Neophobia across social contexts in juvenile herring gulls

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Abstract

Neophobia, the fear or avoidance of the unfamiliar, can have significant fitness consequences. It is typically assessed by exposing individuals to unfamiliar objects when they are alone, but in social species the presence of conspecifics can influence neophobia. However, previous research on the effect of group dynamics on neophobic responses has produced mixed results. Here, we explore the degree of neophobia of an individual in different social contexts in a highly social species, the herring gull. We hypothesise that the distribution of neophobic responses will change in a group context. Specifically, we expect less variance between individuals when tested in a group than when tested individually. However, how much and in what direction the average neophobic response will change, will depend on the social mechanisms at play. To test these predictions, we will expose juvenile herring gulls to novel objects in both individual and group settings, and we will repeat each condition twice to establish replicability.

Keywords: Animal Behaviour, Behavioural Inhibition, Neophobia, Social Behaviour, Herring Gull, Animal Personality

Introduction

Neophobia is the fear or reluctance to engage with new or unfamiliar objects, places or scenarios. It is often considered to be a consistent personality trait across species, affecting an individual's survival and adaptation (Both et al., 2005; Greggor et al., 2015; Kimball and Lattin, 2023; Vrublevska et al., 2015). Research into animal behaviour is increasingly focusing on neophobia because of its significance in the context of rapid environmental change. The world is rapidly urbanising, with the footprint of urban land cover expected to at least double by the end of the century (Gao and O'Neill, 2020). Many species must therefore adapt to human-induced changes in their environment, and hence, to unfamiliar scenarios (Lee and Thornton, 2021; McKinney, 2002). In such situations, neophobia can, on the one hand, serve as a survival mechanism, allowing individuals to avoid potential threats and increase their chance of survival (Greenberg and Mettke-Hofmann, 2001). On the other hand, excessive aversion to novelty can restrict exploratory behaviour, limiting an individual's ability to locate and exploit novel resources, learn from its novel environment and adapt to environmental changes (Biondi et al., 2010; Greenberg, 2003).

To assess neophobia, individuals are typically exposed to novel food, objects, or spaces (Greggor et al., 2015; Mettke-Hofmann, 2017). For example, in the 'novel object task', which we use in the present study, an individual encounters an unfamiliar object, often placed next to a food reward, in a familiar environment. The latency to approach the food (in the presence of the novel object) or to interact with the novel object itself, is then used as a measure of neophobia (Greggor et al., 2015; Miller, Lambert, et al., 2022; Vernouillet and DM Kelly, 2020). These measures have been used in cross-species comparisons to investigate, for example, the socio-ecological drivers of neophobia (Mettke-Hofmann et al., 2002; Miller, Lambert, et al., 2022), or within species, to investigate both the causes and consequences of individual differences in neophobia (Greenberg and Mettke-Hofmann, 2001).

Most research on neophobia has focused on individual animals, both in laboratory and field settings. However, it is important to consider that many species are to various extents reliant on social information, so individuals can influence each other's behaviour. This is also true in the context of adapting to environmental changes and urbanisation (Lee and Thornton, 2021). For instance, when individuals encounter a new environment, they may learn from others about appropriate roosting or nesting sites, food sources, or unfamiliar predators (Harel et al., 2017; Keen et al., 2020; Loukola et al., 2012). In this context, several studies suggest that the presence of conspecifics also influences neophobia. However, the mechanisms behind this social phenomenon are still a topic of debate due to the various patterns that have been observed.

First, some studies have found that individuals in groups are generally less neophobic than when tested alone. For example, Coleman and Mellgren presented zebra finches (*Taeniopygia guttata*) with novel feeders and decorated the feeders with novel objects (Coleman and Mellgren, 1994). Individuals in a group approached and started using the new and decorated feeders more quickly than when tested alone. Other studies reported similar patterns in different species for some (but not necessarily all) measures of neophobia (Benson-Amram and Holekamp, 2012; Kareklas et al., 2018; Moretti et al., 2015; Soma and Hasegawa, 2004). Such mitigating effects of social context on neophobia may be attributed to 'risk dilution' (Krause and Ruxton, 2002) or 'social buffering' (Kikusui et al., 2006). These theories predict that neophobia, or fear responses in general, are reduced in the presence of others.

