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Sex and Order of Presentation Influence the Decoy Effect in Shoal Size Preference Task in Adult Zebrafish

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Abstract – The decoy effect is a cognitive bias where the introduction of an inferior third option shifts relative preference between two alternatives. Such biases influence foraging, mate choice, and social interactions across species. We investigated whether adult zebrafish (*Danio rerio*) exhibit the decoy effect in shoal size preferences by comparing their decisions in dichotomous (two-choice) and trichotomous (three-choice) contexts. In Experiment 1, using females as display fish, we compared dichotomous (4 vs. 2 and 6 vs. 3) and trichotomous (4 vs. 2 vs. 1 and 6 vs. 3 vs. 1) sets while counterbalancing the order of presentation. In the trichotomous sets, a single-fish shoal was added as a decoy, representing the most inferior alternative relative to the two primary options. Only females showed a baseline preference for the larger shoal in both the 4 vs. 2 and 6 vs. 3 contrasts. Males preferred the larger shoal in dichotomous trials only when they had been exposed to the decoy in the preceding trial. In contrast, females that initially preferred the larger shoal in the dichotomous condition lost this preference when the decoy was introduced in the subsequent trichotomous condition. Although the conventional attraction-type decoy effect was not observed, prior exposure to the decoy in males elicited a repulsion-like shift to prefer the larger shoal, suggesting cognitive adjustment to the geometry of the choice set rather than random dilution. In Experiment 2, we replicated the trichotomous-first condition for males and the dichotomous-first condition for females, using males as display fish with the 4 vs. 2 contrast. Females showed no baseline preference for the larger shoal, and males did not exhibit a decoy effect. Notably, our findings show that zebrafish evaluate shoal size options contextually, influenced by presentation order, geometry of the choice set, and sex. These results provide new insights into shoaling decisions, with methodological implications for comparative studies of rationality and decision-making across species.

Keywords – Decoy effect, Shoaling preference, Zebrafish, Rationality, Multi-alternative decision making, *Danio rerio*

Animals in the wild consistently make decisions that enhance their survival. Since poor choices can be costly, animals are expected to make decisions that maximize their fitness. Economic rationality defines individuals as rational when they consistently choose options that maximize their value obtained from their choices (Glimcher & Fehr, 2013). Rationality is upheld if choices follow the rules of transitivity and the independence of irrelevant alternatives (IIA), both of which pertain to the stability of preference order. Transitivity holds if an individual that prefers option A over B, and B over C, also prefers A over C

(Glimcher & Fehr, 2013). The independence of irrelevant alternatives principle states that the relative preference between two options should remain constant regardless of the presence of additional alternatives (Ray, 1973). Specifically, Luce's choice axiom of constant ratios IIA(L) is upheld when the ratio of the probabilities of choosing A and B in the choice set A, B remains constant even with a larger choice set A, B, C (Luce, 1959).

Both transitivity and independence of irrelevant alternatives are frequently violated by humans (Dumbalska et al., 2020; Trueblood et al., 2013; Tversky & Simonson, 1993) and non-human animals (slime molds: Latty & Beekman, 2011; ants: Edwards & Pratt, 2009; birds: Bateson et al., 2002, 2003; monkeys and humans: Louie et al., 2013). These violations of rationality largely stem from the context dependence of decision-making, implying that the cognitive systems evaluate options relative to context or through comparisons across choice attributes (Vlaev et al., 2011). Rather than assigning stable, intrinsic values to options, animals may rely on heuristic or non-compensatory decision-making strategies that adjust based on contextual cues (Latty & Trueblood, 2020).

A well-documented violation of the independence of irrelevant alternatives is the decoy effect, where the presence of a strategically placed third option, known as a decoy, shifts preferences between two primary alternatives. Decoys are typically asymmetrically dominated within a two-attribute choice space: they are clearly inferior in one attribute (e.g., entrance size in *Temnothorax* nest sites, where colonies prefer smaller entrances) but comparable in another (e.g., interior darkness, which is also strongly preferred by *Temnothorax* colonies) (Edwards & Pratt, 2009). By disproportionately influencing one attribute dimension, decoys can bias choices toward the dominant option and give rise to context specific interactions between the psychophysical value functions of different attributes (Bateson et al., 2003, 2002; Hu & Yu, 2014; Latty & Beekman, 2011; Latty & Trueblood, 2020; Morgan et al., 2012; Nachev et al., 2017; Parrish et al., 2015; Rivalan et al., 2017; Shafir et al., 2002; Trueblood & Pettibone, 2017). The attraction effect, where adding a decoy shifts preference toward the alternative most similar to it (Huber et al., 1982), has received particular attention in both human (Trueblood et al., 2013, 2015) and non-human animal studies (Bateson et al., 2003; Latty & Beekman, 2011; Shafir et al., 2002). Despite extensive investigation in multi-attribute choice contexts, the decoy effect has been only rarely examined in single attribute decisions (for example, Morgan et al., 2012).

Cognitive biases, like the decoy effect, pose an evolutionary challenge because they can lead to suboptimal decision-making that deviates from utility maximization (Cohen & Santos, 2017). Natural selection may favor decision-making rules that, though not perfectly optimal, perform well under the ecological conditions an organism typically encounters, making them ecologically rational (Fawcett et al., 2014; Hutchinson & Gigerenzer, 2005; Todd & Gigerenzer, 2007). Such heuristics enable animals to make rapid and effective choices using limited information, minimizing cognitive and energetic costs, while maintaining adequate accuracy (Fawcett et al., 2014; Marsh, 2002). Reverse engineering these biases by first identifying cognitive biases that are not explained by existing theoretical frameworks, and then exploring their adaptive significance, can provide insights into the evolutionary pressures shaping decision-making processes (Fawcett et al., 2014).

Shoal size preference in fish provides an ecologically relevant context for examining cognitive biases such as the decoy effect, requiring individuals to evaluate multiple social alternatives that differ quantitatively in group size. Most fish species prefer larger shoals, which confer multiple benefits such as reduced predation risk, enhanced foraging efficiency, and greater reproductive opportunities (Agrillo & Dadda, 2007; Binoy & Thomas, 2004; Buckingham et al., 2007; Seguin & Gerlai, 2017; Svensson et al., 2000). Shoal size decisions are also linked to numerical competence and often follow Weber's law, where perceived differences between numerical sets are represented logarithmically rather than linearly (Gomez-Laplaza & Gerlai, 2016; Miletto Petrazzini et al., 2016; Seguin & Gerlai, 2017). Zebrafish (*Danio rerio*), a well-established model in genetics, developmental biology, and biomedical research (Choi et al., 2021; Norton & Bally-Cuif, 2010), have increasingly become a focus in behavioral and ecological studies (Parichy, 2015; Spence et al., 2008). Like many other fish species, zebrafish prefer associating with a shoal over isolation (Ariyasiri et al., 2019; Etinger et al., 2009), and their shoaling preferences are shaped by factors such as shoal size, familiarity, and composition (Krause et al., 1999; Pritchard et al., 2001; Swaney et al., 2025; Velkey et al., 2022). Sex differences have also been reported in social behavior: as compared to males, females exhibit a stronger preference for larger shoals (Etinger et al., 2009; Ruhl & McRobert, 2005), can discriminate fine strain differences (Snekser et al., 2010), and show increased shoal proximity following ethanol pre-exposure (Clayman et al., 2017).

A typical shoaling preference test consists of a three-tank setup, where a focal fish in the central tank is presented with two shoal size options in adjacent tanks. The fish's preference is inferred from the time spent or frequency of visits near the zones adjacent to the display tanks (Lucon-Xiccato et al., 2017; Seguin & Gerlai, 2017). Reding and Cummings (2019) extended the shoaling preference test in mosquitofish (*Gambusia affinis*) to explore multi-alternative shoaling choices and investigate the decoy effect in shoal size preferences. A female focal fish in a circular transparent tank was tested under three conditions: first, a dichotomous choice between shoals of two and four fish; then, two trichotomous choices in which an additional shoal of one or three fish was included. The fish did not alter their relative preference for the larger shoal (4 fish) over the smaller shoal (2 fish) in the presence of the decoy shoals (1 or 3 fish).

