Designing an Interactive Device for Contact with Corvids: Towards Exploring Aesthetic Sensibilities

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Abstract

The study highlights Corvids' notable cognitive abilities and aims to fill the gap in accessible research tools for observing these birds in their natural habitat. Utilizing iterative design and 3D printing, the project produced a modular feeder integrating puzzles to engage Corvids, facilitating non-intrusive observation and study. Results indicate the device's success in attracting Corvids, proving its value as a research tool and platform for further exploration of Corvid cognition. The study suggests potential future directions, including advanced cognitive experiments.

I. Problem

I. Background

Research in the intersection of human and animal domains has significantly advanced our understanding of ecologies and even offered great insight into animal aesthetics. As a potential subject for such research, Corvids stand out for their cognitive abilities[4] and have shown remarkable adaptability and cohabitation with humans [6]. Specifically, in Berlin, the omnipresence of Hooded Crows, magpies, and jays makes researching these specific birds convenient.

Corvids cognitive research has shown them able to pass the mirror test [9], and solve intricate puzzles [12].

Their cognitive abilities extend as well to the social realm, exhibiting trading behaviours [3], excellent human facial recognition [7], alongside their capacities for speech and communication [10], as well as episodic memory.

Corvids display these constant abilities with playful activities, interacting with other animals in teasing manners and using funerals to learn about danger [11].

For all these reasons, it is relevant to create an experimental environment in which further studies on Corvid's cognitive abilities and their hypothetical relationship to aesthetics can be conducted.

II. State of the Art

The comparison between studies on captive versus free-living animals in avian research presents a significant divide. Recently, bird enthusiasts have sought non-intrusive ways to do so through innovative feeders, such as the Bird Buddy [1], which offers a novel way to engage with and study birds in a wild setting. Despite existing Corvid research, both in captivity and through the deployment of specialized devices such as the Crowbox [5], these solutions are often prohibitive in terms of cost and complexity. However, the development of an open-source, Corvid-specific feeder designed for field research remains unaddressed. Such a device would not only facilitate the specific study of Corvids in their natural habitats but would also be accessible, cheap, and easily reproducible. This represents a critical gap in the current research landscape, promising to lay the groundwork for extensive future experiments in the field.

II. Problem Parametrization

I. Study of Wild Crows

The main concern in the study of wild Corvids centres around ethical and practical methodologies that involve no capture and allow free access for the subjects of study, ensuring their safety and that of human observers. To this end, an ideal research apparatus must enable easy observation of Corvids while selectively discriminating against other bird species to ensure the focus remains on the intended subject group. Safety for birds and humans is a fundamental requirement underpinning the research design.

II. Accessibility

Accessibility of the research apparatus is critical for widespread adoption and utility. It hinges on several key factors:

- **Modularity:** The design should allow easy modifications to cater to various experimental setups.
- **Cost-effectiveness:** The materials and manufacturing process should be inexpensive, enabling researchers and enthusiasts with limited budgets to participate in Corvid research.
- **Reproducibility:** Ease of replication is essential, ensuring that others can recreate the design accurately based on shared plans and specifications.
- **Open Source:** By adopting an open-source model, the project can benefit

from collaborative improvements and innovations, enhancing its utility and effectiveness.

III. An Experimental Platform

The design must seamlessly integrate with various sensing technologies to facilitate a diverse range of experiments. This includes easily attaching cameras and microphones and transforming the research apparatus into a versatile platform capable of capturing behavioural data. Such integration expands the scope of potential research and enhances the quality and depth of observational data, contributing to a more nuanced understanding of Corvid behaviour and cognition.