Second, some studies found the opposite pattern. For example, common ravens (*Corvus corax*) and carrion x hooded crows (hybrid; *C. corone, C. cornix*) approached novel objects faster when alone than when accompanied by a conspecific (Miller, Bugnyar, et al., 2015; Stöwe, Bugnyar, Heinrich, et al., 2006; Stöwe, Bugnyar, Loretto, et al., 2006). Other studies have observed similar patterns in other species, including Indian mynahs, *Acridotheres tristis* (Griffin et al., 2013), house sparrows, *Passer domesticus* (TR Kelly et al., 2020), and even zebra finches (Kerman et al., 2018; St. Lawrence et al., 2021), thus failing to replicate the findings of the aforementioned study by Coleman and Mellgren (1994). Interestingly, however, some of these studies found that once individuals reached the novel object, they spent more time interacting with it when in the presence of others (either in pairs or in groups) than when isolated (Miller, Bugnyar, et al., 2015; Stöwe, Bugnyar, Heinrich, et al., 2006). It has therefore been suggested that the slower approach latencies may be due to conspecifics 'negotiating' who will approach the novel object first.

Third, some studies failed to find effects of social context on average neophobic responses altogether (e.g Apfelbeck and Raess, 2008). While, it is of course possible that social context does not matter for some species, it is also possible that the presence of conspecifics alters behaviour of individuals without changing the mean response. Specifically, in environments where conspecifics' behaviour serves as an indicator of appropriate responses, individuals may adjust their own behaviour to match that of others (Herbert-Read et al., 2013). This synchronisation of behaviours within the group, or 'social conformity', enhances cohesion and helps the group to adapt to their environment. For example, observations in a variety of species, such as zebra finches (Schuett and Dall, 2009) and gouldian finches, *Erythrura gouldiae* (King et al., 2015), show how individuals adapt their behaviour and mirror their partners' character traits. For instance, if a gouldian finch exhibited bold behaviour, the observing individual tended to become bolder as well, while if the partner displayed shyness, the observing individual mirrored this trait. Thus, this study found that the neophobic response was similar on average for individuals tested alone or in pairs, but there was less variation between individuals in the paired condition compared to the alone condition.

Current study The aim of this study is to investigate if and how the social context affects neophobia in the herring gull (*Larus argentatus*). Gulls' natural coastal habitat is rapidly disappearing, forcing them to live closer to humans in urban environments and to rely more on anthropogenic food sources (Coulson, 2015; Nager and O'Hanlon, 2016). Although reports in popular media may suggest that herring gulls are generally not neophobic due to their approach towards humans or stealing food, such anecdotes ~~don't~~ do not necessarily reflect the species' behaviour at a population level (Inzani et al., 2023). In fact, significant levels of ~~neopobia~~ neophobia as well as individual differences therein exist within populations (Inzani et al., 2023). The latter finding suggests that for some individuals, it might be easier to adapt to environmental change and urbanisation than for others. Indeed there ~~exists~~ is considerable intraspecific variation in how herring gulls utilise urbanised areas, ranging from minimally to almost complete dependence (O'Hanlon et al., 2017; Pavlova and Wronski, 2020). Herring gulls are a highly social species~~though~~, utilising cues not only from conspecifics, but even from other species, including humans. This suggests that social learning is a key aspect of gull behaviour (Feist et al., 2023; Frings et al., 1955; Gandolfi, 2009; Goumas et al., 2020). Thus, when assessing their neophobia, it is important to do this not only in an individual context, but also in a social (group) context.

Based on previous findings, we predict that the distribution of neophobic responses will depend on the social context. However, the direction of the effects will depend on the social mechanisms at play. In Figure 1, we provide a template for testing the three different hypotheses of group effects, taking into account ~~three~~ two measures, namely the average neophobic response ~~,~~ and the variance between individuals~~, and the repeatability of the measures across social contexts~~.

