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More evidence that less is better: Sub-optimal choice in dogs

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Abstract

The less-is-better effect is a preference for the lesser of two alternatives sometimes observed when they are evaluated separately. For example, a dinner service of 24 intact pieces might be judged to be more valuable than a 40-piece dinner service containing nine broken pieces. Pattison and Zentall (*Animal Cognition,* 17: 1019-1022, 2014) reported similar sub-optimal choice behavior in dogs using a simultaneous choice procedure. Given a choice between a single high-value food item (cheese) or an equivalent high-value item plus a lower-value food item (carrot), their dogs chose the individual item. In a subsequent test, the dogs preferred two high-value items to a single high-value item, suggesting that avoidance of multiple items did not cause the sub-optimal choice behavior. In two experiments, we replicated Pattison and Zentall's procedure while including additional controls. In Experiment 1, habituation of neophobia for multiple items was controlled for by intermixing the two types of test trial within a single experimental session. In Experiment 2, we controlled for avoidance of heterogeneous rewards by including test trials in which a choice was offered between the combination of items and a single low-value item. In both experiments we observed sub-optimal choice behavior which could not be explained by either of these putative mechanisms. Our results, as well as those of Pattison and Zentall, are consistent with the suggestion that dogs' assessment of the total value of multiple items is based, at least partly, on their average quality.

Keywords Comparative cognition · Decision making · Choice · Affective heuristic · Dogs

Introduction

In a variety of situations, people make decisions that are sub-optimal and are based on heuristics rather than a rational and objective consideration of all available information (Kahneman & Tversky, 1979). That is, they sometimes behave in a manner that is inconsistent with maximizing their potential net gains. This can be true when people are asked to make a choice between alternatives or when they evaluate a single option. Some examples of such behavior are the justification of effort (e.g., Aronson & Mills, 1959; Gerard & Mathewson, 1966; Norton, Mochon & Ariely, 2012), the sunk cost effect (e.g., Arkes & Blumer, 1985), and gambling. Explanations for these behaviors include (but are not limited to) cognitive dissonance (Festinger, 1957), loss aversion (Thaler, 1980), difficulty interpreting probabilities (e.g., Denes-Raj & Epstein, 1995), and an intrinsic enjoyment of engaging in the behavior (e.g., Ocean & Smith, 1993). Animals have also been found to display behavior consistent with the justification of effort and sunk cost effects, as well as gambling (for a review see Zentall, 2015).

The less-is-better (or less-is-more) effect is another example of sub-optimal behavior in which people rate a smaller quantity as being better than a larger alternative. Hsee (1998) described a series of experiments in which participants: (i) judged the gift of a (relatively expensive) US$45 scarf as being more generous than that of a (relatively cheap) US$55 coat despite the absolute values of the two gifts, (ii) were willing to pay more for a 5-oz cup overfilled with 7 oz of ice cream than a 10-oz cup underfilled with 8 oz of ice cream even though they were told exactly how much ice cream was in the cup, and (iii) were willing to pay more for a dinner service of 24 intact pieces than for a dinner service containing the same 24 intact pieces, plus an additional 16 pieces, nine of which were broken. In a baseball-card auction, List (2002) found that both professional sports card dealers and non-dealers made higher bids for bundles of ten mint condition cards (with a total value of $15) than they did for bundles containing ten

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mint condition cards plus three cards in poor condition (which had a total value of US$18). Similar effects have been observed in a variety of situations. Medvec, Madey, and Gilovich (1995) reported that athletes who won bronze medals at the 1992 Summer Olympic games tended to be happier than those who won silver medals. Chernev (2011; see also Jiang & Lei, 2014) found that participants who were concerned about their weight estimated that the calorie content of several unhealthy meals (e.g., a hamburger or a bacon and cheese waffle sandwich) was greater than that of the same meal plus a healthy food item (some celery or an apple).

Some of these instances of the less-is-better effect may be attributed to counterfactual thinking ("I could have won gold" vs. "I could have won nothing"), or misconceptions about the benefits of healthy food. The most common explanation of the effect, however, is that people's decisions are influenced by affective heuristics based on attributes of an item that are readily evaluable (Hsee, 1996). It might be relatively difficult, for example, to say just how valuable a 24-piece, or a 40-piece, dinner service is, but it is obvious that one containing broken pieces is sub-standard.

