# Call of the Wild Web: Parrot Engagement in Live vs. Pre-recorded Video Calls

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**Figure 1: Parrots in video calls. In the top row, parrots attend to calls with pre-recorded videos, and the bottom row live parrot calls.**

## ABSTRACT

The concept of the animal Internet has flourished, with many conceptualisations proceeding from the premise that connecting animals online may enrich their social life. Yet we remain unaware of how – or even whether – online interactions (either live or with pre-recorded material) might affect how animals engage with other animals. We implemented a system for parrots to trigger live video calls with other birds or playback from a pre-recorded video call. The goal was to identify differences in engagement and behaviours. Over a six-month study, parrots triggered significantly more live calls and engaged longer in that setting relative to the playback condition, while the animals' caregivers found greater value in the latter but preferred the live alternative for the birds under their care. The results begin to question what animals make of online remote connections, putting forward considerations as to how the internet can affect animals' experiences.

## CCS CONCEPTS

• **Human-centered computing** → **Collaborative and social computing**.

## KEYWORDS

Animal–Computer Interaction, Animal Internet, Parrot


*CHI '24, May 11–16, 2024, Honolulu, HI, USA*

ACM ISBN 979-8-4007-0330-0/24/05.
https://doi.org/10.1145/3613904.3641938

**ACM Reference Format:**
Ilyena Hirskyj-Douglas, Jennifer Cunha, and Rebecca Kleinberger. 2024. Call of the Wild Web: Parrot Engagement in Live vs. Pre-recorded Video Calls. In *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24), May 11–16, 2024, Honolulu, HI, USA.* ACM, New York, NY, USA, 14 pages. https://doi.org/10.1145/3613904.3641938

## 1 INTRODUCTION

Various approaches have been suggested to address the lack of socialisation in domesticated animals, including environmental enrichment and positive-reinforcement-based behaviour modification [55]. Recently, the concept of an animal Internet, and especially the use of video calls for animal-to-animal engagement [32] and human–animal contact [24], has garnered attention connected with aims of meeting pets' socialisation needs by using technology to bridge the space between animals in separate locations [23]. Prior studies' findings suggest overall that animals trained in and given access to such systems voluntarily engage in video calls with other animals [24, 32]. However, exploring the potential of online calls to facilitate animal communication necessitates deeper investigation of what this technological tool means to the animals and for their experiences.

Although significance is a complex matter, avenues exist for assessing some aspects of sense-making of live connections in an ethical and agency-promoting manner. For centuries, humans have attempted to traverse the gap between species and, thereby, grasp animals' subjective experiences [49]. Indigenous peoples have long relied on communication, of various types, for their coexistence with animals, and more recently researchers have directed effort to training animals to mimic human speech, employ sign language, and use electronic communication systems. In associated

work, the 'mirror test', designed for gauging self-recognition in animals, has expanded our comprehension of their cognitive capacities. When marked and given a mirror, some animals (e.g., chimpanzees, dolphins, elephants, fish, ants, and various birds) exhibit self-recognition by displaying behaviours such as examining themselves and using mirrors strategically to explore their surroundings [16]. While this technique has been long touted for revealing the hallmarks of cognition across species [35], it has attracted criticism too [28, 60]. Authors musing on why some animals do not pass the mirror test have suggested that reflections do not afford enough awareness of 'self' across all cases: the test relies considerably on vision and touch, which may lack biological relevance (not all animals with a mark made on their body express a need to investigate and touch it), and might be overly reductionist [28, 60, 61]. Many have concluded that animals' conscious experience of self and others is not limited to binary awareness [12]; rather, it spans multitudinous phenomenological facets of subjective experience [44].

Recognising animals as engaging in subjective experiences prompts one to ask whether they would choose to use Internet-enabled social technology and about the implications its application – and what they gain from such use more broadly – holds for their lives. Although we recognise the inherent difficulty in accurately encapsulating the complete subjective experience of an animal, given the intricate interplay of various factors, looking at animals' behaviours over time can provide a window to their decisions and, thereby, internal states [58]. Researchers have started investigating how animals perceive and react to visual and acoustic signals from social agents [37, 53, 54], but what being 'online' means to them remains quite opaque. To understand how animals choose to engage with technology, we must delve into what their interactions reveal about their evolving understanding of self and others in an increasingly digitalised world. Thus we can explore the many intriguing aspects of how animals perceive and engage with the digital realm.