Overall, we predict that there will be lower variance between individuals when they are tested in a group, compared to when they are tested alone. After all, all of the major hypotheses discussed above assume that individuals become more similar to each other by spreading risk, jointly buffering stress, negotiating with each other, or simply through social conformity. ~~This reduced variance will also result in a reduction of across-context repeatability.~~ However, there are three possible scenarios regarding the average neophobic response. First, the 'risk dilution' hypothesis predicts that herring gulls will be *less* neophobic on average when in a group compared to when they are alone (scenario A in Figure 1). Second, the 'negotiation' hypothesis predicts that individuals will approach novel objects *slower* when in group (scenario B in Figure 1). Third, according to the 'social conformity' hypothesis, individuals will tend to mimic one another's behaviours—those who are neophobic will show a decrease in their fear of novel objects when surrounded by others who are less neophobic, and vice versa (scenario C in Figure 1). Thus, in this third scenario, there is a reduction of variance but no change in the average response. These three predictions are contrasted with the null hypothesis that social context does not modulate variance, ~~repeatability,~~ or group means ('Null Hypothesis', Figure 1).

To test these predictions, juvenile herring gulls will be subjected to four distinct conditions: individual or group tests paired with a control or novel object. Each condition will be repeated twice. The guidelines for designing neophobia tests of Greggor et al. (2015) were followed, and a within-subject design with a relatively large sample size (N = 80) was chosen to further increase the statistical power of the study. ~~After all, one~~ One additional reason for the inconsistent previous findings is that sample size was relatively low in many studies (see also Farrar et al., 2020). In addition, the herring gulls used in this study will be raised by hand from the egg to control for sampling bias, a recurring issue when testing wild animals. After testing, they will be released in the wild.

~~Overview of hypotheses~~

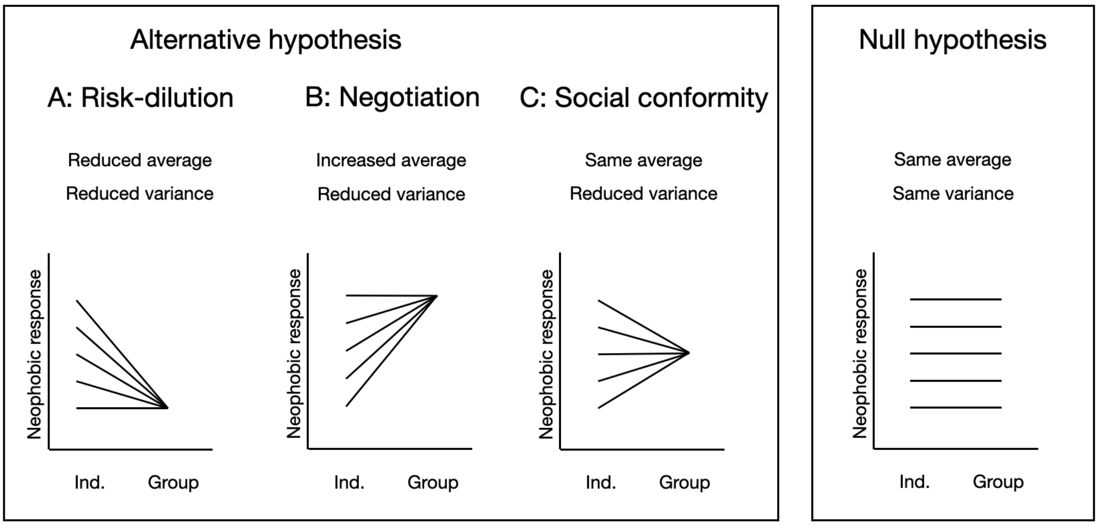


Figure 1. Overview of hypotheses

Material and methods

Sample size

We will test 80* herring gulls twice across a 2x2 design (thus eight tests per individual; see above). We performed ~~a~~ an *a-priori* power sensitivity analyses using G*Power (Erdfelder et al., 2009), for a repeated measures MANOVA with three within-subject factors: *Context* (with levels Group and Individual), *Object* (with levels Control and Novel Object), and *Trial* (with levels 1 and 2). Our sample size is sufficient to detect small main effects of *Context, Object, and Trial* (Cohen's f effect size of ~~0.113~~ 0.11 (Cohen, 2013); Power = 0.80 ; cor. among RM = 0.5), as well as an interaction between Context and Object with small effect size (~~0.113~~0.11; Power = 0.80 ; cor. among RM = 0.5). Our sensitivity analyses are based on MANOVAs (repeated-measures, within-species factors). However, as discussed below, we will analyse our data with (G)LMMs, which are currently not covered by G*Power or most other power-estimation tools. These mixed-effect models are more flexible in assigning variance as they allow for the specification of both fixed and random effects. ~~However, by~~ By accounting for unexplained variance, our proposed mixed-effect models are more powerful than the fixed-effect MANOVAs used in our sensitivity analyses.

