured to the wall with bracket and screws. A horizontal crossbar (another copper pipe, 1.27 cm × 60 cm) was fitted into the vertical track created by the two sides of the apparatus. A measuring cup (1 cup, GoodCook) was secured to the bottom of the crossbar. The height of the crossbar was controlled by the experimenter with a string and pulley system attached to the ceiling. A tape measure secured to the wall was used to measure the height of the measuring cup (see Figure 1). Dogs wore a backpack (Outward Hound, size small or medium depending on the size of the dog). Free weight plates in increments of 2.5 lbs (1.13 kg) and 8 oz. glass mason jars of water (0.6 lbs., 0.27 kg.) were used in the Weighted Backpack Condition.

--- Insert Table 1 about here ---

--- Insert Figure 1 about here ---

Procedure. At the beginning of the experiment, a leashed dog was brought into room by the owner/caretaker. The dog was weighed by one of the experimenters and was prompted to sit or stand in front of the treat delivery apparatus. To familiarize the dog with the apparatus, a food treat (chopped hot dogs, Great Value, Wal-Mart brand), was placed into the cup adjusted to the dog's eye height. The dog was prompted to eat the treat by the experimenter. Once this occurred, the treat was replaced. This procedure was repeated until the dog ate the treat without prompting (typically 3-5 replacements). Once this occurred, the dog was prompted to sit or stand approximately 0.5 meters away from the apparatus.

The experimenter placed another treat into the cup and raised it approximately 5 cm from its initial height. The dog was again prompted to eat the treat. This process was repeated until the dog no longer attempted to reach with the head only (see Figure 1, left) and instead attempted to do so by rearing (see Figure 1, right). A rear was defined as raising itself on its hind legs with both front paws completely off the ground. The experimenter then lowered the cup approximately 1.25 cm. This process was repeated until the dog no longer attempted to reach for the food treat by rearing and instead reached for it with the head only. The experimenter then raised the food container by 1.25 cm to reestablish the rearing behaviour.

The minimum height at which rearing occurred, as determined by this procedure, was the rearing boundary for that animal. At minimum, this procedure required 3 adjustments of treat height; most dogs required between 5 and 7 adjustments. Rearing boundaries for each dog satisfied the criteria that (1) rearing occurred twice at this height and (2) rearing did not occur one increment (1.25 cm) below this height.

Each dog performed this task in two different Backpack conditions. In the Weighted condition, weight plates and water bottles were inserted into pockets of the backpack such that the amount of weight was approximately equal to 10% of the dog's weight. Weight was distributed as evenly as possible across left and right pockets of the backpack. In the Unweighted condition, the backpack was empty. Order of Backpack conditions was counterbalanced across subjects.

At the conclusion of the experiment, the experimenter measured shoulder height (from the ground to the highest point of the scapula), hip height (from the ground to highest point on pelvis), and chest-to-tail length (from tip of sternum to pelvis).

Results

Dogs were divided into tall and short groups *post hoc* by shoulder height. Dogs shorter than 58.0 cm were placed into the Short Group (n = 13), and dogs equal to or taller than 58.0 cm were placed into the Tall Group (n = 7). This boundary was based on the range of shoulder heights for the American Kennel Club categories of medium (approximately 44 cm – 51 cm) and large (approximately 58 cm – 66 cm) size dog breeds (cf. Wagman et al., 2017). The mean shoulder height of dogs in the Short Group was shorter (M = 43.0 cm, SD = 11.3 cm) than that of dogs in the Tall Group (M = 62.4 cm, SD = 3.3cm), $t(18) = 4.42$, $p < .001$, Cohen's d = 2.66.

Mean rearing boundaries (in cm) in each condition were compared in a 2 (Height Group: Tall vs. Short) × 2 (Backpack: Weighted vs. Unweighted) Analysis of Variance (ANOVA). A main effect of Height Group revealed that rearing boundaries occurred at taller heights for dogs in the Tall (M = 94.6 cm. SD = 5.5 cm) than in the Short group (M = 67.4 cm, SD = 13.6 cm), $F(1, 18) = 24.94$, $p < .001$, $\eta_p^2 = .58$. A main effect of Backpack revealed that rearing boundaries occurred at taller heights in the No Weight (M = 82.4 cm, SD = 18.1 cm) than in the Weight Condition (M = 79.5 cm, SD = 16.9 cm), $F(1, 18) = 32.87$, $p < .001$, $\eta_p^2 = .64$. The Height Group × Backpack interaction was not significant (see Figure 2, top).