To investigate perceptions and engagement involving the animal Internet, we built a system via which a parrot in the home setting can connect to other parrots online by using a tablet computer to initiate either a live call with another parrot or playback of pre-recorded video of a parrot call. We chose parrots because these highly social birds [2] frequently are bereft of species-specific socialisation when under humans' care [64]. The adverse effects on their psychological well-being, coupled with resultant behaviour issues, have led veterinary organisations to declare socialisation fundamental for socially healthy parrots that, through opportunities to express natural behaviours and form suitable responses, are equipped for greater independence and improved emotional states [66]. In the study, we provided training such that the birds could use the tablet system to select a target parrot for a video call, introduced them to other birds, and then made the system accessible in their home for three months (available for up to three hours a day). The study involved the parrots' human caregivers also: they learned to teach the parrots, and we surveyed them to investigate how best to support the birds in the home. We provided six live video-calling sessions (denoted as S1–S6), after which we introduced these birds to new parrots and again let them call within the limits of a three-hour session on each day of the study, with another six sessions (S7–S12) over three months. This time, however, on the other end of the line were pre-recorded parrots. The playback condition aided in exploring whether the presence of live interaction affected video-calling behaviours, to cast light on what it is like to be a parrot on the Internet. We sought answers to the following research questions:

**RQ1** Do parrot engagement differ between a live call with a parrot and a call presenting a pre-recorded parrot?

**RQ2** How do parrots' caregivers perceive the utility and feasibility of the video calls and parrot-Internet system for themselves and for their birds?

This work ultimately aims to provide social enrichment for animals in human-managed settings. While studies had already demonstrated that pet parrots can benefit from social enrichment afforded by live calls [32], such calls' resource-intensive nature – they demand significant time of caretakers and require synchronisation for the presence of another bird – led us to wonder whether playback of another bird could yield similar results, for a lower barrier to birds' social enrichment. Developing and deploying suitable means of assessing animal-technology systems constituted another important aspect of our work. The methods should keep high standards of animal welfare and well-being in the foreground at every stage in the research. Accordingly, we devised a force-free investigation proceeding from genuine agency, in aims of benefiting the participating animals and, more generally, enhancing the species' future.

The parrots' interactions with the video-call system, examined alongside caregiver diaries, questionnaire responses, and interview data, revealed that parrots both initiated significantly fewer video calls and spent considerably less time in the ensuing calls when the set-up pivoted to pre-recorded video stimuli instead of live calls. In addition, our analysis did not reveal any significant changes in either measurement of engagement (number or length of calls) as time elapsed after that point. These findings together supply ample fuel for speculation about parrots' ability to discern the live nature of a call. Alongside the birds' greater propensity to engage in video calls when communicating live with other parrots, caregiver feedback points to strong potential for adoption of such systems. The humans believed that the bird benefited especially from the live calls (three quarters of them considered the live calls better, and just over half believed the parrot to have benefited from pre-recorded videos also), though generally preferred the pre-recorded version for their ease. Results such as these offer insight into how video calls can meet animals' and their caregivers' needs.

Simultaneously, they shed light on how animals make sense of the social Internet more generally. Our work promotes vital understanding of animals' experiences by providing evidence of behaviours indicative of parrots' awareness of, and responsiveness to, technology-mediated social interactions at a certain level. Further probing how animals comprehend and engage with digital representations of other beings can illuminate their consciousness and cognitive abilities. While we could not directly ascertain whether animals possess self-awareness or complex consciousness akin to that shown by humans online, we now possess valuable knowledge of the potential value of such technology to address the social-enrichment needs of pet birds. Also, by advancing understanding of how animals perceive and respond to their digital environment, we add to the ongoing dialogue about animal consciousness and cognition.

## 2 RELATED WORK

Technology's rapid development and integration into more and more of day-to-day life has given impetus to research investigating how animals engage with screen-based stimuli, and constant evolution in the fields of human–computer interaction (HCI) and animal–computer interaction (ACI) has cultivated frameworks and tools aligned with this aim [14]. We anchored our study in prior work exploring screen-mediated interactions among birds, animal agency, and video calling for animals.