In this study, we adapted the design of Reding and Cummings (2019) to investigate the decoy effect in adult zebrafish using a multi-alternative shoal size choice task. A focal fish, placed in a central cylindrical transparent tank, observed multiple shoals in surrounding display tanks. Shoaling preferences were tested unidimensionally by varying only the shoal size. Binary choices were presented between shoals of *4 versus* 2 fish and *6 versus* 3 fish, with a single fish serving as the decoy, the most inferior option in the set. While both contrasts maintained a constant ratio of 2:1, they differed in absolute magnitude. These ratios were chosen because zebrafish have been shown to reliably discriminate shoal size contrasts of 2:1 or greater (Seguin & Gerlai, 2017). To assess potential order effects, subject fish experienced either a dichotomous-first condition (binary choice first, then the decoy) or a trichotomous-first condition (decoy introduced first, then removed), with both sexes tested as subjects and displays. This design allowed us to examine how the decoy, presentation order, and sex influence shoaling preferences, and whether the addition or removal of a decoy shifts preference between two shoal sizes.

Methods

Ethics Statement

All procedures involving animals were conducted in accordance with the guidelines established by the Committee for Control and Supervision of Experiments on Animals (CCSEA), adhering to both national and institutional ethical standards for the care and use of animals. Ethical approval was obtained from Ashoka University's Institutional Animal Ethics Committee (approval no. ASHOKA/IAEC/2/2022/6).

Subjects

Adult captive-bred zebrafish (*Danio rerio*) (N=118; age <1 year) were procured from a local pet store in Daryaganj, New Delhi, India. All fish were maintained in the ZebTec Active Blue - Stand Alone system (Tecniplast, PA, USA) and maintained on a 12:12 light:dark (10 a.m. - 10 p.m.) circadian cycle at 7.50-8.50 pH, 28-30°C and 650-700 µS conductivity at Ashoka University, Sonipat, Haryana, India. Fish were fed *ad libitum* twice a day with powdered Tetra-Tetramin flakes.

Fish of similar size were individually housed for two weeks prior to the shoaling experiments in separate, adjacent transparent tanks within the same ZebTec system, under the same environmental and feeding conditions described above, with visual access to neighboring individuals of the same sex. Adult fish from the same population were randomly selected as display fish for the shoal choice assay.

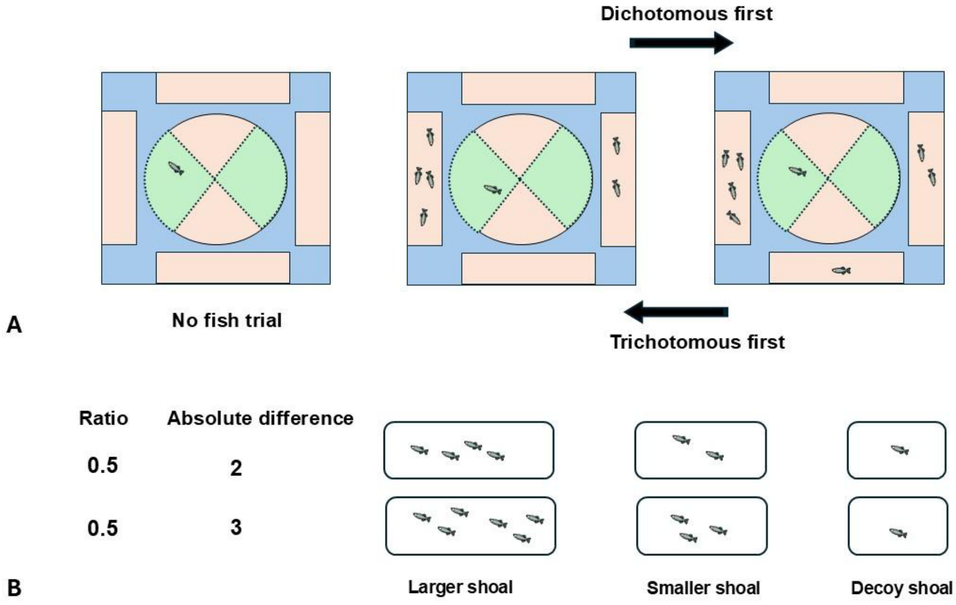
Shoal Choice Apparatus

The shoaling setup comprised a transparent cylindrical acrylic focal tank (24 cm diameter, 4 mm thickness) within a larger square glass main tank (54 cm x 54 cm x 31 cm; Figure 1B). Rectangular display tanks (27 cm x 10 cm x 30 cm) were attached inside each face of the main tank, positioned 4cm away from the focal tank. All joints were sealed with DOWSILTM GP silicone sealant. The main tank rested on a raised platform, with its outer faces covered in opaque paper to prevent external visual cues. Laminated black paper covered the perpendicular faces of the display tanks to prevent interaction between display fish.

An LED light strip (Mufasa Copper Non-Waterproof LED Strip 5050) was attached to each display tank to provide internal lighting and prevent shadows. Trials were recorded using a GoPro Hero 8 camera (1080p, 30fps, linear mode) mounted on a tripod overlooking the main tank. To control for any potential influence of the tripod on fish behavior, a second identical tripod (without a camera) was placed on the opposite side at the same height. The entire setup was enclosed by a 3 m × 3 m black photography cloth to block external visual cues, ensuring that the display tanks were the sole light source. The use of a cylindrical focal tank in our setup allowed us to introduce options from all four surrounding display tanks while minimizing potential corner effects, which could influence fish preference in standard square or rectangular tanks commonly used in shoal size preference tasks. Although cylindrical tanks can increase distortions due to refraction, we mitigated this by surrounding the focal tank with water between the focal and display tanks. The back face of the display tanks, behind the display fish, was covered with a green laminated sheet, following Lucon-Xiccato et al. (2017).

Figure 1

Diagrammatic Representation of (A) The Experimental Design and (B) The Shoal Contrast Conditions, Including the Corresponding Ratios and Absolute Differences between the Primary Shoaling Options



Note. Fish movements were recorded for 5 min in each trial, including the no-fish control and the subsequent shoal size preference trials (dichotomous or trichotomous), with a 2 min interval of visual isolation between trials. Time spent in the two sectors facing the display tanks (in green) was calculated from trajectory data. The shoal choice sets of *4 versus* 2 (decoy = 1 fish) and 6 *versus* 3 (decoy = 1 fish), differing in absolute shoal size change (2 and 3, respectively) while maintaining the same ratio difference (0.5), were used in Experiment 1 (female display), and the *4 versus* 2 (decoy = 1 fish) set was used in Experiment 2 (male display).

Experimental Design

Two experiments were conducted: one using female display fish (Experiment 1) and the other using male display fish (Experiment 2). In Experiment 1 (female display fish), focal males and females were tested under both dichotomous-first and trichotomous-first conditions, using two choice sets (4 *versus* 2 and 6 *versus*. 3). A total of 78 adults (40 males, 38 females) were tested. In the *4 versus* 2 (decoy = 1) choice set, 19 males and 19 females were assigned to the trichotomous-first condition, while in the *6 versus* 3 (decoy = 1) choice set, 20 males and 20 females were tested under the same condition. To prevent carryover effects, a two-week interval was maintained between tests, during which fish remained in individual housing tanks and were not subjected to any other experimental procedures.

Since effects in Experiment 1 were observed only in the trichotomous-first condition for males and in the dichotomous-first condition for females, Experiment 2 (male display fish) focused exclusively on these two conditions, using only the *4 versus* 2 choice set. In this experiment, 20 males were tested in the trichotomous-first condition and 20 females in the dichotomous-first condition. The order of choice sets was randomized across subjects for both experiments.

Before each trial, a cylindrical opaque plastic sheet was placed between the focal and display tanks to visually isolate the focal fish from the display tanks. Each fish first underwent a no-fish trial, in which it was introduced into the central tank and visually isolated from the empty display tanks by a 2 min period behind a cylindrical opaque plastic sheet. This control trial was used to assess any baseline spatial preferences in the absence of display fish. After the no-fish trial, each fish completed a shoaling preference task i.e., subjected either to the *4 versus* 2 or *6 versus* 3 choice set, with each set tested both with and without a single-fish decoy. Fish were assigned to one of two order conditions: the dichotomous-first condition, in which the binary choice trial preceded the decoy trial, or the trichotomous-first condition, in which the decoy trial was presented first. Assignments were counterbalanced across subjects to control for potential order effects.