III. Aim & Methodologies

I. Design

The development of the Corvid feeding device employed an iterative design and production process, centered around the feeder as the main attraction point for the birds. Several key constraints guided the design to ensure the device was both effective in attracting Corvids and feasible to produce:

- **Material Choice:** The primary material used was recycled plastic bottles, chosen for their cost-effectiveness and ease of availability. This choice underscores the project's commitment to sustainability and accessibility.
- **Modularity and Standardization:** The design leverages standardized screw fittings and modular 3D printed pieces to achieve high levels of standardization and reproducibility. Despite the potential cost of 3D printing filament, the modular nature of the design significantly reduces overall costs.
- **Components:**
  1. **Food Reservoir:** Can hold bird food, such as seeds.
  2. **Tube Food Reservoir Holder:** This component can incorporate an optional puzzle mechanism, designed to engage the Corvids' problem-solving abilities. The puzzle includes a two-step process involving a rotative lever and a trapdoor, both tailored to the birds' physical and cognitive capabilities.
  3. **Puzzles:** The two different puzzles were conceived as a 'cognitive' threshold to discriminate between Corvids and other birds. These puzzles are both optional.
     - **Door:** Rotating door placed at the end of the tube.
     - **Bubble-gum-machine mechanism:** Rotative handle that rotates a ball inside the tube with paddles that push and create food portions.
- Additional pieces were developed to support specific research needs but are considered optional within the broader design framework.

II. Prototyping

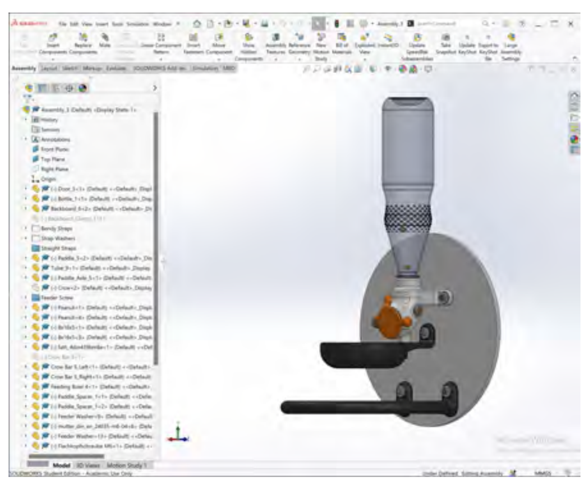

Figure 1: *The Crowbar was mostly designed with Solidworks*

The prototyping phase involved a variety of tools and materials to bring the design to life:

- **Design and Modeling Tools:** Solidworks was utilized for the 3D modeling of the device, ensuring precise construction and design fidelity.
- **Manufacturing:** The device components were produced using both filament 3D printers (Original Prusa i3 MKS3) and resin printers (Original Prusa SL1S speed), facilitating a mix of durability and detail in the printed parts.
- **Materials and Components:** The assembly of the device required a combination of 3D printed parts and readily available hardware, including an empty water bottle, ball bearings, screws, washers, nuts, a clear plexiglass backboard, threaded inserts, and double-sided tape. This combination enabled a robust yet flexible design, allowing for easy assembly and adjustment.

III. Communication

Effective communication and accessibility of information are pivotal for the success and replication of the project. To this end, several steps have been taken to ensure that the findings and developments related to the crowbar are widely disseminated and easily accessible:

- The project's documentation and pertinent information have been publicly available at `crowbar.celest.in`. This platform is the central hub for all project-related details, ensuring that interested parties have immediate access to comprehensive resources.
- In line with the project's commitment to open-source principles, all files related to the Crowbar project are hosted and released under an open-source license. This approach facilitates community contributions, allowing for continuous improvement and project adaptation.
- Detailed instructions on creating and building the crowbar at home are provided, ensuring that individuals or researchers can replicate the study's tools. These instructions are designed to be user-friendly, enabling a wide range of enthusiasts and scholars to engage with the project directly.

IV. Testing

The project's testing phase is integral to validating the design and functionality of the crowbar. In our paper *Enhancing Urban Corvid Observation: A Modular Approach with 'The Crowbar' Feeding Device*[8], This paper introduces 'The Crowbar', and details our testing methodology which included deploying the device in an urban setting and observing and recording bird interactions with the device, facilitated by a live stream setup.