Mean rearing boundaries for each dog in each condition were divided by the shoulder height of that dog. These ratios were compared in a 2 (Height Group: Tall vs. Short) × 2 (Backpack: Weighted vs. Unweighted) ANOVA. A main effect of Backpack condition revealed that ratios were larger in the No Weight (*M* = 1.60, *SD* = 0.14) than in the Weight Condition (*M* = 1.52, SD = .15), $F(1, 18) = 35.08$, $p < .001$, $\eta_p^2 = .66$. Neither the main effect of Height Group nor the Height Group × Backpack interaction were significant (see Figure 2, bottom)[1].

--- Insert Figure 2 about here ---

General Discussion

Previous research has shown that the height at which dogs transition from a head-only reach to rearing occurs at a taller height for tall than for short dogs but at the same ratio of treat-height-to-shoulder-height for both groups (Wagman, et al., 2017). Such research shows that in dogs, as in people, choices about when to transition between two different modes of performing a given behaviour reflect the task-specific fit between action capabilities and environmental properties. However, such choices typically occur not at the absolute critical boundary on a given behaviour but when the stability (or comfort) of one mode of performing that behaviour exceeds that of another mode (Mark et al., 1997). We expected that reaching with the head only would be less stable (or less comfortable) when dogs wore a weighted backpack (especially at the upper limits of this ability). Consistent with this expectation, we found that dogs chose to transition from reaching with the head only to rearing at a shorter height and at a smaller ratio of treat-height-to-shoulder-height when they wore a weighted backpack than when they wore an unweighted backpack.

Importantly, the fit between action capabilities and environmental properties is not static. Rather, it changes continuously over multiple time scales. This fit can change over the course of weeks, months, or years as a person (or dog) undergoes developmental changes in size, strength, coordination, and locomotion experience. Perception of affordances reflects these changes. For example, infants with different degrees of locomotion experience perceive different affordances for traversing surfaces (Adolph, 2008), and younger and older adults perceive different affordances for stair climbing (Konczak, Meeuwsen, & Cress, 1992). This fit can also change from moment-to-moment as a person (or dog) changes body posture or locomotion speed, becomes fatigued, or wears an object attached to the body. Perception of affordances reflects these changes as well. For example, rock climbers perceive different affordances for reaching holds as fatigue during a climb (Pijpers, Oudejans, & Bakker, 2007), and people perceive different affordances for standing on an inclined surface depending on how a backpack changes postural stability (Malek & Wagman, 2008). The results of the experiment reported here suggest that dogs are also sensitive to moment-to-moment changes in fit between action capabilities and environmental properties. Presumably, one of the ways that wearing a weighted backpack changes this fit is by (further) destabilizing the behaviour of reaching to a distance near the limits of one's ability. That dogs transitioned from a head-only reach to rearing *sooner* when wearing a weighted backpack than when wearing an unweighted backpack suggests that they were sensitive to this change.

Much of the research on perception of affordances has focused on perception of affordances by humans (see Dotov et al., 2012). Such work has shown comparable abilities to perceive a given affordance by means of different perceptual modalities or with different configurations of a given modality (see Carello et al., 1989; Rosenblum, 2011; Rosenblum, et al., 1996; Wagman & Hajnal, 2014; Wagman & Hajnal, 2016). Such findings suggest that information about a given affordance is simultaneously available in multiple energy arrays e.g., light, vibration patterns in air, tissue deformation patterns). Therefore, the particulars of a given energy array may be irrelevant to perceiving a given affordance so long as that array can be lawfully structured by the relevant animal-environment relationship. In other words, perceiving a given affordance may not depend on a sensitivity to a particular kind of energy pattern.

A growing body of research, however, has focused on perception of affordances by non-human animals such as rats and hamsters (Cabrera, Sanabria, Jiménez, & Covarrubias, 2013), frogs (Ingle, 1973), mollusks (Branch, 1979), snakes (Jayne, Lehmkul, & Riley, 2014) and hermit crabs (Sonoda, Asakura, Minoura, Elwood, & Gunji, 2012). Such work has shown comparable abilities to perceive a given affordance by different species. Such findings suggest that information about a given affordance is simultaneously available to many different animal species. Therefore, the particulars of *a nervous system and brain* may be irrelevant to perceiving a given affordance so long as the animal is sensitive to how the relevant animal-environment relationship lawfully structures a given energy array. In other words, perceiving a given affordance may not depend on *a particular kind* of brain and nervous system. The results reported here build on this body of research and lend further support to this possibility.