To illustrate a single trial run, in the dichotomous-first condition, the trial began immediately after the no-fish control trial. First, display fish were placed in the display tanks while the focal fish remained visually isolated behind the opaque sheet. The focal fish was then allowed to explore the tanks and make a choice in the dichotomous trial, which lasted 5 min. After this, the fish underwent a 2 min isolation period while the display fish were replaced for the trichotomous trial, which followed immediately. Once both trials were completed, the focal fish was returned to its holding tank.

To prevent potential side biases, display fish were randomly assigned to the four available display tanks. Additionally, the axis of presentation, the side of the larger shoal, and the position of the third choice in trichotomous trials were randomized using the Sample() function in R 4.4.0 (R Core Team, 2024).

DeepLabCut-Based Fish Tracking

All videos were cropped to a fixed duration of 5 min, starting from the moment the sheet covering the focal tank was raised, using the Python-based video editing tool Moviepy. The videos were then processed using DeepLabCut (DLC), a Python-based pose estimation package (Mathis et al., 2018), to track the head, body, and tail of the fish. A subset of videos was randomly selected to generate training frames, manually marking pre-defined body parts. The default Artificial Neural Network ResNet 50 was trained for more than 400,000 iterations. Labeled videos were generated for each shoal contrast and testing day to verify tracking accuracy. Tracking data for each body part were converted and stored in .csv format. We chose the body part which was most efficiently tracked by inspecting the labeled tracked videos, which in most cases was the ‘body’ point, rather than the head or tail.

Analysis

The circular arena was divided into two opposite angular sectors, one facing the larger shoal and the other facing the smaller shoal. Each sector measured 6 cm in width, approximately twice the body length of an adult zebrafish, and served as a preference zone for assessing shoaling behavior (Figure 1). Trajectory data from DLC tracking was processed using the custom R script DLC-Analyzer (Sturman et al., 2020) to calculate the time spent in each sector. The preference index for the larger shoal was calculated based on the time spent in each sector as follows:

$$Preference\ Index\ (PI) = \frac{Time\ spent\ with\ larger\ shoal\ sector}{Time\ spent\ with\ larger\ shoal\ sector + Time\ spent\ with\ smaller\ shoal\ sector} \quad (1)$$

The preference index data in Experiment 1 was analyzed in two steps: (1) a generalized linear mixed model (GLMM) for direct comparisons and (2) a one-sample t-test to compare results against chance. For direct comparisons, we used a GLMM with the Preference Index for the larger shoal as the response variable. The explanatory variables included the presentation of the shoals ("shoals", dichotomous or trichotomous), the order of presentation (“order,” dichotomous first or trichotomous first) and the sex (“sex,” male or female), with individual identification (fish ID) included as a random factor. The analysis was conducted separately for the *4 versus* 2 (decoy = 1) and 6 *versus* 3 (decoy = 1) choice sets. All possible interactions between explanatory variables were included to capture the effects of the decoy option. Since the preference index ranged between 0 and 1, we applied a GLMM with a beta family distribution and a logit link function using the ‘glmmTMB’ package in R (Brooks et al., 2017). Residual dispersion was checked using the ‘DHARMa’ package in R, with no significant issues detected (Hartig, 2018) (see Figures S1 and S2). Pairwise comparisons were conducted using a post-hoc Tukey correction with the ‘contrast’ package in R.

One-sample t-tests were used to determine whether the relative preference for the larger shoal deviated from chance (preference index of 0.5) for both Experiments 1 and 2. These tests were used to assess the preferences for each combination of shoal presentation, order, and sex. Since each test addressed independent and parallel hypotheses without influencing one another, the alpha level for all tests was maintained at 0.05.

The time spent with larger, smaller shoal and decoy option was compared between dichotomous and trichotomous presentations across all treatments of sex and order for both the Experiments 1 and 2, using the paired t-test. Sample sizes for each sex and order condition were ensured using a smallest-effect-size-of-interest (SESOI) approach (raw difference = 0.1 for preference index), targeting a statistical power of 0.80, following Nachev et al. (2021). Normality of the preference index and time spent in zone data was confirmed using the Shapiro-Wilk test.

Results

Experiment 1 – 4v2 decoy1 | Female display

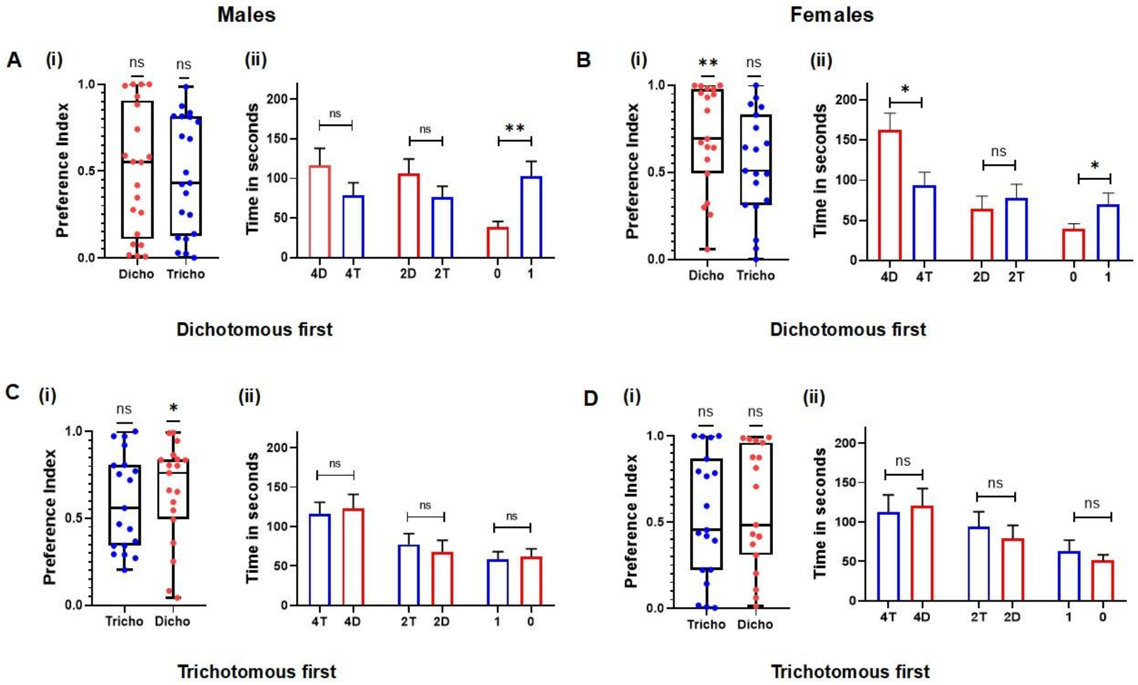
No significant differences in the preference index were observed across all combinations of shoal presentation, sex, and presentation order (see Tables S5 and S6; Tukey post-hoc test; $p > .05$ for all comparisons) for both the *4 versus* 2 (decoy = 1) and *6 versus* 3 (decoy = 1) choice sets.

To test for shifts in relative preference for the larger shoal against chance (0.5), we further investigated these effects using one-sample t-tests against a chance-level preference index of 0.5 for each combination of sex, presentation order, and shoaling condition.

Males did not exhibit a baseline relative preference for the larger shoal (4 fish) over the smaller shoal (2 fish) in the dichotomous-first condition. The introduction of a decoy in the trichotomous choice set did not significantly alter preference index. In the trichotomous-first condition, there was no initial relative preference for the larger shoal in the trichotomous choice set, but a significant preference for the larger shoal emerged in the subsequent dichotomous choice set (Figure 2, Table 1; Mean = 0.65, SEM = 0.06, $t(18) = 2.27$, $p = .03$). Females initially preferred the larger shoal in the dichotomous-first condition (Figure 2, Table 1: Mean = 0.70, SEM = 0.06, $t(18) = 2.92$, $p = .009$), but this preference disappeared in the following trichotomous choice set. In the trichotomous-first condition, no significant relative preference was observed in either choice set.

Figure 2

Experiment 1 - 4v2 (Decoy 1) | Female Display Fish



Note. Preference indices for the larger shoal (*4 versus* 2) and corresponding time spent in choice zones for males and females across dichotomous and trichotomous choice sets, under dichotomous-first and trichotomous-first conditions. Preference index values range from 0 to 1, with 0.5 indicating chance level. Male data are shown in panels A and C (i: preference index, ii: time in zone), and female data in panels B and D. Significance: $*p < .05$, $**p < .01$.