### 2.1 Animal–Computer Interaction for Enrichment

The emerging discipline of ACI investigates how animals interact with digital technology and how we can design interfaces that cater to their specific biological needs and cognitive abilities [25]. In particular, pet-associated technology has seen a marked upswing in recent years; from smart feeders to interactive toys, digital advancements are becoming increasingly woven into pets' day-to-day living [8, 24, 46]. Often, these technologies get sparked by impacts of animals being left alone for long periods, which poses behaviour-related challenges [20]. Much of the modern pet-technology market is focused on offering solutions to problematic behaviour via interactive cameras, treat-dispensers, remote cameras with two-way audio, toys that respond to verbal commands, and game-centric applications. Their objective is to keep pets engaged, offer mental stimulation, and provide a semblance of human interaction during caregivers' absence. Parrots, with their recognised extensive cognitive and social needs, can benefit from such technological interventions. Among prior efforts in this direction are physical interfaces to let them control their sonic environment [33], investigations into how they can use screens [31] and make sense of virtual objects [3] and even some systems that utilise tablets for video calls to other birds [32]. However, the design of screen-based interactive tools for animals often falls short of considering the crucial dynamics at play. Developers need to model the way the animals perceive not only the visual interface but also the interaction mediated by technology.

### 2.2 Screen Technology for Parrots

Several factors cause obstacles to a bird faced with visuals on screens tailored for human perception. Interpreting the colour spectrum and the critical flicker-fusion rate may be particularly problematic. Many parrots detect ultraviolet (UV) ranges [38] and might interpret the screen's content accordingly. There is considerable variety in this regard: while some birds refer to UV for mating [21] and foraging [69], many can understand visuals without UV [69], and pet birds might adapt to limited-UV environments over the course of exposure to standard indoor lighting.

Another concern is the critical flicker-fusion frequency (CFF), the rate at which a blinking light appears constantly lit. Most flight-capable species have a CFF threshold higher than humans' [39], with parrots' CFF being nearly double that of humans [50]. It is entirely conceivable that they may perceive a standard screen as flickering.

There is evidence that, despite these challenges, birds can process complex screen visuals. Precise colour or movement reproduction isn't always essential for meaningful interpretation [13]. For instance, tits (*Cyanistes caeruleus* and *Parus major*) proved able to learn prey species' defences by watching videos that show the negative effects of other birds' foraging experiences [19]. Pigeons (*Columba livia*) appear to respond to movement in a video as if it were present in front of them [36], and studies attest that several types of bird react to social cues from videos [15]. To assess animals' reactions to video content vs. stimuli in their physical presence, which is crucial for a valid study [13], researchers commonly measure attention by comparing focus on screens to that on 'real' objects [3, 9, 10].

### 2.3 The Dynamics of Screen-based Interaction

Building upon studies that point to parrots being able to perceive and understand screen-based stimuli [32], we set out to ascertain whether the nature of the content – live *versus* pre-recorded – has distinct implications for the animals' experiences. Historically, birds have demonstrated some ability to interact with screens in various capacities, from guiding missile trajectories in the 1940s [59] to discriminating quantities [57] and recognising faces in photographs [62]. Using screens, scientists have found that budgerigar parrots (*Melopsittacus undulatus*) [7] and pigeons [47, 63] can successfully distinguish between others' faces on a screen, rooks (*Corvus frugilegus*) can recognise conspecifics in videos [4], and pigeons differentiate between computer-generated pigeons on the basis of whether they display normal or physically impossible behaviours [67]. Further, pigeons have been shown to discriminate between real-time and delayed images of themselves [63]. Perhaps most tellingly in social terms, manakin birds (*L. punctulata*) engage more in foraging behaviours when exposed to video images of other birds (i.e., to prospective competitors), and budgerigars imitate actions shown on a screen [22, 42]. Given these findings, researchers have suggested that birds are probably sensitive to images of other individuals and that these video/still images influence the behaviour of the birds viewing them [29]. Recent developments have seen the integration of screen-based interactions into pet birds' life, primarily through video calls [32]; however, a pivotal question has remained with regard to what appears onscreen: do parrots differentiate between live interactions, wherein their actions might evoke real-time responses, and pre-recorded videos, in which the sequence remains unchanged, irrespective of the viewer's behaviour?