**~~Note:~~* *As gulls ~~will be~~ are reared from the egg, in a small number of cases (typically less than 10%), herring gull eggs are mistaken for those of the phylogenetically and ecologically related lesser black-backed gull. The species can only be determined after testing (when the individuals are older). ~~We will run the analyses twice: once with all individuals and once without the~~ Test data from lesser black-backed gulls (if any) will be excluded from subsequent analysis. We conducted a power analysis that accounts for a potential 10% drop-out to ensure that even with this* *potential reduction, our study would still have sufficient statistical power (Cohen's f effect size of 0.17) to detect significant effects.*

Subjects

Egg Collection and Incubation

The herring gulls used in this study are part of a larger research project and are raised and tested at the avian research facilities of Ghent University (Lab number LA1400452), located at the Wildlife Rescue Centre (WRC) in Ostend, Belgium. Eggs are collected in May and June 2024, from nests of roof-breeding parents, by the Agentschap voor Natuur en Bos (ANB) and the gull patrol team, authorised to remove eggs along the Belgian coasts for nuisance prevention. Collected before the pipping stage, the eggs are transported to the WRC under stable conditions for further incubation, using Brinsea Ova-Easy incubators (temperature = 37.5°C; humidity = 45%). Upon arrival eggs are marked with a unique nest identifier and the two largest eggs are incubated. They are checked twice daily for small cracks, indicating pipping. Eggs showing signs of pipping, are moved to a MS700U Hatchery (temperature = 37.2°C; humidity = 50%).