Time spent in each zone (larger, smaller, and decoy/empty) was compared between dichotomous and trichotomous conditions for each sex and order of presentation (Figure 1). A significant difference in time spent with the larger shoal was found only among females in the dichotomous-first order, where they spent more time near the 4-fish shoal in the dichotomous condition than in the trichotomous condition (Figure 2, Table 2; $t(18) = -2.65$, $p = .016$). Time spent with the 2-fish shoal did not differ across conditions for any sex or order. In the trichotomous condition, time spent near the decoy (1 fish) was significantly higher than that spent in the corresponding empty sector of the dichotomous trial, but only in the dichotomous-first order for both sexes (Figure 2, Table 2; males: $t(19) = 2.94$, $p = .008$; females: $t(18) = 2.36$, $p = .029$).

Table 1

Results From One-Sample T-Test for Preference Index Comparisons Across Each Condition

4 vs. 2 (decoy 1)					6 vs. 3 (decoy 1)				
	Mean	+/- SEM	t	*p*		Mean	+/- SEM	t	*p*
Experiment 1					**Experiment 1**				
Males dichotomous first (N=20)					**Males dichotomous first (N=19)**				
Dichotomous	0.49	0.08	-0.03	.97	Dichotomous	0.51	0.08	0.16	.86
Trichotomous	0.47	0.07	-0.35	.72	Trichotomous	0.50	0.07	0.06	.95
Males trichotomous first (N=19)					**Males trichotomous first (N=20)**				
Dichotomous	0.65	0.06	2.27	.03*	Dichotomous	0.63	0.05	2.49	.02*
Trichotomous	0.59	0.06	1.49	.15	Trichotomous	0.48	0.07	-0.25	.80
Females dichotomous first (N=19)					**Females dichotomous first (N=19)**				
Dichotomous	0.70	0.06	2.92	.009**	Dichotomous	0.62	0.07	1.70	.10
Trichotomous	0.54	0.06	0.60	.55	Trichotomous	0.58	0.07	1.11	.28
Females trichotomous first (N=19)					**Females trichotomous first (N=20)**				
Dichotomous	0.57	0.08	0.96	.34	Dichotomous	0.52	0.07	0.31	.75
Trichotomous	0.53	0.08	0.38	.70	Trichotomous	0.54	0.07	0.59	.56
Experiment 2									
Males trichotomous first (N=20)									
Dichotomous	0.55	0.06	0.86	.39					
Trichotomous	0.54	0.06	0.73	.47					
Females dichotomous first (N=20)									
Dichotomous	0.46	0.07	-0.51	.61					
Trichotomous	0.57	0.06	1.08	.29					

Note. *$p < .05$ **$p < .01$

Table 2

Results from Paired T-Test for Time in Zone Comparisons Across Each Condition

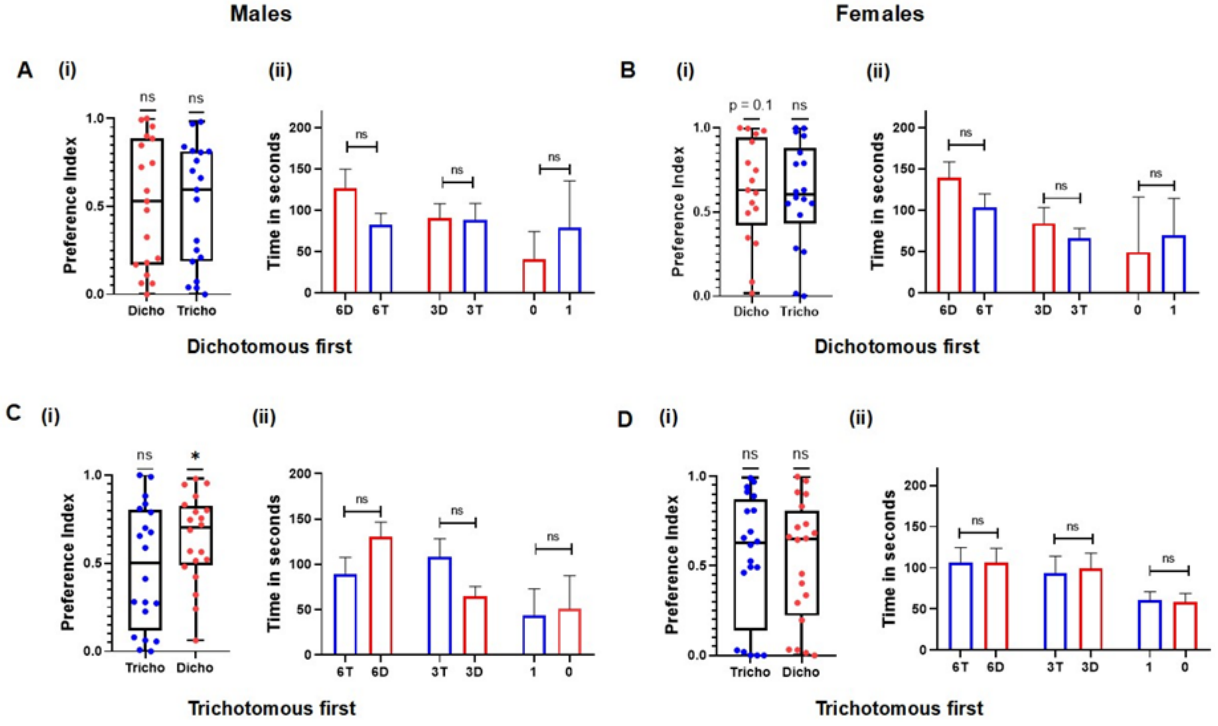
	4 vs. 2 (decoy 1)					6 vs. 3 (decoy 1)			
	Mean +/- SEM Dichotomous	Mean +/- SEM Trichotomous	t	*p*		Mean +/- SEM Dichotomous	Mean +/- SEM Trichotomous	t	*p*
Experiment 1 **Males dichotomous first (N=20)**					**Males dichotomous first (N=20)**				
Time with 4-fish	116.53 +/- 21.35	78.66 +/- 15.85	-1.455	.160	Time with 6-fish	126.96 +/- 22.86	82.90 +/-13.34	-1.465	.160
Time with 2-fish	106.40 +/- 18.11	75.98 +/- 14.17	-1.298	.208	Time with 3-fish	90.47 +/- 17.65	88.53 +/-19.66	-0.070	.944
Time with 0-fish/1-fish	38.39 +/- 7.16	103.03 +/- 18.61	2.943	.008**	Time with 0-fish/1-fish	41.12 +/-7.61	78.61 +/-13.01	2.034	.056
Males trichotomous first (N=19)					**Males trichotomous first (N=20)**				
Time with 4-fish	123.05 +/- 17.81	115.794 +/-15.02	-0.320	.752	Time with 6-fish	130.70 +/- 15.88	89.19 +/-18.33	-1.670	.109
Time with 2-fish	67.50 +/-15.05	77.49 +/-13.47	0.551	.588	Time with 3-fish	64.98 +/- 10.76	108.10 +/-20.32	1.911	.071
Time with 0-fish/1-fish	62.10 +/- 9.58	58.52 +/- 9.58	-0.2411	.812	Time with 0-fish/1-fish	50.93 +/-8.20	43.37+/-6.83	-0.586	.565
Females dichotomous first (N=19)					**Females dichotomous first (N=18)**				
Time with 4-fish	163.06 +/- 20.27	93.29 +/-16.62	-2.65	.016*	Time with 6-fish	138.88 +/- 19.60	103.69 +/-16.07	-1.423	.173
Time with 2-fish	63.91 +/-16.25	78.27 +/-16.75	0.63	.53	Time with 3-fish	84.28 +/- 18.99	65.86 +/-12.36	-0.811	.428
Time with 0-fish/1-fish	38.88 +/-6.88	69.66 +/-14.40	2.36	.029*	Time with 0-fish/1-fish	49.40 +/- 16.13	70.08 +/-10.71	0.967	.347
Females trichotomous first (N=19)					**Females trichotomous first (N=20)**				
Time with 4-fish	120.21 +/- 22.34	112.66 +/-21.89	-0.25	.802	Time with 6-fish	105.97 +/- 17.76	106.25 +/-18.28	0.018	.985
Time with 2-fish	78.68 +/-17.07	93.95 +/-19.04	0.67	.509	Time with 3-fish	99.22 +/-18.79	93.45 +/-20.65	-0.401	.692
Time with 0-fish/1-fish	51.11 +/-7.33	62.95 +/-13.94	0.73	.470	Time with 0-fish/1-fish	58.15 +/-10.95	60.35 +/-10.48	0.155	.878