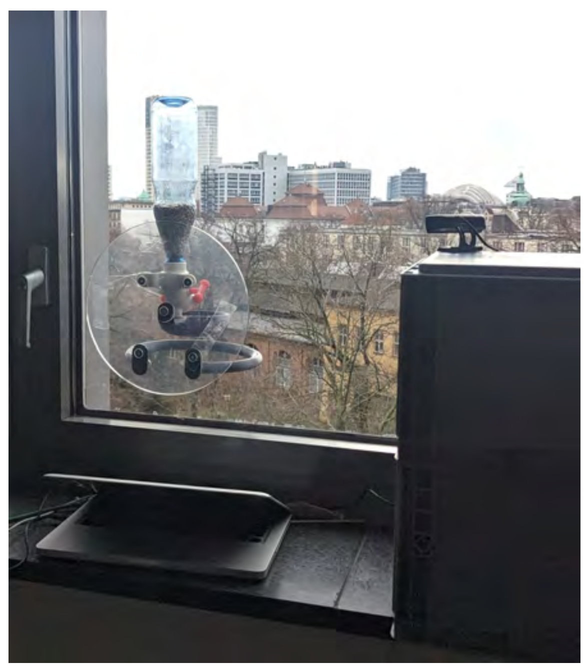

Figure 2: *This setup was used to record and collect data on birds' interaction with the Crowbar*

IV. Design Methods

I. Feeding Tube Improvements

The Feeding Tube is the cornerstone of the project. It is where we can attach the bottle to hold the food, and place the puzzle.

I.1 Version 1

Improvements were focused on enhancing the structural integrity and usability of the feeding tube. The initial design featured a simplistic construction comprising only a basic right-angled tube with a single door. This was revised by drilling a hole into the sidewalls to facilitate the addition of a rotary feeder. Furthermore, the tube's wall thickness was initially too thin at 3mm, making it vulnerable to damage from pecking; this was increased to 5mm for improved durability. An attachment port was also added to secure the feeding bowl, addressing the absence of any additional means for bowl attachment in the original design.

I.2 Version 2

The second version aimed at refining the attachment mechanism and enhancing the overall design for better functionality. The attachment wings were lengthened to correct the issue of the bottle being unable to screw into the feeding tube securely. Threading was standardized inside the bottle mounting hole to accommodate all standard bottles, and the rotary axle hole was relocated to the front of the feeding tube to prevent the rotary knob from colliding with the mounting panel, ensuring proper rotation.

I.3 Version 3

This version made modifications to the feeding bowl attachment and door mechanism. The feeding bowl attachment hole was enlarged, and an additional mounting point was added for increased stability. The door hinge was moved from the top to the side of the tube opening, and a stopping arm was introduced to control the door's swing, addressing the issue of the door swinging too freely.

I.4 Version 4

Adjustments were made to the feeding tube opening and rotary axle hole. The opening was redesigned to have angled faces to prevent excessive accumulation of food within the tube. Additionally, the rotary axle hole was adjusted to accommodate an 8x16x5mm ball bearing, enhancing the smoothness of rotation.

I.5 Version 5

The design was simplified by reducing the number of mounting points for the feeding bowl from two to one. This change made the bowl less wide and increased the connector's wall thickness for added stability.

I.6 Version 6

The wall thickness around the feeding tube bottle thread was reduced from being excessively thick to 5mm, conserving material while maintaining sufficient stability.

I.7 Version 7

Improvements in this version included reducing the size and form of the door stop abutment for better aesthetics and functionality. Additionally, M10 threading was added inside both the door mounting hole and the feeding bowl hole to enhance the assembly process.

I.8 Version 8

The overall size of the feeding tube was reduced to fit within the print bed, saving material and making the design more practical for 3D printing.