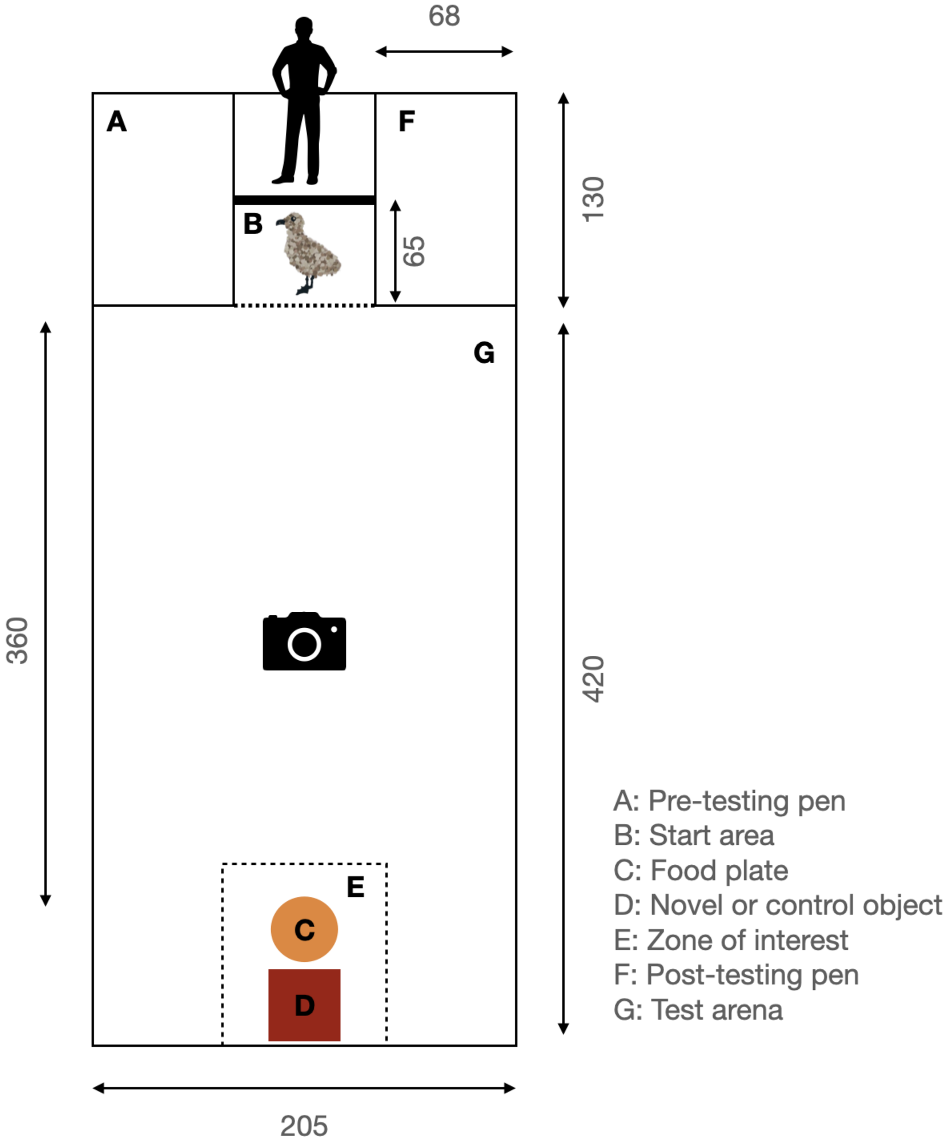
Chick Rearing

Once hatched and fully dried, the chicks receive a unique combination of colour rings for identification. The chicks are then housed in groups of 10 in boxes with netting bottoms (size = 120 x 60 x 60cm, LWH) within heated rooms (ambient temperature= 15-25°C; humidity=40%-80%; under natural light conditions). Each box contains a heating plate (30 x 30cm). The semi-precocial chicks are hand-fed small pieces of fish and dog pellets soaked in water, supplemented with Akwavit, a complementary feed specially developed for fish eating animals (Kasper Faunafood, The Netherlands). Food is available ~~ad libitum~~*ad libitum*. Once the chicks are at least 5 days old and their weight exceeds 60 grams, they are moved to outside enclosures (size = 500 x 205 x 265cm, LWH), housed in stable groups of 10 individuals. ~~A heating plate is~~ Outside, heating plates are provided during the first ~~days, depending on the weather conditions~~few days when night-time temperatures are forecast to drop below 5°C, or in the event of adverse weather conditions such as heavy rain or storms. Food consists of a mixture of dog pellets soaked in water and fish, provided 4 times per day, following the default policy at the WRC. Water is provided ~~ad libitum~~*ad libitum*. Individuals are tested when they are approximately 30 days old, shortly before they reach fledging age. After testing, the birds are moved to a large flight cage (approximately 180m^2) for dehabituation from handling. Once they are 8-10 weeks old, birds are released in the wild, and a subset (n = 50) receives a GPS-tracker.

Behavioural Test: Novel Object Task

Task Design: ~~Initially, birds are randomly allocated into stable~~ For testing purposes, each home enclosure containing ten birds is pseudo-randomly divided into two separate testing groups of five~~(forming two groups per home enclosure); these configurations serve as the basis for grouptests.~~. This division ensures nestmates are not placed in the same testing group. This arrangement allows to maintain consistent housing conditions when not testing, while facilitating specific configurations during testing sessions. In the 'novel object' condition, birds are exposed to a pseudo-randomly selected novel object (Supp. table 1). Conversely, in the 'control object' condition~~involves~~, a familiar object ~~, previously placed in their~~ is placed in the home enclosure for ~~three days before testing.~~ six days prior to testing. By placing a familiar object behind the food plate prior to testing, we can observe responses during testing that are elicited by the novelty of the object and not just the presence of the object itself (see e.g. (Greggor et al., 2015) for justification). Throughout the testing period, the familiar object remains in place and the novel object is introduced only during the testing sessions to avoid dishabituation from the familiar object. To preserve the integrity of the experimental design, the novel object introduced in each of the four sessions is unique, thus each bird's interaction with it marks their first encounter. The experimental timeline spans from late June to mid-July, lasting for 8 consecutive days.

Objects: We will use five objects of similar size (approximately the same size as a four weeks old gull), but of different colour, form and texture.



~~Test setup.~~

Figure 2. Test setup in home enclosure.

Prior to the Task: In preparation of the novel object task, and following a series of cognitive tests as part of another study (three tests in total), the test setup will be introduced into the birds' home enclosure when the birds are not present. This setup includes the pre- and post-testing pens, the start area, and one of our five pseudo-randomly selected objects, which will later act as the control object in the neophobia assessments. After having introduced the test setup, birds are allowed to accustom to the presence of the test apparatus for a period of three days. This habituation period minimises any potential stress towards a new environment, which may influence the behavioural outcome of the test trials.