Kralick, Xu, Knight, Khan, and Levine (2012) found a similar less-is-better effect in rhesus monkeys when they were offered a simultaneous choice between two food rewards. Both laboratory and wild monkeys showed a preference for a single high-value food item (a grape or a piece of apple) over a combination of the same high-value item plus a lower-value item (a sugar snap pea, green bean, or slice of cucumber). When the low-value item was offered by itself, the monkeys readily ate it, suggesting that rejection of the combination of items was not due to an aversion for the lower-value item. Kralick et al. concluded that monkeys may employ an affective heuristic when making choices in time-sensitive situations such as foraging.

The less-is-better effect has also been observed in non-primate species. Zentall, Laude, Case, and Daniels (2014) found that pigeons preferred a single high-value pea over a pea plus a low-value milo seed when the birds were fed on a relatively unrestricted diet, although the effect was reversed for food-deprived pigeons. Pattison and Zentall (2014) tested dogs who would each readily eat pieces of both carrot and cheese alone, but preferred cheese when given a choice between them. On test trials, nine out of their ten dogs showed a preference for a piece of cheese by itself over a piece of cheese plus a piece of carrot. One possible explanation for this effect is that dogs prefer single items of food over multiple items, at least when they are well-fed. To test for this possibility, in a second test session Pattison and Zentall gave the dogs a choice between a single piece of cheese or two pieces of cheese. The dogs chose the two pieces of cheese on almost every occasion. It is possible, however, that the dogs avoided multiple items when they first encountered them in the initial, less-is-better, test session, but that this avoidance response habituated over the course of the session and was not present on the subsequent control test session.

The purpose of the experiments reported here was twofold. First, to replicate the procedure of Pattison and Zentall (2014) to further explore the evidence for a less-is-better effect is domestic dogs. Second, to control for potential explanations for the effect in terms of avoidance of either (i) multiple rewards (Experiment 1), or (ii) heterogenous rewards (Experiment 2).

Experiment 1

The design of Experiment 1 was very similar to that of Pattison and Zentall's (2014) experiment. In a preliminary session of training we established that each dog would consume each of the three rewards used in the experiment – a single high-value food item, a single low-value food item, and the combination of the high- and low-value items – and that they showed a preference for the high-value item when offered a choice between it and the low-value item. In a subsequent test session, three types of choice trials were administered. On 24 standard trials a choice was offered between a single high-value item and a single low-value item. Randomly intermixed with the standard trials were six probe test trials and six control trials. On each probe test trial the dogs were offered a single high-value item in one hand or the combination of a high-value item and a low-value item in the other hand. On the basis of Pattison and Zentall's results, it was expected that dogs would choose the single high-value item in preference over the mixture of items. That is, we expected the dogs to demonstrate a less-is-better effect by selecting the smaller overall reward on these trials. On control trials, dogs chose between a single high-value item in one hand and two high-value items in the other hand. These trials were included because, other than on the probe test trials, the dogs had not previously been offered the choice between one and two items as part of the experiment. It is, therefore, possible that a less-is-better effect could be observed simply because the dogs avoided multiple items in favor of individual items. Pattison and Zentall included similar control trials in their experiment, but in a second test session at least 6 h after the less-is-better test session. Because the control trials were administered in a later session it is possible that their dogs had an initial tendency to avoid multiple items but that this avoidance response habituated over the course of training and was not evident in the session test session. By intermixing probe test and control trials within a single test session, we were able to rule out this explanation of our results.

Method

Participants Nine dogs were recruited for the experiment (see Table 1 for details). All were owned by members of the public known to one of the authors. The dogs were aged between 5

Table 1 Information about the dogs that participated in the experiments

Dog	*Breed*	*Age (months)*	*Weight (kg)*	*Sex*	*High-value item*
Arthur	English Cocker Spaniel x Schnauzer	14	7	M	Hotdog
Barney	English Cocker Spaniel	15	14	M	Cheese
Benson	English Cocker Spaniel x Poodle	12	12	M	Hotdog
Fudge	Cavalier King Charles Spaniel	120	18	M	Chicken
Harvey	Doberman Pinscher	48	45	M	Hotdog
Hetti	English Cocker Spaniel x Jack Russel Terrier	19	8	F	Hotdog
Loroli	Cavalier King Charles Spaniel x Bichon Frise	53	10	F	Chicken
Poppy	Jack Russel Terrier	76	9	F	Chicken
Ralph	English Cocker Spaniel	5	16	M	Cheese

and 120 months old (M = 40.2; SD = 38.2), weighed between 7 and 45 kg (M = 15.4; SD = 11.7), and six were male. There were two English Cocker Spaniels, one Doberman Pinscher, one Cavalier King Charles Spaniel, one Jack Russel Terrier, and four spaniel cross-breeds (Cavalier King Charles Spaniel x Bichon Frise, English Cocker Spaniel x Poodle, English Cocker Spaniel x Schnauzer, English Cocker Spaniel x Jack Russel Terrier).