### 2.4 Nuances of Interacting with Live vs. Pre-recorded Content

Distinguishing between live video engagement and playback of pre-recorded videos relies on a combination of cognitive and sensory cues related to interactivity. Live video often implies an active exchange with participants able to respond to each other's visual and auditory cues synchronously. In contrast, pre-recorded content is static by its very nature: it does not adapt or respond to viewer actions. Humans start manifesting an ability to differentiate between social interaction and playback of pre-recorded material at roughly two years of age, when they start demonstrating different reactions and begin learning better in the former setting than in the latter [43]. In light of such findings, some ACI researchers

and practitioners express a growing preference for live interactive connections over pre-recorded content [30, 32, 56]. This shift reflects increasing awareness of animal communication's complexities, many nuances of which have gone uncharted or misunderstood. As our understanding deepens, the risks of misinterpretation and of out-of-context playback causing distress to animals become more evident. In work with animals, 'portals' that enable genuine inter-animal interactions in real time may furnish a more ethical and sensitive way forward, sidestepping the many pitfalls associated with pre-recorded stimuli [34]. While such live connections may offer a more authentic and contextually appropriate experience, empirical validation remains imperative. When we know whether animals recognise and respond differently to live-interaction settings as opposed to playback, we can ensure that our technological interventions truly align with their well-being. It makes sense to hypothesise that parrots might be able to recognise incongruities between interactive and pre-recorded video, in that parrots are inherently social animals [27] with high visual acuity [18] and strong auditory discrimination [45]. However, budgerigars exposed to both increase their behaviour's synchrony with the content shown [29], with no evidence of which option might be preferred between live and playback calls, let alone of the details of parrots' possible reaction to either. It is an open question if parrots, as humans do, detect a difference between these two formats, and how live and non-live formats influence a birds engagement, understanding, and emotional experience.

## 3 PARTICIPANTS

For parrots to participate in our study, which received ethics approval from the University of Glasgow's veterinary-ethics board (EA 01/22) and human-research ethics board (300210172), we advertised online via social media and personal networks. To be included, a parrot had to be more than one year old, display no known behavioural or health issues, and have enough space available for the touchscreen-device installation. Each caregiver was required to have two devices, one for the bird's use and one to record the parrot's interactions. Nine parrots took part in the study (P1–P9), all of them living in the family home where the system was set up. Table 1 characterises the sample by specifying each parrot's species, sex, prior experience with technology, and video-calling devices.

Before the study, all of the parrots had been exposed to videos on television or online within the home. Two thirds of the caregivers (those of P2, P4, P5, P7, P8, and P9) believed that the bird paid attention when the caregiver was watching videos, with the rest believing that the parrot sometimes watched. Of the caregivers, five played videos especially for the bird with mention being made of YouTube 'children's/toddlers' programmes' (P1), 'kids' YouTube' (P2), and 'children's books being read with either pictures or cartoon characters' (P5) and three caregivers playing bird, human, and animal videos for the parrot – 'mostly birds, sometimes other animals' (P9) or 'other birds, of people she knows' (P3) from such sources as 'Instagram parrot reels' (P4). When probed about the birds' prior video-watching behaviour, caregivers mentioned the bird 'flying over to see what it is' during viewing of a video (P8) or being 'interested while I'm scrolling through videos' regarding the parrot approaching during smartphone use (P7). In the same number, caregivers (of P2, P3, P4, P7, and P9) believed the bird was interested in watching the videos in question, while two concluded that the bird was sometimes interested, commenting that a video in some cases 'doesn't hold his attention for too long' (P8) or that the bird watches videos 'when I'm not with him' (P1). The other two caregivers believed their birds were not generally interested in watching videos. Finally, seven of the humans stated that their parrot had seen videos of other parrots before. Of the seven parrots with experience of bird videos (P1, P2, P3, P4, P7, P8, P9), six had seen them on YouTube, four from another online platform, and one via television. None of the parrots had ever seen another bird live in a video call.

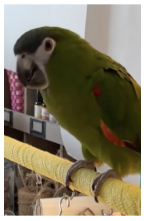
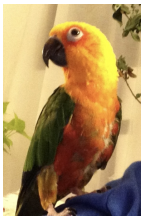
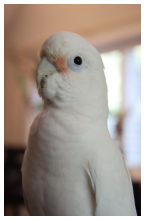
## 4 METHOD

Over the six-month course of the study, each bird in the at-home setting was individually supported by bird-behaviour experts and individually supported, with each video-call session being reviewed accordingly. The study involved the following steps:

- **Step 1 – training**: We trained each caregiver in using the video-call system (with a bell and tablet) and in bird-welfare indicators, then demonstrated how to teach the bird to use the system.
- **Step 2 – live-stage 'meet & greet'**: Each parrot was introduced to the other parrots available for engagement in the live condition.
- **Step 3 – open calling**: Birds had a three-hour window in which they could use the system to trigger calls to a live bird of their choice and receive calls. It was available up to three occasions per week.
- **Step 4 – interview and questionnaire**: Caregivers completed an interview and questionnaire on their and the bird's experience of the live calls.
- **Step 5 – 'meet & greet' for the playback stage**: Introduction to novel pre-recorded video parrots.
- **Step 6 – open calling**: The parrots could use the system to trigger calls that connected them to a pre-recorded parrot video. The time conditions were the same as in Step 3.
- **Step 7 – final interview and questionnaire**: With a wrap-up caregiver interview and questionnaire, we probed caregivers with regard to the parrot's and their own experience of the live and playback phases.

For the study, caregivers recorded all the training provided and the video calls, submitting these via our website after every training episode or session. We also asked them to make diary entries to accompany each call, describing their experience and that of the bird. To supply timely behaviour-specialist and researcher feedback, we watched all of the videos within 24 hours of receiving them and monitored the diaries. Throughout the study, 24/7 text and e-mail support was available from the team. For assurance of full agency, each parrot had food and water *ad libitum*. Treats were provided only during the initial-training phase with the bell, picture, and call association (Step 1). We instructed caregivers to use the parrot's natural environment (cages, play areas, or other locations the parrot comfortably frequented) for all calls. The procedure is elaborated upon further in the course of the description below.

**Table 1: Participant details**

|  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
| Participant 1 (P1)<br>M, cockatiel<br>2 years old<br>Comboard trained<br>iPad Mini (5th gen.) | Participant 2 (P2)<br>M, parotlet<br>2 years old<br>Comboard-trained<br>iPad Mini (6th gen.) | Participant 3 (P3)<br>F, Hahn's macaw<br>3.5 years old<br>No prior experience<br>iPad (7th gen.) | Participant 4 (P4)<br>F, Congo African grey<br>2 years old<br>Plays tablet games<br>iPad Pro | Participant 5 (P5)<br>F, conure<br>26.5 years old<br>Plays tablet games<br>iPad Pro | Participant 6 (P6)<br>M, Quaker<br>12.5 years old<br>No prior experience<br>iPad Air | Participant 7 (P7)<br>F, Goffin cockatoo<br>4.5 years old<br>Plays tablet games<br>Samsung Galaxy Tab A | Participant 8 (P8)<br>M, black-headed caique<br>1.5 years old<br>No prior experience<br>iPad (2nd gen.) | Participant 9 (P9)<br>M, cockatiel<br>3.5 years old<br>Watches videos<br>Revvl 2 Plus phone |

## 4.1 Materials

Each participating bird had a tablet (or mobile phone) for interaction with the video device, a kickstand or tripod to hold the tablet, a camera filming the bird interactions, and a dedicated toy bell. We also recommended a protective case for the call device. Many caregivers employed their everyday mobile devices that their birds were familiar with (see Table 1 for device details). The caregivers set screen brightness at 75%, in light of the tablet's factory-setting recommendation. Video calls were implemented on the Facebook Messenger platform, because the participants were acquainted with it already. Figure 2 provides an example of the set-up. While the study could have benefited from examining how any differences in format or quality (resolution, sample rate, colour balance, brightness, resolution, etc.) between the pre-recorded and the live content affected the parrots, study settings such as ours – the homes of people using their own devices and their own Internet connection – precluded analysis of such data. Neither could these settings be kept constant: at multiple levels, video quality and features get optimised for the connection speed and device features.

**Figure 2: The set-up for parrots' video calls. The parrots are shown in their home environment with the recording device, the tablet, the stand for it, and the bell.**

## 4.2 Training

Before we could compare either initiation or duration of calls between playback and live video, we had to train the parrots to place calls. To make a video call, the parrot rang a bell, whereupon the caregiver would present the calling system on the calling device's screen (see Fig. 3). The parrot then selected the photo of a bird to call, and the caregiver initiated a call accordingly (as Fig. 4 shows).