~~To~~ In order to distinguish the birds when they are being tested in a group, ~~on the day of the set-up, each individual get~~ each individual will receive a unique marker ~~that~~ a few days before the test, which can be easily detected ~~on a camera.~~ by a roof-mounted camera, as the colour rings are not visible in the video recordings."

Testing Protocol: The testing commences after the ~~three-day~~ six-day habituation period. Order of conditions is counterbalanced to incorporate control and novel object conditions, as well as individual versus group

~~Novel or control objects.~~

Figure 3. Novel or control objects.

settings, with the entire sequence repeated twice~~()~~. The animals are food deprived since their last feeding moment the evening before each test at 5:30 PM, to reduce motivational differences before testing. Testing begins at 8:30 AM and is expected to be completed around 11 AM. ~~Both~~ In both group and individual ~~tests will take~~ trials, individuals will have a maximum of 10 minutes ~~,~~ for entering the test arena, and an additional 10 minutes to feed, which is consistent with previous novel object studies (Brown and Nemes, 2008; Bruijn and Romero, 2021; Lecuelle et al., 2011). All tests will be recorded with roof-mounted cameras.

Prior to testing, all the birds will be moved to the pre-testing holding pen. ~~Afterwards, food~~ Next, a stacked plate of fish and an object (novel or control, depending on the condition) will be placed at the back of the enclosure, with ~~a food bowl~~ the food plate placed in front of ~~it~~the object to rule out directional preference. A single bird, or group of birds, depending on the social context, will be placed in the start area. The tester will lift the door of the start area after 15 seconds and leave, giving the bird(s) access to their home enclosure (Figure 2). The first 10 minutes start the moment the door starts moving~~. After ,~~, the second 10 minutes start once all individuals left the start box. The testing session ends once all birds interact with the food, or once 10 minutes have passed. Next, the tester moves the tested bird(s) to the post-testing holding pen and starts a new test ~~begins~~with a new (group of) bird(s).

Data processing and analysis

Video coding. We will code all videos using the free, open-source software BORIS (Behavioural Observation Research Interactive Software) (Friard and Gamba, 2016). We will code four events, namely 'start of trial', 'test arena entry', 'eating', and 'zone of interest' (see Table 1 for full descriptions). Based on the coded events, we will determine latencies and cumulative times. By extracting the time difference between 'start of trial' and 'test arena entry', we will determine the latency to leave the start area (Figure 2). In order to determine the latency to approach the food, we will extract the time difference between 'test arena entry' and 'eating'. Time spent in the zone of interest (i.e. in proximity to the food reward and/or novel object, see Figure 2) is calculated as the cumulative time over the ~~10 min period~~length of the trial. If an individual does not perform a specific behaviour, we will assign the maximum latency, meaning the full task duration (in seconds), to that behaviour. For example, the behaviour 'test arena entry' will have a latency of 600 seconds if an individual does not enter the test arena. For the group tests, we will follow each bird individually to code their behaviours.

Video coding will be a shared task between multiple experimenters, with 20 percent of all videos being double-coded to assess inter-rater-reliability (IRR) using Cohen's Kappa. We aim for 0.81 $\leq$ Cohen's Kappa $\leq$ 1.0, which indicates strong to almost perfect agreement between coders (McHugh, 2012). If we will have a Cohen's Kappa below this value, we will assess each behaviour individually to determine which behaviours need to be recoded for all videos.

Table 1. **Ethogram of behaviours that will be coded in BORIS.** The 'Zone of interest' is defined as a fixed rectangle that includes the object and the food bowl. To ensure comprehensive observation coverage, this area is expanded by the approximate body length of a 4-week-old gull (30 cm). This ensures that all relevant activities within and around the novel object are captured.

Action	**Definition**
Start of trial (Point event)	Moment the door starts moving.
Test arena entry (Point event)	~~Both feet need to be outside the start area. If the feet are not visible, then when the front half of the~~ When the entire bird is outside the start area.
Eating (Point event)	When the beak touches the food.
Zone of interest (State event)	When the front half of the bird crosses the (notional) line.