Materials Following Pattison and Zentall (2014), carrots (Grower's Selection, ASDA) were used as the low-value item for all dogs. High-value items were chosen for each dog individually based on the recommendation of its owner, and were given as treats as part of that dog's normal diet. The high-value item was string cheese (Cheestrings Original, Cheestrings) for two dogs, cooked chicken (Chicken Chunks, SPAR) for three dogs, and hotdog sausages (Original Hot Dogs, Princes) for the remaining four dogs. Low- and high-value items were cut into 5-mm slices of 10-mm diameter for dogs weighing over 12 kg and 2.5-mm slices of 5-mm diameter for smaller dogs. All food items were placed in separate plastic containers and were kept out of sight and reach of the dogs during the experiment. Fragrance-free wipes (Chemical Free Baby Wipes, Waterwipes) were used after each trial to clean the experimenter's hands.

Procedure All testing took place in the dogs' homes in the presence of their owners over two sessions. At the beginning of the screening session, three simple consumption tests were administered in which the dog was offered: (i) a single low-value item, (ii) a single high-value item, or (iii) a low-value item and a high-value item. These tests were conducted in a random order for each dog, with an interval of 5 min between tests. Once it had been confirmed that all dogs would consume the different foods, ten standard choice trials were delivered, using a procedure closely modelled on that used by Pattison and Zentall (2014). On each trial, the experimenter knelt on the floor directly in front of, and facing, the dog that was seated approximately 1 m away. The dog's owner was seated immediately behind the dog, and held onto the dog's collar until instructed to let go. At the beginning of each trial, the experimenter held up her left hand, keeping it open, and announced the food that was being offered. The same was repeated with her right hand, so that the dog could see and smell the items in each hand. Both hands were then lowered, palms facing up, and with the items in the center of each palm, until they were flat on the floor in front and to the sides of the experimenter's legs. Throughout this process, the experimenter's gaze remained fixed on the floor in front of her. After approximately 3 s the experimenter gave the verbal cue "Choose," at which point the owner released their hold on the dog's collar. As soon as the dog made contact with either one of the experimenter's hands, the other hand was closed to cover the overlooked item(s), and the dog was allowed to consume the chosen item(s) before returning to its owner. The experimenter then cleaned her hands with water wipes and prepared the items for the next trial. On each of these standard trials, the dogs were given a choice between a single low-value item and a single high-value item. The hand containing the high-value item varied from trial to trial in a pseudo random order with the constraints that it was held in each hand on half of the trials and that there were no more than three successive trials on which it was held in the same hand. There was an interval of approximately 1–2 min between successive trials, as the dog returned to its owner and the experimenter prepared for the next trial.

The experimental session took place on the following day. This session consisted of 24 standard trials that were conducted in the same manner as those during the screening session. Twelve test trials were randomly intermixed with the standard trials. Six of these were probe trials in which the dogs were given a choice between a single high-value item and the combination of a low-value item and a high-value item. The remaining six trials were control trials in which the choice was between a single high-value item and two high-value items. Across standard, probe, and control test trials, the high-value item was offered equally often in each hand. There were an equal number of each type of test trial in the first and second halves of the experimental session. No more than four standard, or two test, trials occurred in succession.

Results and discussion

All dogs ate each of the three items or combinations of items during the initial consumption test. No dog exclusively chose one hand during the screening trials, but two (Benson and Harvey) did choose the right hand on nine out of ten trials. An exact binomial test indicated that this was more than would be expected by chance, p = .021. No dog, however, showed a significant side bias during the experimental session. The most times that any dog chose either one side during that session was 24 times out of 36, which an exact binomial test found was not statistically significant, p = .065. The three dogs who chose one side 24 times (Barney, Benson, and Poppy) were included in the analyses reported below, but additional tests were performed from which their data were excluded. Because these tests revealed the same overall pattern of results and significant effects, their results are not reported.

The proportion of trials on which each dog made the optimal choice (high-value item on standard trials or the combination of two items on test trials) is shown in Fig. 1. All dogs chose the single high-value item more often than the single low-value item on standard trials. The mean percentage of trials on which the high-value item was chosen was 71.3% (range 54–96). A one-sample t-test of individual choice behavior showed that the high-value item was chosen significantly more than the low value item, $t(8) = 5.47$, $p < .001$, d = 1.82, 95% confidence interval of the mean (CI) 62.3–80.3.