Experiment 2				
Males trichotomous first (N=20)				
Time with 4-fish	88.57 +/-13.44	89.12 +/- 11.80	0.026	.978
Time with 2-fish	73.53 +/-11.14	70.42 +/- 11.99	-0.177	.861
Time with 0-fish/1-fish	83.69 +/-11.10	70.07 +/-10	-0.823	.421
Females dichotomous first (N=20)				
Time with 4-fish	75.92 +/-13.75	94.81 +/- 14.24	1.121	.276
Time with 2-fish	89.57 +/-15.48	66.65 +/- 11.47	-1.176	.254
Time with 0-fish/1-fish	84.01 +/- 12.03	82.87 +/- 13.89	-0.067	.946

Note. **p* < .05 ***p* < .01

Figure 3

Experiment 1 - 6v3 (Decoy 1) | Female Display Fish



Note. Preference indices for the larger shoal (6 vs. 3) and corresponding time spent in choice zones for males and females across dichotomous and trichotomous choice sets, under dichotomous-first and trichotomous-first conditions. Preference index values range from 0 to 1, with 0.5 indicating chance level. Male data are shown in panels A and C (i: preference index, ii: time in zone), and female data in panels B and D. Significance: **p* < *.05,* ***p* < .01.

Experiment 1 – 6v3 Decoy 1 | Female Display

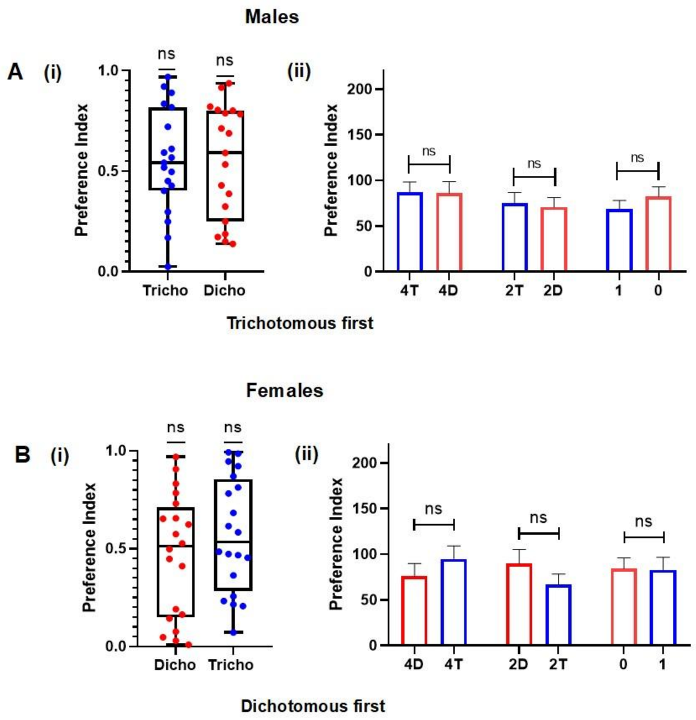
Males did not show a relative preference for the larger shoal (6) over the smaller shoal (3) in the dichotomous-first condition. The introduction of a decoy led to a shift towards the smaller shoal (3), although this change was not statistically significant when comparing relative preference against chance. A significant relative preference for the larger shoal (6) emerged in the dichotomous choice set of the trichotomous-first condition (Figure 3, Table 1; Mean = 0.63, SEM = 0.05, t(19) = 2.49, *p* = .02). Females showed only a weak and nonsignificant baseline preference for the larger shoal (Figure 3, Table 1; Mean = 0.62, SEM = 0.07, *t*(19) = 1.70, *p* = .10) in the dichotomous-first condition and did not exhibit any significant preference in either choice set of the trichotomous-first condition. Time spent in each zone (larger, smaller, or decoy/empty) did not differ between dichotomous and trichotomous conditions for any sex or order of presentation (Figure 3, Table 2).

Experiment 2 – Male Display

To test whether the observed effects were specific to the sex of the display fish, we replicated the *4 versus* 2 (decoy 1) choice set only for the trichotomous-first order in males and the dichotomous-first order in females, as shifts in relative preference had been observed only in these subsets in Experiment 1. We observed no shift in relative preference in either males or females between dichotomous and trichotomous conditions, unlike Experiment 1. Females showed no baseline preference for the larger shoal in the dichotomous-first order (Figure 4, Table 1; Mean = 0.46, SEM = 0.07, *t*(18) = -0.51, *p* = .61). There was also no significant difference in time spent in any zone (larger, smaller, or decoy/empty) between dichotomous and trichotomous conditions (Figure 4, Table 2).

Figure 4

Experiment 2 - 4v2 (Decoy 1) | Male Display Fish



Note. Preference indices for the larger shoal (*4 versus* 2) and corresponding time spent in choice zones under the trichotomous-first condition for males (A) and females (B). Each panel shows (i) preference index and (ii) time in zone. Preference index values range from 0 to 1, with 0.5 indicating chance level. Significance: **p* < .05, ***p* < .01.

Discussion

We tested whether the addition of a single-fish shoal, inferior to the main contrasts of 4 fish *versus* 2 fish and 6 fish *versus* 3 fish shoals, influenced the relative preference for the larger shoal in adult zebrafish. This study provides the first evidence that the inclusion of a decoy option alters shoal size preferences in zebrafish, and that this effect depends on both the order of presentation and the sex of the subject. In males, exposure to a decoy shoal of one fish in the preceding trial led to an increased preference for the larger shoal in both the *4 versus* 2 and 6 *versus* 3 contrasts. In contrast, females, which showed a baseline preference for the larger shoal, became indifferent to the contrast following exposure to the decoy (1 fish). Although no significant differences were detected in direct comparisons of relative preference, consistent deviations from chance may reflect subtle yet ecologically meaningful effects.

Among the two sexes, the effect observed in males is particularly intriguing, as it leads to an increased preference for the larger shoal (4 or 6 fish) in the trial following decoy exposure, for two reasons that suggest this pattern represents a more conclusive expression of the contextual decoy effect compared to females. First, the loss of preference for the larger shoal upon introduction of single fish decoy observed in females may be explained by the random *dilution effect* (Bateson et al., 2002). This occurs when a portion of choices are made randomly, and the introduction of a third option absorbs some of these random selections. Although the underlying preference between the two main options remains unchanged, the decoy disperses this random noise, thereby reducing its masking effect on the true bias (Bateson et al., 2002). Second, in males, the increased preference for the larger shoal in the subsequent dichotomous trial (when the decoy was no longer present) cannot be explained by random dilution. Instead, it appears to reflect a change in the cognitive evaluation of the options shaped by the geometry of the choice set. Consistent with this interpretation, the time-in-zone data show that when the trichotomous trial was presented first, the increased relative preference for the larger shoal among males resulted from both increased time spent near the larger shoal and reduced time near the smaller one. At the same time, males spent almost similar durations near the former decoy location, indicating that they continued to track the missing decoy fish, suggesting a lingering effect on cognitive adjustment in how the remaining options were represented following the decoy's removal.

The increased relative preference for larger shoals (both 4 and 6) observed in males following exposure to a single-fish decoy resembles a *repulsion effect*, wherein the introduction of an inferior option disrupts the balance between the original choices and strengthens preference for the favored alternative (Spektor et al., 2018). Mechanistically, this repulsion effect, observed in our one-dimensional design where choices varied only in shoal size, is best explained by the *similarity effect*, in which a poor option reduces the attractiveness of a similar alternative, thereby amplifying preference for the more distinct, larger shoal (Frederick et al., 2014). This repulsion-like increase in male preference might reflect an adaptive response to social isolation or perceived risk. In natural conditions, encountering a solitary conspecific might signal predation threat or group instability, potentially triggering a stronger drive to associate with larger, safer groups. The continued time males spent near the former decoy location might indicate a lingering vigilance or tracking response, suggesting that the decoy could have influenced not only the geometry of choice but also the *social–emotional context* of decision-making (Harding et al., 2004).