I.9 Version 9

To avoid collisions between the feeding tube and the rotary knob caused by the reduced size of the tube, the knob was strategically placed on the side of the tube but closer to the opening, ensuring unimpeded operation.

Figure 3: *Feeding Tube test print*

II. Feeding Bowl

The Feeding Bowl is an optional module that will hold the food after it falls down the food reservoir, through the tube.

II.1 Version 1

The initial design of the feeding bowl presented challenges in terms of placement and stability due to its oval shape, which was altered to a circular form to enable consistent concentric positioning. Additionally, the mounting connectors were initially too unstable, prompting an increase in the thickness and a redesign of the mounting arm's shape for enhanced stability and durability.

II.2 Version 2

The second iteration addressed the issue of excessive bowl wall thickness by reducing it to 5mm. This adjustment optimised material use and improved the bowl's functionality without compromising its structural integrity.

II.3 Version 3

Modifications in this version focused on the feeding bowl's mounting mechanism. The mounting arm was lengthened and its form was adjusted to facilitate smooth force distribution, effectively reducing tension spikes and ensuring a secure attachment. Furthermore, a flat cutout was created on the curved underside of the bowl mounting arm, allowing for the placement of a washer under the screw to improve the connection's reliability and ease of maintenance.

III. Crow Bar Perch

The Crow Bar Perch is also optional. It is intended for the birds to sit comfortably and interact with the device.

III.1 Version 1

To enhance the structural integrity of the bar perch, the connection points to the mounting plate were initially found to be too small, presenting a risk of breaking under stress. This was addressed by increasing the thickness of the connection ends of the perch bar, ensuring a more robust and durable connection to the mounting plate.

III.2 Version 2

The perch's original rectangular shape was identified as a contributing factor to large angular momentum at the connection point, which could lead to increased stress and potential failure. The design was thus revised to adopt an ovular shape, harmonizing with the circular form of the feeding bowl and reducing angular momentum for a more stable and secure installation.

III.3 Version 3

The bar's dimensions were initially too large for the printing platform, necessitating a reduction in size and a division into two separate parts for practical manufacturing. Additionally, the oval shape was too wide for the mounting plate, prompting a change to a circular shape to ensure a proper fit and enhanced compatibility with the mounting system.

III.4 Version 4

Concerns about the perch bar being too thin and at risk of snapping, especially considering the average weight of a crow being around 500g, led to an increase in the bar's diameter. This adjustment provided the necessary strength to support the weight and activity of a crow without compromising the perch's integrity.

III.5 Version 5

The bar perch's connection to the mounting system lacked stability, prompting a reevaluation and adjustment of the connection component's shape and arrangement for improved stability and reliability. Moreover, the connection plate was still deemed too thin for optimal performance, increasing plate thickness to ensure a more secure and durable mounting solution.

IV. Rotary Paddle

The Rotary Paddle is part of the optional bubble-gum-machine-like puzzle.

IV.1 Version 1

The original design of the rotary paddle featured a wing count that was too small, which allowed nuts to pass through the mechanism when positioned at a 45-degree angle. To counteract this issue, the wing count was increased from 4 to 8, significantly reducing the likelihood of feed passing through undesirably. This increase in wing count inherently reduced the radius between wings, addressing the issue of the overly large radius that was initially present.

IV.2 Version 2

Concerns were raised regarding the material thickness around the paddle's central axle cutout, which was deemed too thin and potentially susceptible to wear or damage. The material thickness in this area was increased to ensure durability and the paddle's integrity.

IV.3 Version 3

The interface between the rotary paddle and the ball bearing was improved to ensure a more consistent and reliable operation. Originally, the contact surface between the rotary paddle and the ball bearing was inconsistent, which could lead to operational inefficiencies. To remedy this, two spacing rings were added on either side of the paddle to maintain consistent axial spacing and ensure optimal contact with the ball bearings. Additionally, the contact surface between the spacing ring and the ball bearing was initially too round, leading to potential slippage or uneven wear. This was addressed by flattening the contact surface to improve engagement and reduce wear.