On probe test trials, six of the nine dogs chose the combination of a high-value item and a low-value item less often than the single high-value item. The remaining three dogs chose the two alternatives equally often. Overall, the combination of items was selected on just 27.8% of trials (range 0–50), which a one-sample t-test found was significantly less than the single high-value item, $t(8) = 3.02$, $p = .016$, d = 1.01, 95% CI 10.8–44.7.

Seven of the nine dogs chose the two high-value items more often than a single high-value item on the control test trials. The other two dogs showed no preference. The two high-value items were chosen on 68.5% of all trials (range 50–83%), which was significantly more than the single high-value item according to a one-sample t-test, $t(8) = 4.26$, $p = .003$, d = 1.42, 95% CI 58.5–78.5.

We successfully replicated the less-is-better effect previously reported by Pattison and Zentall (2014). Six out of nine dogs showed a less-is-better effect: A preference for a single high-value item over the combination of a high-value item plus a low-value item. The remaining three dogs showed no preference for either alternative. On control trials, most dogs also showed a preference for two high-value items over a single high-value item. This suggests that the less-is-better effect was not due to avoidance of multiple items on the probe test trials. The probe test trials were, however, the only occasions on which the dogs were given a choice where one of the alternatives consisted of a mixture of different items. It is, therefore, possible that the less-is-better effect was caused by an avoidance not of multiple items, but of a heterogeneous collection of items. The purpose of Experiment 2 was to test this possibility.

Experiment 2

The same nine dogs were tested in a single session at least a week after the completion of Experiment 1. This session was the same as the test session of Experiment 1 with the exception that the dogs were offered a choice between a single low-value item and a combination of a low-value item and a high-value item on the six control trials.

Method

Participants The participants were the same nine dogs that took park it Experiment 1.

Materials The materials were the same as for Experiment 1.

Procedure Testing took place approximately 1 week after Experiment 1. The procedure was the same as for Experiment 1 with two exceptions. Because all the dogs had taken part in Experiment 1, there was no initial screening session and all testing took place in a single session. On each of the six control trials, the dogs were given a choice between a single low-value item and the combination of a high-value item and a low-value item. The hands in which these were held was counterbalanced across trials.

Results and discussion

No dog showed a significant side bias during the experimental session. The most times that any dog chose one side during that session was 23 times out of 36, which an exact binomial test found was not statistically significant, p = .132.

The proportion of trials on which each dog made the optimal choice (high-value item on standard trials or the combination of two items on test trials) is shown in Fig. 2. All dogs chose the single high-value item more often than the single low-value item on standard trials. The mean percentage of trials on which the high-value item was chosen was 90.7% (range 79–96%). A one-sample t-test of individual choice behavior showed that the high-value item was chosen significantly more than the low value item, $t(8) = 19.8$, $p < .0001$, d = 6.60, 95% CI 86.0–95.5.