~~Ethogram of behaviours that will be coded in BORIS. Note: the zone of interest will be a fixed rectangle, which includes both the object as the food bowl. This area will be expanded by an additional buffer, approximately equal to the body length of a 4-week-old gull, to ensure comprehensive observation coverage.~~

Statistical analysis Statistical analyses will be conducted using R, version 4.3.X (R Core Team, 2021). Mixed-Effects Models (MMs), either linear MMs (LMMs)or generalised LMMs (GLMMs), will be fitted using the `lme4` package (Bates et al., 2015). For LLMs, parameter estimation and p-values for the estimated models will be calculated by means of the `lmerTest` package (Kuznetsova et al., 2017) via the the Satterthwaite's degrees of freedom method; for GLMMs, the `car` (Fox and Weisberg, 2019) or `carData` (Fox, Weisberg, and Price, 2022) package will be used. For the GLMM, we will use partial η-squared (η_p^2) as effect sizes, and they will be calculated by means of the ~~`effectsize`~~`r2glmm` (Jaeger, 2017) package. Models will be fitted to the different latency ~~types~~ measures separately, as well as combined. For the combined analysis, the approach proposed by Snijders and Bosker, 2012 will be used, which allows for the simultaneous analysis of multiple dependent variables in the case of nested data structures, thereby considering within-group and between-group variance in latency measures.

As we aim to determine whether the average neophobic response differs between individual and group trials, a (G)LMM with Type III sum of squares will be performed on the latency measures (Table 1). This analysis will include both fixed and random effects to explore the impact of different experimental conditions. The model will incorporate *Object*, *Context*, and their interaction as key fixed effects to explore how the type of object and the social setting (alone vs. in a group) interactively affect latency responses. Additionally, *Trial* will be included as a fixed effect to control for the impact of trial repeat. To ~~capture~~ specifically assess the variability in ~~the effect of being in a group versus an individual trial, a random slope for *Group_Dummy* associated with each *GroupID* will be included (for each specific group of 5 birds), but without a random intercept for each group, thereby focusing on the variability of the group effect . Moreover,~~ latency across individual and group trials, we will compare the estimated variance components within our mixed-effects model. Variance for individual trials will be estimated from the *Indiv_Dummy* effect at the BirdID level. For group trials, the ~~variability in the individual response due to the~~ combined estimated variances of the *Group_Dummy* effect at both the BirdID and GroupID levels will be evaluated. This comparison aims to determine whether individual differences are more pronounced in solitary compared to group settings, with an expectation that individual variances and the total variance might be higher in individual trials. Additionally, an analysis at the BirdID level between the estimated variances of the *Indiv_Dummy* and *Group_Dummy* ~~will be modeled as random effects within *BirdID*. This approach recognizes that while individuals participate in both settings, the impact of the social context may vary with *groupID*~~effects will further elucidate how individual differences manifest under different trial conditions, potentially highlighting the influence of group dynamics on individual behaviour.

$$\begin{aligned}\text{Latency} \sim {} & \text{Object} \times \text{Context} + \text{Trial} \\ & + (1|\text{NestID}) \\ & + (-1 + \text{Group\_Dummy}|\text{GroupID}) \\ & + (-1 + \text{Indiv\_Dummy} + \text{Group\_Dummy}|\text{BirdID})\end{aligned}$$

In the model, *Object* refers to the stimulus presented, distinguishing between control and novel objects. *Trial* captures the two testing sessions conducted, and *Context* indicates the social environment, differentiating between individual and group settings. Random effects structures are tailored to accurately reflect the individual and group-level variability in responses. Specifically, *NestID* is included to control for similarities within nests, *Group_Dummy* identifies trials conducted in group setting, effectively marking the presence of social interactions during the test. Conversely, *Indiv_Dummy* indicates the absence of such group dynamics, highlighting trials where subjects are tested alone.

In all instances, model plots will be generated using the `performance` package (Lüdecke et al., 2021) to inspect violations of model assumptions, such as heteroscedasticity, non-normality of residuals, and the presence of outliers. Multicollinearity and autocorrelation will be evaluated, with potential model adjustments including transformation of variables or modification of the model structure (e.g., switching from LMM to GLMM). In terms of model design, binary predictors will be encoded using contrast coding (-0.5 vs. 0.5), optimizing the interpretability and efficiency of our analyses in the context of our perfectly balanced predictor variables. Post-hoc analyses, following significant findings, will be performed with Bonferroni-Holm corrected contrasts to further explore the data. Given the balanced nature of our model predictors, concerns related to multicollinearity are minimised, negating the need for variance inflation factor (VIF) assessments traditionally used to identify redundancy among predictors.