IV.4 Version 4

Testing revealed that the rotary diameter was too large, causing even tiny sunflower seeds to jam in the rotary mechanism. To resolve this issue, the rotary diameter was decreased to allow a 5mm gap between the wall and the rotary wings. This adjustment ensured that the feed did not fall through completely, allowing the rotary to act as a blocking mechanism and as an extruder of feed. This change optimized the functionality of the rotary paddle, ensuring smooth operation and preventing jamming issues.

V. Rotary Paddle Axel

The Rotary Paddle Axel is part of the optional bubble-gum-machine-like puzzle.

V.1 Version 1

The axle's endpoint was initially harsh and uncountable, leading to a potential issue with fitting and operation. To address this, the endpoint opening was modified to ensure a smoother interface and enhanced compatibility with the rotary mechanism.

V.2 Version 2

The original axle diameter of 6mm was found to be too thin, posing a risk of cracking under stress. The diameter was increased to 8mm to mitigate this issue, providing a stronger axle capable of withstanding greater forces without compromising its integrity.

V.3 Version 3

Adjustments were made to the cutout for the rotary paddle, which was initially too shallow and could result in a fit that was too tight, potentially hindering the paddle's rotation. The cutout diameter was increased to allow for a more suitable fit. The original design included a hole cutout at the end of the axle for a securing dowel, deemed impractical and unreliable for securing ball bearings. This was replaced with threading added to the axle to allow for the connection of an M8 nut, ensuring a more secure and reliable assembly.

V.4 Version 4

The axle arms were initially too large, leading to a collision with the Feeding Tube. This issue was resolved by decreasing the arms' length by 10mm, which allowed for sufficient clearance and smooth operation. Furthermore, the filled radius at the contact point with the ball bearing was too large, reducing the contact surface and potentially affecting the mechanism's efficiency. The radius of the fillet was decreased to optimize the contact surface and ensure the effective operation of the rotary paddle system.

VI. Door

The optional door is placed at the end of the tube and stops the food from flowing down directly.

VI.1 Version 1

The door's initial design was too thin, making it vulnerable to damage from crow pecking. The thickness was increased to 5mm to address this issue, providing a more robust barrier that could withstand such interactions. Additionally, the beak handle's shape was impractical and did not allow the crow's beak to engage easily. The handle's shape was changed to spherical to facilitate more manageable and intuitive interaction by the crows.

VI.2 Version 2

Several enhancements were made to improve the door's functionality and durability. The hole diameter for the screw was increased, along with the addition of an extrusion rim, to enhance stability and increase the contact surface, ensuring a more secure attachment. Furthermore, to prevent the door from swinging completely counterclockwise—which would prevent it from swinging closed—a blocking abutment was added to the interior of the door. This restricts the degree to which the door can be opened, ensuring it remains functional. Additionally, with the change in the shape of the door swing blocking the abutment on the feeding tube, another abutment was needed to block the swing on the door itself. This abutment was added to prevent the door from continuing on a clockwise path, enhancing the overall reliability of the door mechanism.

V. Results

The outcomes of the Crowbar project are pivotal in understanding its impact on the study of wild crows, its accessibility, functionality as an experimental platform, production feasibility, and effectiveness in communication.

I. Study of Wild Crows

The project set out to observe wild crows without necessitating capture, and this objective was successfully validated. Free access was provided to the crows, allowing them to interact with the device without any restrictions. Observations were facilitated by the device's design, which proved to be easily placed in various locations, thereby ensuring versatile usability. It effectively distinguished between the targeted crows and other bird species, adhering to the study's specific requirements. Moreover, the entire setup was deemed safe for both the birds and human observers, confirming the ethical viability of the research method.