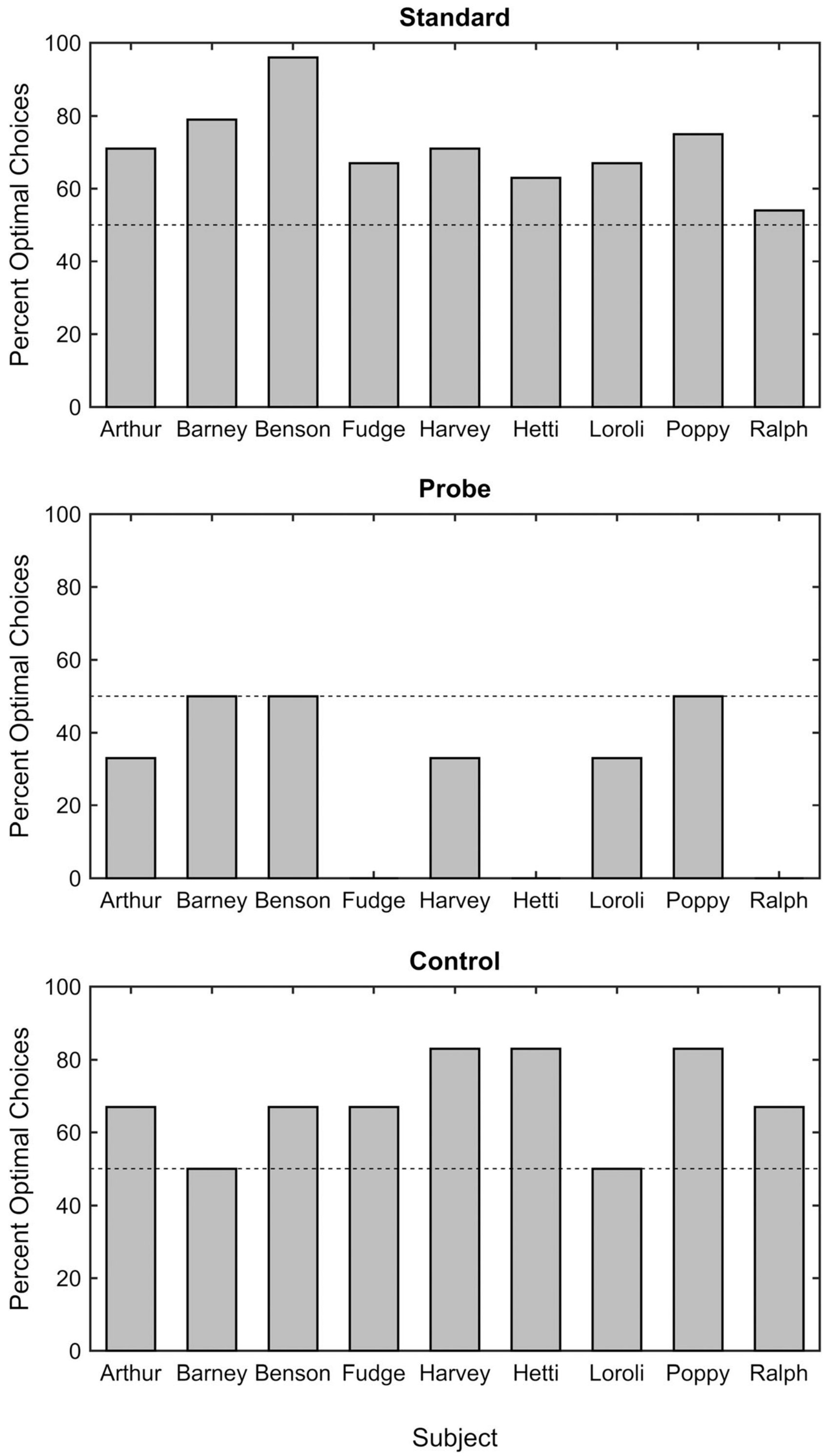

Fig. 1 Percent optimal choices made by each dog during Experiment 1. Dogs reliably chose the high-value item over the low-value item on standard trials (top panel). They also tended to choose a high-value item over a high-value item plus a low-value item on probe test trials (middle panel). Two high-value items were preferred to a single high-value item on control trials (bottom panel). Dotted lines show chance performance (50%)

On probe test trials, all of the nine dogs chose the combination of a high-value item and a low-value item less often than the single high-value item. Across all trials, the combination of items was selected on just 13% of trials (range 0–33%), which a one-sample t-test found was significantly less than the single high-value