To convey the associations among ringing of the bell, the photos of the birds on the screen, and the ability to connect with a parrot by selecting the corresponding photo, we trained the parrots through associative conditioning, or operant conditioning [65]. In the training phase, the bird was taught to touch the bell for a treat reward three times, followed by touching the screen three times for a treat. The researchers and behaviour specialist not only reviewed caregivers' uploaded recordings of the training via the project Web site but also supported the screen-touching–bell-ringing interaction by providing live training with the parrot-behaviour specialist (via Zoom) and related videos, including training advice. For any parrots struggling with the process, we provided one-on-one training support from the behaviour expert. The association training was delivered over several days, so as not to fatigue the parrot, for approximately one week in all. To mitigate potential distress stemming from the calls and to follow advice from experts in parrot behaviour, we managed the first call ourselves in the next step: in the 'meet & greet' setting, the first use of the system began with the volume muted, and it gradually increased as the device was slowly moved toward the parrot's area. We instructed the caregiver to either stop and wait for calm behaviour or end the call if the parrot showed any signs of discomfort. This process ensured a gradual introduction. To simplify the introduction process for the caregivers, we developed a script for them to use throughout the study: 1) when the parrot has rung the bell, the caregiver was to ask 'want to call a friend?', 2) then say 'you want to call [bird's name]' once a bird had been selected.

## 4.3 The 'Meet & Greet' Step

After the parrots were successfully touching the bell and the screen as intended, they moved on to the next step, the 'meet & greet' engagement introducing the action of selecting a parrot so as to trigger a call to the bird shown. This step consisted of the parrot touching the bell, choosing a photo of a parrot on the selection screen, and then the caregiver initiating a call to the other parrot. Figure 5 shows screenshots from the videos of parrots during this process. To populate the selection screen, we had requested a photo of each participant, which we used as a 'profile photo' presented on the selection screen for every other parrot. An analogous step

followed before the study's playback-condition phase: instead of a bird for live interaction, the selection made with the second 'meet & greet' introduction specified which parrot a pre-recorded video would present. In addition to initiating calls, this step covered the other end of the connection: the second caregiver practiced answering a call at the same time. The 'meet & greet' introductions, spread over several days so as not to fatigue the parrots and each bird became familiar with every other parrot.

## 4.4 Open Calling

After training and introductions, we gave the birds access to the video system for 12 open-calling slots – six sessions with two-possible calls to live birds and, later, six for video from pre-recorded calls. Hence, the video-call system was available for 36 hours in all: 18 hours with live birds and 18 hours with playback of parrots. We limited system use to three occasions per week and no more than three hours a day because we wanted to safeguard against fatigue and stress for the birds in case the caregiver missed signs of welfare issues. Likewise, there was a session-specific limit of two outbound calls per bird, and the study employed a five-minute cutoff for each call. Once a bird had initiated two calls during any given session, the bell for signalling the intention to make a call was removed from the parrot's space. While many birds still had the video-call device accessible (for other day-to-day interaction in their living space), in the bell's absence they could no longer use it to place calls or view its video-calling interface. From the parrot's standpoint, the session ended after making two calls or once the three hours had elapsed.

For the calls in each condition, we supplied constant e-mail and instant-messaging access to the researchers and our parrot-behaviour expert in case needed. The sessions' timing meshed with the regular schedule for the parrots' interactions and generally matched the hours in which they were most active. To assure of clear cues during video calls, we instructed the caregivers to provide the parrots at least one metre of space for approaching or retreating from the screen and to equip the area with a visual barrier so that the bird could hide if it were frightened. For Step 5, each caregiver was given a unique order in which to play the pre-recorded video content when the bird signalled for a call. We provide further details in our discussion of the birds' choice in the two conditions, below.

After each session (with either live or pre-recorded video), the caregiver completed a diary entry on the experience and uploaded the session recording. The diary form asked for the call's date and timing of the call; the origin or target of the call, as applicable; a sense of the bird's mood before, during, and after the call; and any other notes or observations that the caregiver wished to share.

If two sessions went by without the parrot triggering a video call, we instructed the caregiver to repeat the training process described above, to reinforce the procedure of touching the bell and the tablet.

## 4.5 The Caregiver Questionnaire and Interviews

At the end of each phase (live and playback), we conducted a one-on-one interview with the caregivers to capture the overall experience of the relevant condition. We also sent them a questionnaire form, which every caregiver filled in as requested. It is standard practice in the animal-computing field to consider feedback from humans who care for animals alongside the animal-generated data; this can aid in quantitatively capturing their technology experience [25].