Discussion

Appendices

These are your appendices

Acknowledgements

This is your acknowledgments.

Fundings

Conflict of interest disclosure

The authors declare that they comply with the PCI rule of having no financial conflicts of interest in relation to the content of the article.

Data, script, code, and supplementary information availability

All necessary data, scripts, and code required to replicate our study's findings will be made openly accessible at the article's OSF repository. Supplementary information, supporting our results, will also be made available at this repository.

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Supplementary material

Day/Cage
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
Day 12
Day 13
Day 14
Day 15

Day/Cage
Day 16
Day 17

~~**Neophobia testing schedule** Note: "GC" signifies Group Control, "IC" indicates Individual Control, "GT" represents Group Te~~

~~Discussion~~

~~Appendices~~

~~These are your appendices~~

~~Acknowledgements~~

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~~Fundings~~

~~Conflict of interest disclosure~~

~~The authors declare that they comply with the PCI rule of having no financial conflicts of interest in relation to the content of the article.~~

~~Data, script, code, and supplementary information availability~~

~~All necessary data, scripts, and code required to replicate our study's findings will be made openly accessible at the article's OSF repository. Supplementary information, supporting our results, will also be made available at this repository.~~

Question	Hypothesis	Sampling plan	Analysis Plan	Rationale for deciding the sensitivity of the test for confirming or disconfirming the hypothesis	Interpretation given different outcomes	Theory that could be shown wrong by the outcomes
Does the individual degree of neophobia differ across social contexts in a highly social species, the herring gull?	We hypothesise that the distribution of neophobic responses will change in a group context. Specifically: a.) There is a reduction of the variance in group tests. b.) The average response differs between group/individual tests, depending on the social mechanism at play	We will test 80 herring gulls twice across a 2x2 design. These four distinct conditions are: individual or group tests paired with a control or novel object. Each condition will be repeated twice. In the 'novel object' condition, birds are exposed to a pseudo-randomly selected novel object Conversely, the 'control object' condition involves a familiar object, previously placed in their home enclosure for six days before testing. Testing trials will be randomised, see Supplementary table 1 in the main manuscript	A (G)LMM with Type III sum of squares will be performed on the different latency measures. Models will be fitted to the different latency types separately as well as combined. For the combined analysis, we will use the approach proposed by Snijders and Boskers (2012), which allows for the simultaneous analysis of multiple dependent variables in the case of nested data structures, thereby	*A-priori* power sensitivity analyses were conducted in G*Power (Erdfelder et al., 2009), using a MANOVA. This indicated that our sample size of 80 animals is sufficient to detect a small effect of *Context, Group* and *Trial*. However, we will analyse our data with (G)LMMs, which are currently not covered by G*Power or most other power-estimation tools. These models are	If social context fails to modulate variance, or group means, it could suggest that social contexts hold little significance for neophobic responses among herring gulls.	Social context may either modulate the group mean, the variance, or both. The risk dilution hypothesis suggests that being in a group will reduce both the mean and the variance of neophobia. Conversely, the negotiation hypothesis predicts an increase in mean neophobia but a decrease in within-group variance. The social conformity hypothesis predicts no change

	~~c.) The average response differs between group/individual tests, depending on the social mechanism at play~~	for a detailed testing schedule. Testing groups comprise 5 individuals by semi-randomly allocating gulls to one group. We will split nest mates across groups. Sexing is unfeasible prior to testing. While we will consider sex differences in our statistical analyses, we do not expect an effect of sex since herring gulls only reach sexual maturity at 4-years of age. Groups may also include a lesser black-backed gull. We will include all gulls for testing but will remove the lesser black-backed gulls prior to conducting the statistical analysis.	considering within-group and between-group variance in latency measures. The model will incorporate *Object*, *Context*, their interaction and *Trial* as fixed effect. A random slope for *Group* associated with each *GroupID* will be included focusing on the variability of the group effect. Moreover, the variability in the individual response due to being in a group or not will be modelled as random effects within *BirdID*.	more flexible in assigning variance as they allow for the specification of both fixed and random effects. However, by accounting for unexplained variance, our proposed mixed-effect models are more powerful than the fixed-effect MANOVAs used in our sensitivity analyses.		in mean neophobia, but a decrease in variance. The design of our study allows us to validate or refute each of these hypotheses.