While the *attraction effect*, in which a decoy draws preference toward the option it resembles, has been widely studied in both human and non-human animals' decision-making studies, recent work suggests that it may not be as prevalent as previously thought. In a large-scale replication effort, Frederick et al. (2014) attempted to reproduce findings from 38 human studies on the attraction decoy effect have been reliably replicated only in tasks involving abstract stimuli, while more naturalistic decision contexts may weaken the perceived dominance relationships among options. In line with this, several non-human animal studies across taxa have reported inconsistent or null effects (Armand et al., 2025; Bateson et al., 2002, 2003; Edwards & Pratt, 2009; Scarpi, 2011). In our context, an attraction effect would have led to an increased relative preference for the smaller shoal, opposite to the pattern observed among males.

The influence of *order* effects in decoy studies has only recently begun to be recognized in human studies (Evans et al., 2021; Stoffel et al., 2023). Evans et al. (2021) examined how the temporal sequence of option presentation influences context effects in a perceptual decision-making task. Human participants judged the area of rectangles varying in height and width, and both attraction and repulsion effects were observed depending on the order in which options were presented. The authors demonstrated that memory bias contributes significantly to these context effects. By incorporating memory decay into the standard Multi-attribute Linear Ballistic Accumulator (MLBA) model, a dynamic evidence accumulation framework, they developed a piecewise MLBA (pMLBA). In this model, drift rates were updated dynamically as each alternative appeared, allowing the reference point to shift based on previously presented options. This sequential updating captured how memory for past options decays over time and influences subsequent comparisons. The pMLBA explained the behavioral data better than other heuristic models, showing that the order of presentation reliably influence, or even reverse context effects.

Among the non-human animals, recent study Orlando et al. (2023) allowed swamp wallabies to choose freely between dichotomous and trichotomous options in the wild, revealing a significant order effect. As order was not the primary focus, the authors mainly discussed the decoy's main effect. Our results provide evidence for a sex-based influence of the order of alternatives on the direction of context effects. Males exhibited a repulsion-like effect when the trichotomous condition was presented first, whereas females showed an attraction-like effect when the dichotomous condition was presented first. The memory-based influence of the decoy was more evident among males, where a shift in preference appeared in the subsequent dichotomous trial following decoy presentation. These findings highlight the importance of considering order effects when investigating context effects in non-human animals, as neglecting them may lead to misinterpretation of the underlying mechanisms. All the putative mechanisms discussed above are summarized in Table 3.

Table 3

Summary of Putative Mechanisms Underlying the Observed Effects

Effect	Brief definition	Sex in which observed	Evidence from the present study
Dilution effect	Reduction in apparent relative preference between two main options due to random choice being absorbed by an additional alternative, without changing the underlying preference structure	Females	Females showed a baseline preference for the larger shoal in dichotomous trials but became indifferent following exposure to the single-fish decoy. This loss of preference may reflect random dilution rather than a genuine contextual shift.
Repulsion effect	Introduction of an inferior option strengthens preference for the superior alternative by disrupting the balance between original choices	Males	Males exhibited an increased preference for the larger shoal in the dichotomous trial following prior exposure to the decoy. This effect involved both increased time spent near the larger shoal and reduced time spent near the smaller shoal following exposure to the most inferior option, a single fish.
Similarity effect	An inferior option reduces the attractiveness of a similar alternative, thereby amplifying preference for a more distinct option	Males	In a unidimensional choice space (shoal size), the single-fish decoy was more similar to the smaller shoal (two fish), potentially reducing its attractiveness and thereby amplifying preference for the larger shoal. Consistent with this, males spent comparable time near the smaller shoal and the former decoy location in the dichotomous trial following decoy presentation.
Social–emotional context effect	Changes in preference driven by altered perceived social or emotional state (e.g., vigilance, perceived risk) rather than purely geometric choice structure	Males	Males spent similar amount of time near the former decoy location even after its removal, suggesting continued tracking or vigilance. Exposure to a solitary conspecific may have altered the perceived social context, contributing to increased preference for larger shoals.
Attraction effect	An inferior option increases preference for the option it most closely resembles	Females	Attraction effect would predict a shift in preference toward the smaller shoal. In females, exposure to the decoy led to a reduction in preference for the larger shoal, a pattern that is consistent with an attraction-like effect; however, this pattern cannot be clearly distinguished from random dilution.
Order effect	Dependence of preference patterns on the sequence in which choice sets are experienced, such that previously encountered options influence subsequent evaluations through memory-based carryover effects.	Both sexes (sex-specific direction)	In males, exposure to a single-fish decoy in the preceding trial led to an increased preference for the larger shoal in both the 4 *versus* 2 and 6 *versus* 3 contrasts. In contrast, females showed a baseline preference for the larger shoals, became indifferent to the contrast following decoy exposure.

In the female display experiment, the observed effects of sex-based differences in shoal size preference (of the subject fish) align with previous reports of similar patterns in shoal discrimination (Etinger et al., 2009; Ruhl & McRobert, 2005; Velkey et al., 2022). However, many other studies on shoal discrimination have not specifically tested for sex-based differences in shoaling behavior (Seguin & Gerlai, 2017; Sheardown et al., 2022). These differences could be driven by distinct evolutionary pressures influencing shoal choice between the sexes (Magurran & Garcia, 2000; Snekser et al., 2010). Sex-based differences in decision rules and heuristics when making social decisions may play a role in how shoals organize and influence schooling fusion-fission dynamics, which remains understudied (Fürtbauer et al., 2020; Miller & Gerlai, 2012; Zheng & Fu, 2021).

We did not observe a preference for the larger shoal in the male display experiment (Experiment 2) for either male or female subjects, unlike previous reports that found such a preference, at least among females who are known to prioritize shoal size over sex (Etinger et al., 2009; Ruhl & McRobert, 2005). However, our result is consistent with Snekser & Diestler (2023), who reported that female display shoals elicited a stronger shoaling preference for the larger shoal compared to male display shoals across both sexes. The observed difference could be due to uncontrolled factors such as sex differences in morphology and activity (Conradsen & McGuigan, 2015; Philpott et al., 2012). The sex-specific pattern of the decoy effect observed in Experiment 1 (female display) may therefore be associated with the sex of the display fish. Although we could not rule out this influence, future experiments using virtual animated fish or biological motion–based point stimuli could help disentangle this effect more clearly.

In the *6 versus* 3 shoal choice task, males showed no clear preference, while females exhibited a weak, non-significant preference for the larger shoal. In contrast, females showed a significant preference for the larger shoal in the *4 versus* 2 task. This differs from Seguin and Gerlai (2017), who reported a population-level preference for the larger shoal in the 6 *versus* 3 task. The discrepancy may reflect differences in experimental conditions, such as zebrafish strains or the use of a perforated divider that allowed both visual and olfactory cues, potentially influencing shoaling choices. This difference could also stem from variations in apparatus design. The use of a cylindrical focal tank in our setup allowed us to present options from four surrounding display tanks while minimizing potential corner effects that can influence fish preferences in the square or rectangular tanks commonly used in shoal size choice tasks. However, replicating this experiment using the standard square/rectangular tank would help assess the robustness of our findings.

Context effects in decision-making have been reported in the fish literature, largely regarding multi-attribute mate choice by females, for example, in the peacock blenny (*Salaria pavo*) (Locatello et al., 2015) and the green swordtail (*Xiphophorus helleri*) (Royle et al., 2008). Apart from the study by Reding and Cummings (2019), which found no evidence of a decoy effect in mosquitofish (*Gambusia affinis*), to our knowledge, no other study has examined context effects in shoal-size choice tasks. We adopted a similar experimental design in our shoal size choice task to avoid the replication crisis seen in human decoy effect studies, where small variations in the task and stimulus modality may have contributed to the differing decoy effects observed (Chau et al. 2014, 2020; Gluth et al., 2018; Rivalan et al., 2017).