References

Adolph, K. E (2008). Learning to move. *Current Directions in Psychological Science*, *17*, 213-218.

Branch, G. M. (1979). Aggression by limpets against invertebrate predators. Animal Behaviour. 27, 408-410.

Cabrera, F., Sanabria, F., Jiménez, Á. A., & Covarrubias, P. (2013). An affordance analysis of unconditioned lever pressing in rats and hamsters. *Behavioural processes*, *92*, 36-46.

Carello, C., Grosofsky, A., Reichel, F. D., Solomon, H. Y., & Turvey, M. T. (1989). Visually perceiving what is reachable. *Ecological psychology*, *1*, 27-54.

Dotov, D. G., de Wit, M. M., & Nie, L. (2012). Understanding affordances: History and contemporary development of Gibson's central concept. *AVANT. Pismo Awangardy Filozoficzno-Naukowej*, 28-39.

Ingle, D. (1973). Spontaneous shape discrimination by frogs during unconditioned escape behaviour. *Physiological psychology*, 1, 71-73.

Gibson, J. J. (2014). *The ecological approach to visual perception: classic edition*. Psychology Press. (original work published in 1979).

Jayne, B. C., Lehmkuhl, A. M., & Riley, M. A. (2014). Hit or miss: branch structure affects perch choice, behaviour, distance and accuracy of brown tree snakes bridging gaps. *Animal Behaviour*, *88*, 233-241.

Konczak, J., Meeuwsen, H. J., & Cress, M. E. (1992). Changing affordances in stair climbing: The perception of maximum climbability in young and older adults. *Journal of Experimental Psychology: Human Perception and Performance*, *18*, 691-697.

Mark, L. S., Nemeth, K., Gardner, D., & Dainoff, M. J. (1997). Postural dynamics and the preferred boundary for visually guided reaching. *Journal of Experimental Psychology: Human Perception & Performance, 23*, 1365 – 1379.

Malek, E. A., & Wagman, J. B. (2008). Kinetic potential influences visual and remote haptic perception of affordances for standing on an inclined surface. *Quarterly Journal of Experimental Psychology*, 61, 1813-1826.

Pijpers, J. R., Oudejans, R. R., & Bakker, F. C. (2007). Changes in the perception of action possibilities while climbing to fatigue on a climbing wall. *Journal of sports sciences*, *25*, 97-110.

Rosenblum, L. D. (2011). *See What I'm Saying: The Extraordinary Powers of Our Five Senses*. WW Norton & Company.

Rosenblum, L. D., Wuestefeld, A. P., & Anderson, K. L. (1996). Auditory reachability: An affordance approach to the perception of sound source distance. *Ecological Psychology*, *8*, 1-24.

Sonoda, K., Asakura, A., Minoura, M., Elwood, R. W., & Gunji, Y. P. (2012). Hermit crabs perceive the extent of their virtual bodies. *Biology letters*, *8*, 495-497.

Wagman, J. B., & Hajnal, A. (2014). Task specificity and anatomical independence in perception of properties by means of a wielded object. *Journal of Experimental Psychology: Human Perception and Performance*, *40*, 2372-2391.

Wagman, J. B., & Hajnal, A. (2016). Use your head! Perception of action possibilities by means of an object attached to the head. *Experimental brain research*, *234*, 829-836.

Wagman, J. B., Langley, M. D., & Farmer-Dougan, V. (2017). Doggone affordances: Canine perception of affordances for reaching. *Psychonomic Bulletin & Review*

Footnote

[1] Linear regressions showed a strong positive correlation between rearing boundary and shoulder height (Weighted: $r^2 = 0.96$, $p < 0.001$; Unweighted, $r^2 = 0.95$, $p < 0.001$) and a weaker negative correlation between ratio and shoulder height (Weighted: $r^2 = 0.46$, $p < 0.001$; Unweighted, $r^2 = 0.52$, $p < 0.001$). Most likely, this (unexpected) negative correlation was due to the influence of three subjects. When these subjects are removed from the analysis, the relationship between ratio and shoulder height is eliminated entirely, as would be expected (Weighted: $r^2 = 0.02$, $p = 0.64$; Unweighted, $r^2 = 0.07$, $p = 0.32$) (see Wagman et al., 2017). Crucially, removing these participants does not alter the results of any of the other analyses.