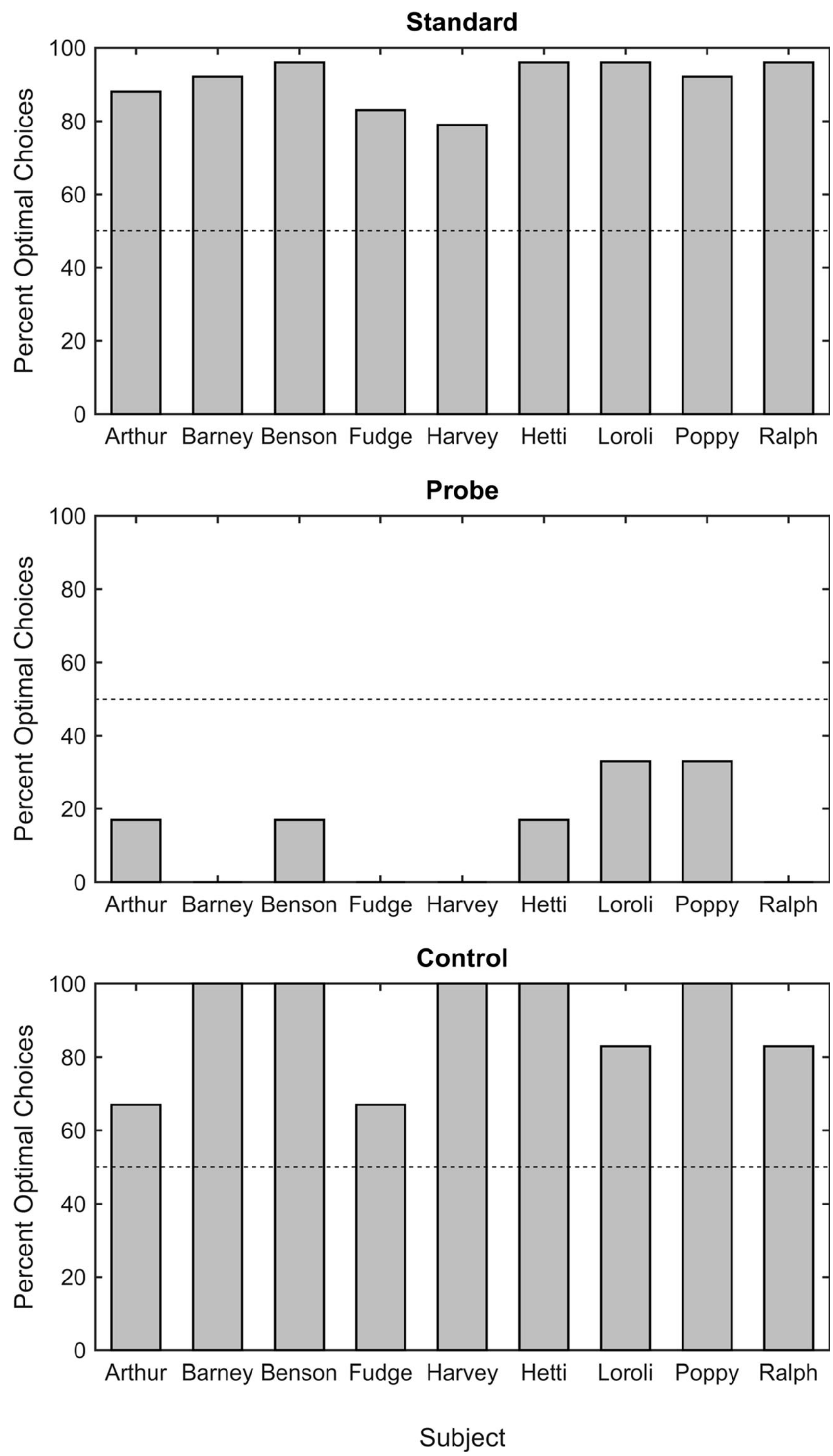

Fig. 2 Percent optimal choices made by each dog during Experiment 2. Dogs reliably chose the high-value item over the low-value item on standard trials (top panel). They also reliably chose a high-value item over a high-value item plus a low-value item on probe test trials (middle panel). The combination of a high-value item and a low-value item was preferred to a single low-value item on control trials (bottom panel). Dotted lines show chance performance (50%)

item, $t(8) = 8.00$, $p < .0001$, $d = 2.67$, 95% CI 2.3–23.6.

All of the dogs chose the combination of a high-value item and a low-value item more often than a single low-value item on the control test trials. The combination of items was chosen on 88.9% (range 67–100%) of all trials, which was significantly more than the single low-value item according to a one-sample t-test, $t(8) = 8.08$, $p < .0001$, $d = 2.69$, 95% CI 77.8–100.0.

We again found a clear less-is-better effect on the probe test trials. Each of the nine dogs selected the single high-value item more frequently than the combination of a high-value item and a low-value item. On the control trials, however, all nine dogs chose the combination of items in preference over a single low-value item. These results suggest that the less-is-better effect is not caused by an avoidance of heterogeneous rewards.

General discussion

In two experiments we observed a less-is-better effect in domestic dogs. Each dog was happy to consume either a high-value item (a piece of cheese, chicken, or hotdog) or a low-value item (a piece of carrot) alone. When given a choice between a high-value item and a piece of carrot, the dogs reliably chose the high-value item. On probe test trials, however, where they were given a choice between a single high-value item and an identical high-value item plus a piece of carrot, the dogs chose the alternative with the lower total value – the single high-value item. Control trials in Experiment 1 showed that this effect was not caused by an avoidance of multiple food items; the dogs chose two high-value items in preference over a single high-value item. On control trials in Experiment 2, the dogs were offered a choice between the combination of a high-value item and a piece of carrot in one hand or a piece of carrot by itself in the other hand. The dogs preferred the combination of items, suggesting that their choice on probe test trials was not determined by an avoidance of heterogeneous collections of food items.