Figure 4: *A Hooded Crow sitting comfortably on the Crowbar*

II. Accessibility

In terms of accessibility, the Crowbar project achieved notable success. The modularity was validated, offering significant flexibility for adjustments and usage across different settings. The cost of production was substantially lower than commercial alternatives, making it a cost-effective solution for similar studies. While the replication of the device was relatively validated, it was noted that a basic understanding of 3D printing and access to the necessary equipment are prerequisites. The project's dedication to open-source principles was upheld, ensuring the design and findings were freely available for community engagement and further development.

III. Platform for Experiments

The device partially validated its efficacy as an experimental platform. According to additional research [8], the Crowbar attracted crows without deterring them and effectively discouraged interactions from non-target bird species. Although direct attachment of sensors to the device was not explored, its design accommodates easy integration with various observation technologies. Specifically, the device's compatibility with transparent windows allows for the use of interior-mounted cameras, facilitating detailed recording of the birds' interactions with the device.

IV. Production

The Crowbar's practical application in research contexts was effectively demonstrated. Using gecko glue tape for attachment to windows and a supplementary security system involving a string confirmed the device's stability and reliability in situ. From a cost perspective, the modular design approach significantly reduced production expenses, with the comprehensive version of the device costing approximately 50 euros and a simplified version estimated at 25 euros. This affordability underscores the project's economic viability.

Figure 5: *Finished Crowbar*

V. Communication

Communication efforts were successfully executed, with all pertinent files and instructions publicly available on `https://celest.in/`. This transparency facilitated wider community involvement and allowed for the replication of the study. Additionally, the device's placement on a transparent window eased the observational processes and simplified live streaming of the birds' interactions, thus enhancing public engagement and educational outreach [2].

The Crowbar project's results underscore its value in advancing the study of wild crows, providing a replicable and safe method for observation, and fostering community involvement through open-source sharing and effective communication.

VI. Where You Go From Here

Although the Crowbar project's scope was limited, the outcomes suggest that further exploration is possible, ranging from advanced studies on Corvid cognition to human-animal interaction.

I. Further Experiments on the Crowbar

The success of the Crowbar as a tool for engaging with wild Corvids invites a series of targeted investigations aimed at deepening our understanding of these complex creatures. Future experiments could explore whether Corvids can generalize the recognition of Crowbars across different contexts, indicating a level of abstract thinking and environmental awareness. Additionally, the efficacy of puzzles integrated into the Crowbar to challenge and measure Corvids problem-solving skills warrants further scrutiny. There lies a significant interest in adjusting the puzzle's difficulty to map the limits of Corvid intelligence and their ability to learn and possibly teach these solutions, shedding light on their communication and social learning behaviours.

II. Experiments on Cognition

The interaction facilitated by the Crowbar between humans and Corvids opens the door to experiments that could significantly advance our comprehension of avian cognition. These interactions could serve as a foundation for developing methods to communicate more profoundly with Corvids, potentially unveiling aspects of their thought processes, decision-making, and possibly even elements of culture within Corvid societies. The role of media in these interactions presents an uncharted territory; exploring how Corvids respond to virtual media, such as screens or sound-based communication, could reveal new dimensions of animal-human interaction and cognition. Furthermore, mythology and its transmission among animals, mainly how stories or legends might be passed down among Corvid populations, represents a fascinating, albeit speculative, study area.

III. Environmental Concerns

Lastly, the environmental implications of the Crowbar project highlight the necessity of sustainable practices in wildlife research. The use of plastics, particularly non-pigmented plastics, has been noted for its reduced longevity in wild settings. Future designs and iterations of the Crowbar or similar devices should consider environmental impact, favouring materials and designs that rely less on colouration and more on shape and functionality to ensure the tool's efficacy and harmony with the environment.

In conclusion, the paths that branch out from the Crowbar project touch upon the intricacies of Corvid intelligence, the potential for innovative communication between species, and the imperative of environmental consciousness in research design. Each of these directions promises to enrich our understanding of the natural world and challenge us to think creatively about our interactions.

VII. Acknowledgments

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