Figure Captions

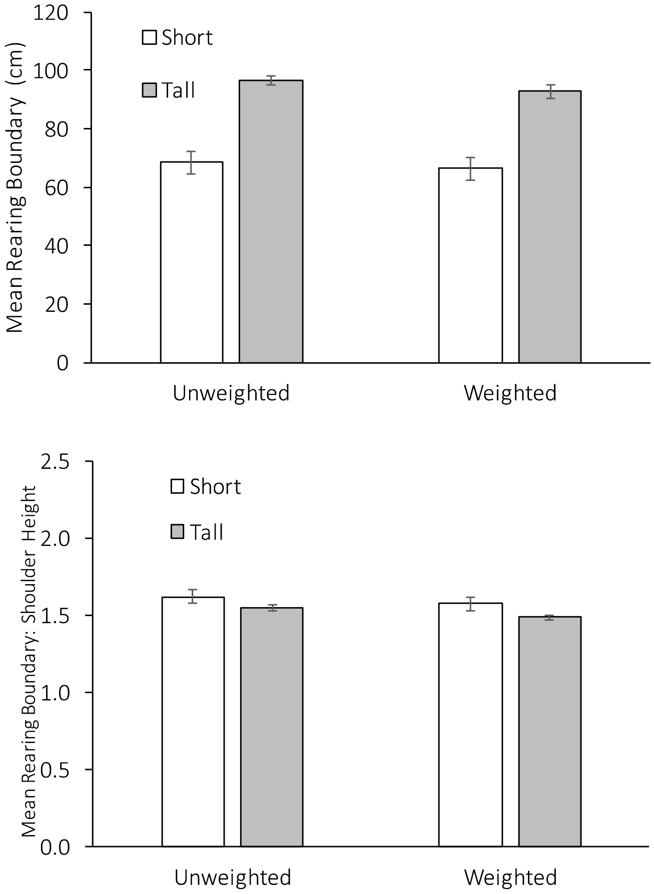
Figure 1. The experimental apparatus, and an example of reaching with the head only (left) and rearing (right).

Figure 2. Mean rearing boundaries (top) and mean ratio of rearing boundaries-to-shoulder-height for Short and Tall dogs in both Backpack conditions.

Table 1. Subject characteristics

Breed	Sex	Age (months)	Status	Shoulder Height (cm)	Chest to Tail Length (cm)	Hip Height (cm)	Dog Weight (kg.)	Backpack Weight (kg.)
Border Collie Mix	F	39	Owned	48.3	53.3	50.8	15.8	1.4
Rottweiler	F	48	Owned	62.2	48.3	62.2	38.3	4.1
Fox Terrier	M	66	Shelter	40.6	45.7	45.7	14.4	1.4
Golden Doodle	M	18	Service	63.5	54.6	63.5	24.3	2.3
Golden Retriever	M	42	Service	68.6	76.2	68.6	52.7	4.5
Chinese Crested	F	108	Shelter	29.2	30.5	29.2	6.8	0.5
Rat Terrier Mix	M	96	Shelter	34.3	26.7	34.3	5.0	0.5
Golden Retriever	M	15	Service	58.4	58.4	55.9	27.0	2.7
Chow Mix	M	33	Owned	61.0	50.8	58.4	27.0	2.7
Bichon Frise	M	96	Owned	27.9	35.6	30.5	11.7	1.4
Shih Tzu/Bichon Mix	F	84	Owned	26.7	29.2	26.7	6.8	0.9
Aussie	M	72	Disabled	57.2	48.3	57.2	27.0	2.7
Brittany Spaniel	M	30	Owned	52.1	43.2	52.1	16.7	1.4
Husky	M	6	Owned	53.3	49.5	52.1	14.4	1.4
Labrador Mix	M	12	Owned	63.5	58.4	63.5	32.4	3.2
Golden Retriever	M	24	Owned	59.7	50.8	59.7	32.9	3.2
Miniature Schnauzer	F	12	Owned	40.6	33.0	40.6	10.4	0.9
Beagle/Terrier Mix	M	24	Owned	53.3	54.6	48.3	22.5	2.3
Miniature Schnauzer	M	60	Owned	38.1	34.3	34.3	9.9	0.9
Shepherd/Lab Mix	M	48	Owned	57.2	48.3	57.2	20.3	2.3
Mean		46.7		49.8	46.5	49.5	20.8	2.0
(SD)		(13.4)		(13.2)	(12.2)	(12.8)	(12.2)	(1.2)


hound


120
100
80
60
40
20
0
Mean Rearing Boundary (cm)
Short
Tall
Unweighted
Weighted
2.5
2.0
1.5
1.0
0.5
0.0
Mean Rearing Boundary: Shoulder Height
Short
Tall
Unweighted
Weighted