Optimal foraging theory (Stephens & Krebs, 1986) suggest that animals should always choose the option that will lead to the greatest net energy gain. In the simple tasks that have been discussed here animals were given a choice between two alternatives with a delay between trials. In these situations, they should select the most calorific option because this will maximize their rate of energy gain over the testing session. Failure to behave optimally does not reflect an inability to discriminate between quantities. Non-human animals including great apes (Beran, 2001; Call, 2000; Hanus & Call, 2007; Rumbaugh, Savage-Rumbaugh, & Hegel, 1987), old world monkeys (Jordan & Brannon, 2006), new world monkeys (e.g., Addessi, Crescimbene, & Visalberghi, 2008; Anderson, Awazu, & Fujita, 2000; Gazes, Billas, & Schmitt, 2017), rodents (Panteleeva, Reznikova, & Vygonyailova, 2013), birds (Kelly, 2016), fish (Agrillo, Dadda, & Bisazza, 2007; Agrillo, Dadda, Serena, & Bisazza, 2008), amphibians (Uller, Jaeger, Guidry, & Martin, 2003), and canids (Baker, Shivik, & Jordan, 2011; Utrata, Virányi, & Range 2012), including domestic dogs (Baker, Morath, Rodzon, & Jordan, 2012; Miletto Petrazzini & Wynne, 2016; Prato-Previde, Marshall-Pescini, & Valsecchi, 2008; Ward & Smuts, 2007), have all been found to be capable of quantity discrimination and, where tested, show a preference for larger quantities over smaller quantities of the same food. We also found evidence for such a preference. On control trials in Experiment 1, the dogs were given a choice between one and two of the same high-value items and showed a significant preference for the two items (see also Pattison & Zentall, 2014).

Quantity judgments are, however, sensitive to a number of factors. For example, when chimpanzees were presented with sets of different-sized pieces of the same food (graham crackers), Beran, Evans, and Harris (2008) found that they sometimes chose the set containing the smaller total amount of food but the largest single item (but see Miletto Petrazzini & Wynne, 2016 for a failure to replicate this effect in dogs). The absolute size of each alternative (the magnitude effect) and the difference between them (the distance effect) also affect preference for the larger total amount of food (e.g., Call, 2000; Hanus & Call, 2007; Silderberg, Widholm, Bresler, Fujita, & Anderson, 1998). Silderberg et al. (1998) also found that rhesus macaques tend to ignore quantities of food larger than that which can be consumed in a single meal, and only assign a value to the preferred food type within a mixture (the selective value effect). While each of these factors might explain a reduction, or the elimination of, a preference for the larger of two collections of food items, none of them, either individually or together, can explain the reversal of the preference observed in our experiments. Beran, Evans, and Ratliff (2009) found that when chimpanzees were given a choice between one large food item and an identical large item plus a smaller piece of the same food, they often showed no preference for either alternative. They speculated that the apes may have been reluctant to choose the pair of items in fear that they might only receive the smaller of the two items. Their later experiments, however, provided no support for this hypothesis and it is unlikely that such a fear could explain the results of our experiments. Six of our nine dogs selected the combination of items on at least two probe test trials, and all dogs chose the two high-value items on at least three control trials in Experiment 1. This gave the dogs plenty of opportunity to learn that they got to keep all items that they chose but, if anything, they showed a greater preference for the single high value item on probe test trials in Experiment 2.

Hsee (1998) attributed the less-is-better effect in humans to the influence of affective heuristics on decision making. Some attributes of objects or situations are difficult to evaluate independently, whereas other attributes are more easily evaluable. When people are asked to make separate evaluations of items, they base their decision on the easily evaluable attributes. It may be difficult to judge the absolute effect that the number of pieces in a dinner service might have on its value, but it is obvious that a dinner service containing broken pieces is deficient. Hence, people may be willing to pay a higher price when presented with a set of 24 intact pieces than when they are presented with a set of 40 pieces, nine of which are broken. If the two alternatives are presented together, however, they may be compared on all of their attributes and a relative judgment can be made. Under conditions of joint evaluation, the less-is-better effect tends to be reversed and people's judgment of items follows their monetary value. Further support for the evaluability hypothesis was provided by Hsee (1996), who systematically manipulated the evaluability of objects' attributes and observed an effect of evaluability when items were separately evaluated, but not when they were jointly evaluated. In the experiments reported here, and in previous demonstrations of the less-is-better effect in non-human animals (e.g., Kralik et al., 2012; Pattison & Zentall, 2014; Zentall et al., 2014), the subjects have been offered a simultaneous choice between the alternative – the condition under which the effect is not observed in humans. In a simultaneous choice task, Beran, Ratliff, and Evans (2009) found that chimpanzees tended to make the optimal choice. Their chimpanzees showed a preference for a single piece of banana over a single piece of apple. When offered a choice between a piece of banana alone, or a piece of banana plus a piece of apple, two chimpanzees preferred the mixture of items whereas two other chimpanzees showed no preference. Kralik et al. (2012) suggest that the difference between the optimal performance on simultaneous choice tasks of humans and chimpanzees and the sub-optimal performance of rhesus monkeys (and, by extension, pigeons and dogs) can be explained if all of these species make use of affective heuristics, but differ in their ability to override the heuristics where appropriate. Hominids' executive functions may allow them to behave more flexibly than other species.