Our results contribute to the small body of evidence documenting unidimensional violations of independence of irrelevant alternatives, a phenomenon that has seldom been explored (Morgan et al., 2012). Examining such effects is essential, as interpreting multi-attribute context effects often becomes difficult when several plausible mechanisms can yield similar behavioral patterns. Morgan et al. (2012) showed that manipulating different single attributes can produce distinct decoy effects, suggesting that context-dependent preferences may be driven by attribute-specific processes. Exploring these processes systematically could yield a deeper understanding of how multiple attributes jointly shape decision-making.

Our study establishes that context effects based on shoal size influence zebrafish shoaling decisions, with distinct effects of order and sex, all in relation to a single attribute, shoal size. The extensive array of pharmacological, genetic, neurobiological, and behavioral tools available in zebrafish will facilitate future research aimed at comprehensively understanding context effects in this model organism. Moreover, these tools will enable the examination of the underlying mechanisms behind sex-specific rationality in contextual decision-making. Furthermore, these results significantly contribute to the existing decoy effect literature by focusing on decoy effects at single dimensions and highlighting their absence in investigations and modeling of multi-alternative, multi-attribute decoy effects.

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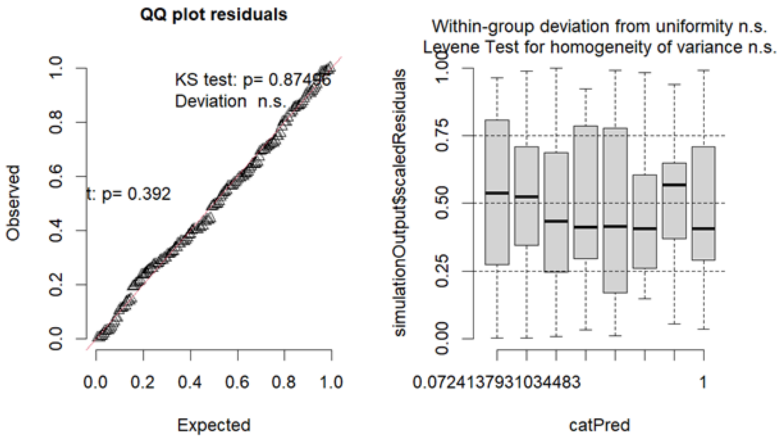
Supplementary Materials

Figure S1

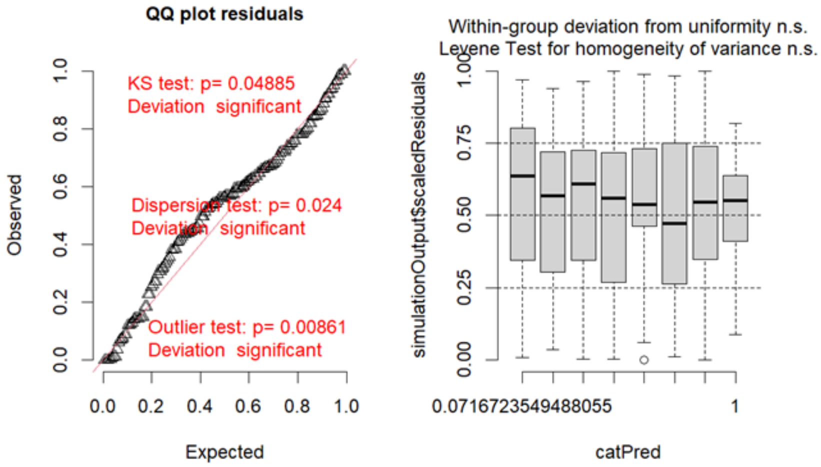
Q-Q and Residual vs Predicted plots for 4 versus 2 decoy 1 beta (logit link) GLMM



Note. Model: Pref_index ~ Shoals*Sex*Order+ (1|ID), family = beta_family(link = "logit")

Figure S2

Q-Q and Residual vs Predicted plots for 6 versus 3 decoy 1 beta (logit link) GLMM model



Note. Model: Pref_index ~ Shoals*Sex*Order+ (1|ID), family = beta_family(link = "logit")

Figure S3

Time Spent In Each Sector During The No-Fish Trials Of The 4 Versus 2 (Decoy 1) Choice Set, Demonstrating No Significant Zone Bias

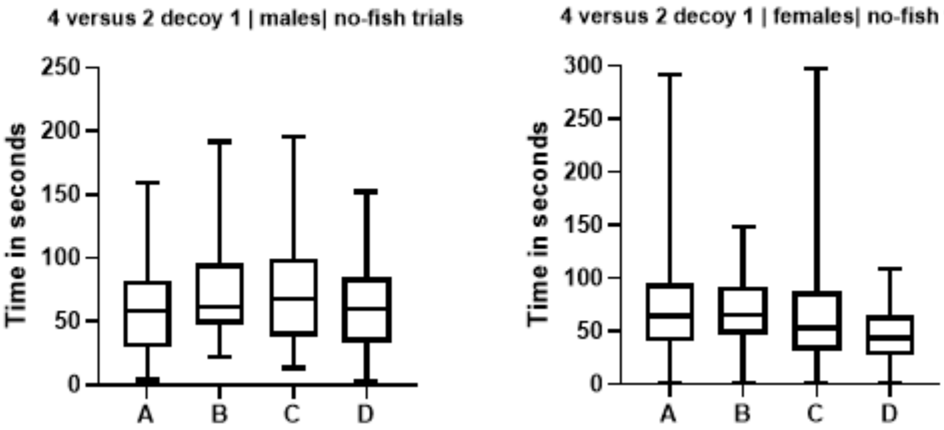


Figure S4

Time Spent In Each Sector During The No-Fish Trials Of The 6 Versus 3 (Decoy 1) Choice Set, Demonstrating No Significant Zone Bias

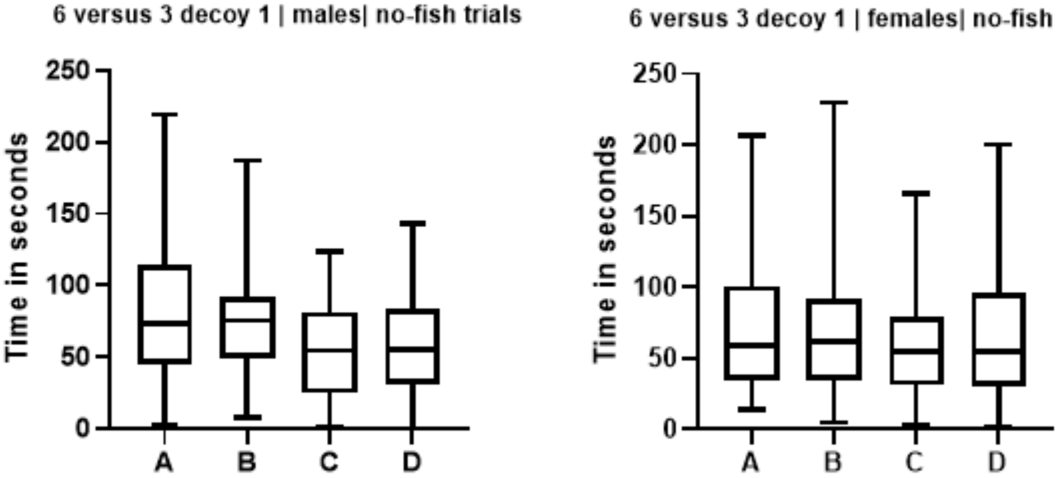


Table S1

GLMM Results for 4v2:Decoy1

Predictors	Estimates	Odds Radio	Back-Transformed	CI (Back Transformed)	*p*
(Intercept)	0.94***	2.56	0.72	0.58—0.82	.003
ShoalsTrichotomous	-.87**	0.42	0.29	0.16—0.46	.022
SexM	-0.59	0.55	0.35	0.19—0.56	.170
OrderT	-0.61	0.54	0.32	0.18—0.56	.171
ShoalsTricho:SexM	0.24	1.27	0.56	0.30—0.78	.651
ShoalsTricho:OrderT	0.86	2.36	0.70	0.45—0.87	.111
SexM: OrderT	0.73	2.08	0.67	0.38—0.87	.238
ShoalsTricho:SexM:OrderT	-0.22	0.80	0.44	0.15—0.78	.764
Random Effects					
τ00 (ID)	0.45				
Std. dev.	0.67				
N (ID)	77				