The questionnaire design presented 28 questions: Likert-scale items, multiple-choice questions, other closed-ended questions (multiple choice, checkbox), and requests for free-form comments. These dealt with demographic and device details, the experience of meeting other birds, and the open-calling sessions. We focused in particular on impressions of the bird's understanding, interest in the calls, any factors that might affect video calls, other environmental influences, whether the caregivers had seen new behaviours emerge, the positive/negative effects of the calls, and their and the bird's perceived enjoyment. We also solicited opinions on possible future use of the system and what that might require. The form used after exposure to the second condition featured additional items, pertaining to the differences between live and pre-recorded video, caregivers' preference between the two, and ease of use from their and the bird's angle.

The informal semi-structured interview at the end of each phase reflected the same themes, with 12 questions about their impressions of the study and its video-call system, how the study affected the bird, the experience from their angle and the bird's, any impact the video calling had on their relationship with the parrot, and musings about future use of the system. The second interview additionally probed preferences between designs.

## 4.6 Pre-recorded Videos Content and Ethics Considerations

There are various ethics factors bound up with playing back audiovisual recordings to animals when we do not understand what has been captured in the recordings or lack full awareness of biologically relevant information. In our case, the switch from live to pre-recorded videos creates further room for speculation with regard to ethics. In the context of traditional animal studies, our project followed the highest ethics standards by working with the animals in their everyday context, maintaining sensitivity to their *Umwelt*, and their relations with others. Nonetheless, parrots employ many sensory modes to gather information, which might well encompass information we do not recognise as such. In addition, we do not know what parrots – or even other humans, for that matter –understand of being online with others of their species. However, we should not shy away from these questions either. It is incumbent upon us to grapple with their complexities and come to terms with their agency and ability to shape their lives by undertaking studies that offer them these capabilities. As Meijer and Bovenkerk [40] noted when discussing the ethics and politics of research involving animals, recognising agency and what is going on in an animal's mind is all the more difficult when one does not engage with the animals in studies, observe their behaviours, and grant them choices. We sought balance in our work through several mechanisms aimed at minimising risk: training the parrots to exercise agency by triggering the calls themselves, sensitising the human caregivers to signs of distress such that they could end the video call if doing so was prudent, setting limits to call times and frequency, and further guarding against possible harm by reviewing all videos and giving regular feedback related to well-being.

**Figure 3: Parrots ringing the bell as a signal for the tablet. From left, P1, P3, P4, and P7.**

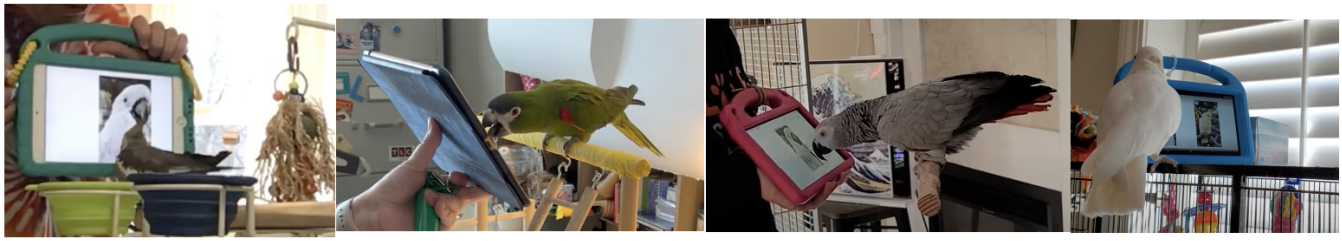


**Figure 4: The parrots (shown in the same order as above) selecting a bird to call from those on the screen.**

**Figure 5: Parrots using their screen devices while engaged in a video call.**

To create the pre-recorded bird videos to play when the parrots triggered calls in the playback condition, we recorded two parrots' side of previous video calls (bird A: a 24-year-old red-vented cockatoo and bird B: an eight-year-old umbrella cockatoo shown in Figure 6.) Limiting each video to five minutes in length, the maximum call time permitted in either condition, we recorded three videos of each parrot, giving us six videos in total. The choice to restrict ourselves in this way was rooted partly in a subsidiary objective of assessing the potential for supporting parrots with a video system in the longer term. By limiting the number of videos available, we modelled our system on a real-world scenario of limited material. This enabled data analysis investigating whether the videos' novelty affects a video-call system. We applied the Latin-square method for assigning each caregiver a specific order in which to play the videos, to prevent an order effect.