Kahneman, Fredrickson, Schreiber, and Redelmeier (1993) exposed human participants to two unpleasant conditions. In one condition, they were required to immerse one hand into cold water (14°C) for 60 s. In the other condition, they immersed the hand in the cold water for 60 s and then for an additional 30 s during which the temperature of the water was gradually raised slightly, but sufficiently to significantly reduce the associated pain (to 15°C). When they were later asked which experience they would prefer to repeat, most participants (69%) chose the longer trial. This result is analogous to the less-is-better effect since participants found the short trial, during which they presumably experienced less total pain, to be more aversive than the longer trial. Kahneman et al. suggested that participants selected the long trial because their retrospective evaluation of the experiences were based largely upon their worst point (which might be expected to be the same in each case) and their final moments. Because the long trial ended with less pain than the short trial, it was evaluated as less unpleasant. It is possible that the choices made by our dogs might be explained in a similar way if we assume that when they chose the mixture of items they ate the high-value item first and the piece of carrot second. We have no way of knowing whether this is the case; when a dog made a choice, the item(s) that they had selected were offered in an open hand and the dog took them into its mouth. The performance of the dogs is, however, consistent with the suggestion that choices were influenced by past behavior. All dogs had some limited experience of the mixture of items in the initial screening session of Experiment 1. During the test session, five of the nine dogs chose the mixture of items on their first probe test trial and one of the other four chose it on their second probe test trial. Hence, including the three dogs who selected the single high value item on all six probe test trials, all of the dogs had experience of the mixture before developing a preference for the single high-value item on their remaining probe test trials. In Experiment 2, which was conducted after the dogs had consumed the mixture of items in Experiment 1, and during which the mixture was also given on control test trial, the magnitude of the less-is-better effect was slightly larger than it had been in Experiment 1. Hence, it appears that the magnitude of the effect was affected by learning across the two experiments. A more direct test of the contribution of the end-point effect to the less-is-better effect in dogs might be conducted by ensuring that dogs receive the multiple food items, when chosen, in a specific order.

Another possibility is that the standard choice trials that made up the majority of trials in both experiments taught the dogs to avoid the piece of carrot. On these standard trials, the dogs were offered a piece of carrot in one hand, and a preferred food item in the other hand. The dogs earned the greatest reward on these trials both for selecting the preferred food and for avoiding the carrot. Hence, the carrot may have been established as an explicit signal that the other alternative was better. This learning may have transferred to the probe test trials where avoidance of the carrot would lead the dogs to choose the single preferred item over the mixture containing carrot. Acquisition of such an avoidance response would explain the increase in the magnitude of the less-is-better effect from Experiment 1 to Experiment 2. This account is also consistent with performance on the control test trials. In Experiment 1, no carrot was present on these trials and so the dogs simply chose the larger reward. In Experiment 2, carrot was present in both alternatives, and dogs chose the option containing the preferred food item.

In conclusion, when given the choice between a single high-value item and an identical high-value item plus a low-value item, dogs chose the single item meaning that they earned less food than they could have. This effect cannot be explained as an avoidance of multiple items, or avoidance of a mixture of items. Nor can it be explained as a failure to discriminate between quantities. Our results are consistent with the suggestion that decision making in animals is influenced by the same type of affective heuristics that affect human decision making. Animals' use of these heuristics may, however, be less flexible than humans'. Our dogs appear to have based their choices on an evaluation of the average quality of each alternative rather than their total calorific value despite their availability for side-by-side comparison. Use of a heuristic based on quality is, however, likely to result in optimal behavior in many natural situations, and only produces sub-optimal behavior in limited situations such as a deliberately contrived laboratory setting using a choice procedure which is unfamiliar to most animals. Alternatively, exposure to the choice procedure in the form of the numerous standard choice trials, might have resulted in the acquisition of a learned avoidance response for the low-value item. Clearly, these last two explanations of our results make opposite predictions about the effect of extended training on the magnitude of the less-is-better effect, which can be tested empirically.

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