Note. **p* < .1 ***p* < .05 ****p* < .01

Table S2

GLMM Results for 6v3:Decoy1

Predictors	Estimates	Odds Radio	Back-Transformed	CI (Back Transformed)	*p*
(Intercept)	0.15	1.16	0.56	0.38—0.68	.622
ShoalsTrichotomous	-0.14	0.87	0.46	0.27—0.65	.716
SexM	-0.06	0.94	0.48	0.28—0.68	.889
OrderT	-0.23	0.79	0.44	0.25—0.64	.577
ShoalsTricho:SexM	-0.05	0.95	0.48	0.23—0.74	.925
ShoalsTricho:OrderT	0.00	1.00	0.50	0.24—0.75	1.00
SexM: OrderT	0.47	1.60	0.61	0.32—0.84	0.432
ShoalsTricho:SexM:OrderT	-0.20	0.82	0.44	0.14—0.79	0.800
Random Effects					
τ00 (ID)	0.22				
Std. dev.	0.61				
N (ID)	78				

Note. **p* < .1 ***p* < .05 ****p* < .01

Table 3

Analysis of Deviance Table (Type III Wald chisquare tests) (4 vs 2 Decoy 1)

Response : Preference Index	Chisq	df	p
(Intercept)	8.86	1	.002
ShoalsTrichotomous	5.21	1	.022
SexM	1.88	1	.17
OrderT	1.87	1	.17
ShoalsTricho:SexM	0.20	1	.65
ShoalsTricho:OrderT	2.54	1	.11
SexM:OrderT	1.39	1	.23
ShoalsTricho:SexM:OrderT	0.09	1	.76

Note. Model: Pref_index ~ Shoals*Sex*Order+ (1|ID) , family = beta_family(link = "logit")

Table S4

Analysis of Deviance Table (Type III Wald chisquare tests) (6 vs 3 decoy 1)

Response : Preference Index	Chisq	df	p
(Intercept)	0.24	1	.622
ShoalsTrichotomous	0.13	1	.715
SexM	0.01	1	.889
OrderT	0.31	1	.577
ShoalsTricho:SexM	0.08	1	.924
ShoalsTricho:OrderT	0.00	1	.000
SexM:OrderT	0.61	1	.432
ShoalsTricho:SexM:OrderT	0.06	1	.799

Note. Model: Pref_index ~ Shoals*Sex*Order+ (1|ID), family = beta_family(link = "logit")

Table S5

Results Of Pairwise Comparisons From Post Hoc Tukey Test For 4 Versus 2 (Decoy 1) Choice Set

Contrast	Estimate	SE	df	z.ratio	p.value
Dichotomous F D - Trichotomous F D	0.87856	0.385	Inf	2.285	.3019
Dichotomous F D - Dichotomous M D	0.5955	0.434	Inf	1.372	.8701
Dichotomous F D - Trichotomous M D	1.232	0.444	Inf	2.772	.1021
Dichotomous F D - Dichotomous F T	0.61187	0.447	Inf	1.369	.8716
Dichotomous F D - Trichotomous F T	0.62937	0.441	Inf	1.428	.8444
Dichotomous F D - Dichotomous M T	0.46829	0.449	Inf	1.044	.9677
Dichotomous F D - Trichotomous M T	0.47347	0.448	Inf	1.056	.9655
Trichotomous F D - Dichotomous M D	-0.28306	0.428	Inf	-0.661	.9979
Trichotomous F D - Trichotomous M D	0.35344	0.438	Inf	0.807	.9928
Trichotomous F D - Dichotomous F T	-0.2667	0.443	Inf	-0.602	.9989
Trichotomous F D - Trichotomous F T	-0.24919	0.434	Inf	-0.574	.9992
Trichotomous F D - Dichotomous M T	-0.41027	0.446	Inf	-0.92	.9843
Trichotomous F D - Trichotomous M T	-0.40509	0.445	Inf	-0.911	.9852
Dichotomous M D - Trichotomous M D	0.6365	0.372	Inf	1.711	.6804
Dichotomous M D - Dichotomous F T	0.01637	0.434	Inf	0.038	1
Dichotomous M D - Trichotomous F T	0.03388	0.424	Inf	0.08	1
Dichotomous M D - Dichotomous M T	-0.12721	0.437	Inf	-0.291	1
Dichotomous M D - Trichotomous M T	-0.12203	0.435	Inf	-0.28	1
Trichotomous M D - Dichotomous F T	-0.62014	0.443	Inf	-1.398	.8584
Trichotomous M D - Trichotomous F T	-0.60263	0.435	Inf	-1.387	.8636
Trichotomous M D - Dichotomous M T	-0.76371	0.446	Inf	-1.711	.6799
Trichotomous M D - Trichotomous M T	-0.75853	0.445	Inf	-1.704	.6849
Dichotomous F T - Trichotomous F T	0.01751	0.382	Inf	0.046	1
Dichotomous F T - Dichotomous M T	-0.14358	0.45	Inf	-0.319	1
Dichotomous F T - Trichotomous M T	-0.1384	0.449	Inf	-0.308	1
Trichotomous F T - Dichotomous M T	-0.16109	0.443	Inf	-0.364	1
Trichotomous F T - Trichotomous M T	-0.15591	0.441	Inf	-0.353	1
Dichotomous M T - Trichotomous M T	0.00518	0.395	Inf	0.013	1

Note. Pref_index ~ Shoals*Sex*Order+ (1|ID) , family = beta_family(link = "logit")

Table S6

Results Of Pairwise Comparisons From Post Hoc Tukey Test For 6 Versus 3 (Decoy 1) Choice Set

Contrast	Estimate	SE	df	z.ratio	p.value
Dichotomous F D - Trichotomous F D	0.1497	0.411	Inf	0.364	1
Dichotomous F D - Dichotomous M D	0.0606	0.436	Inf	0.139	1
Dichotomous F D - Trichotomous M D	0.265	0.439	Inf	0.604	.9988
Dichotomous F D - Dichotomous F T	0.239	0.429	Inf	0.558	.9993
Dichotomous F D - Trichotomous F T	0.3887	0.427	Inf	0.911	.9851
Dichotomous F D - Dichotomous M T	-0.18	0.439	Inf	-0.41	.9999
Dichotomous F D - Trichotomous M T	0.2287	0.429	Inf	0.533	.9995
Trichotomous F D - Dichotomous M D	-0.0891	0.434	Inf	-0.205	1
Trichotomous F D - Trichotomous M D	0.1153	0.438	Inf	0.264	1
Trichotomous F D - Dichotomous F T	0.0893	0.427	Inf	0.209	1
Trichotomous F D - Trichotomous F T	0.239	0.425	Inf	0.562	.9993
Trichotomous F D - Dichotomous M T	-0.3297	0.437	Inf	-0.754	.9952
Trichotomous F D - Trichotomous M T	0.079	0.428	Inf	0.185	1
Dichotomous M D - Trichotomous M D	0.2044	0.408	Inf	0.501	.9997
Dichotomous M D - Dichotomous F T	0.1784	0.426	Inf	0.419	.9999
Dichotomous M D - Trichotomous F T	0.3281	0.423	Inf	0.775	.9944
Dichotomous M D - Dichotomous M T	-0.2406	0.435	Inf	-0.553	.9993
Dichotomous M D - Trichotomous M T	0.1681	0.427	Inf	0.394	.9999
Trichotomous M D - Dichotomous F T	-0.026	0.429	Inf	-0.061	1
Trichotomous M D - Trichotomous F T	0.1237	0.427	Inf	0.29	1
Trichotomous M D - Dichotomous M T	-0.445	0.439	Inf	-1.013	.9726
Trichotomous M D - Trichotomous M T	-0.0363	0.43	Inf	-0.084	1
Dichotomous F T - Trichotomous F T	0.1497	0.388	Inf	0.386	.9999
Dichotomous F T - Dichotomous M T	-0.419	0.428	Inf	-0.978	.9776
Dichotomous F T - Trichotomous M T	-0.0103	0.419	Inf	-0.025	1
Trichotomous F T - Dichotomous M T	-0.5687	0.426	Inf	-1.333	.8862
Trichotomous F T - Trichotomous M T	-0.16	0.417	Inf	-0.383	.9999
Dichotomous M T - Trichotomous M T	0.4087	0.404	Inf	1.011	.9729