**Figure 6: Screencapture from two pre-recorded videos, showing bird A and bird B**

## 5 DATA ANALYSIS

The primary data consisted of the diary entries and the caregiver-submitted recordings from the calls for a total of 703 minutes of call time excluding training, 561 minutes from the live phase and 142 from the playback phase. For quantitative analysis, we noted the time at which the parrots made the calls, their lengths, and which parrot/video the bird selected for calling. Firstly, to cross-check call length, we referred to the videos for any evidence of disengagement. While we had instructed and trained the caregivers to end the call if the bird began squawking loudly, walked/flew away, or showed signs of discomfort, the team had to adjust the length recorded for one call, from the playback phase, in light of the researchers' and behaviour expert's review – the bird flew away, but the caregiver brought it back to the device rather than cut the connection. Using the timing details and the session-specific number of times each parrot triggered a call (within the limits set),

we could then calculate both individual- and group-level differences in initiation and duration between conditions. Our quantitative comparison considered, in addition, how much of each three-hour session passed before the parrots placed the first call.

A significant skew from a normal distribution emerged for the number of calls ($W(108) = 0.76$, $p < 0.001$) and for system-use duration ($W(119) = 0.86$, $p < 0.001$). Therefore, we utilised the one-sided Wilcoxon signed-rank test to evaluate the effect of live vs. played-back video calls on both. Because we did not have paired call-initiation or duration data (i.e., there were more data points in the live-condition set than from the playback condition), we applied the one-sided Mann–Whitney $U$-test approach. We plotted the call-initiation and duration figures against time (session number) by means of the Pearson correlation. To measure engagement in absolute terms, we quantified call time relative to the total call time available. Additionally, linear regression afforded the above-mentioned checks for novelty effects of the video stimuli: we looked at whether call duration changed with the number of times the pre-recorded videos were watched. All data analysis (reflected in tabular form below with means, modes, and absolute frequencies included) was conducted with SPSS software.

Quantitative analysis of the questionnaire's Likert-scale and multiple-choice data, in turn, used percentages. For open-ended questions, we coded representative extracts. Likewise, relying on the interview transcripts the researchers and parrot-behaviour specialist worked together to code the associated data for thematic analysis, using our research codes for engagement, the system's benefits (for the parrot, human, or both), the human experience, and potential future use of the system. Then we grouped these codes by theme to characterise differences between live calls and playback calls and to capture experiences of the system and its prospective further use.

## 6 RESULTS

Every bird participating in the study initiated at least one call, with the live-call phase witnessing 65 calls out of the 108 possible (60% of the number allowed) while there were 40 in the pre-recorded-video sessions (37% of the maximum); see Table 2. Every call triggered was answered by the other bird/human. The second key finding arose from qualitative material related to the caregiver's experience, which is crucial to supporting parrots in their home. Many caregivers (P1, P2, P5) commented that taking part in the study gave them time with the bird, offered the bird more options in day-to-day life, and increased their trust in their relationship with the parrot.

Reflecting on the benefits of the video-call system as a whole, the caregivers unanimously concluded that the parrot gained from live video calls, while 55% judged the bird to have benefited from the playback-based calls. As for particular content, most believed that the bird reacted positively to all calls, with figures of 77% and 70% for the live and pre-recorded video, respectively.

### 6.1 Calls Made

In the live phase, parrot P6 made the most calls (23/24, 96% of the limit set) and P8 the fewest (4/24, 17%). On average, 26% of the sessions passed without the parrot placing any calls. Parrots placed one call in 28% of the sessions and two in 46% of them. The corresponding figures for pre-recorded videos were 52%, 22%, and 26%, respectively. These results clearly attest to a greater likelihood of placing the maximum number of calls when the system used live videos rather than pre-recorded ones. The number of calls that birds placed with our video-call system fell significantly when the system switched from live to pre-recorded content, as Table 2 shows ($Z$ = -2.8637, $p = 0.00424$, $p < 0.005$). Caregivers of those birds initiating few or no calls once the system switched mode described the differences in behaviour with such comments as 'She did not move toward the screen very much and was generally irritated' (P3) and 'He wasn't interested – he would just fly away. He is not shy about "ditching out" (P8). We tested whether a habituation factor was at play (animals repeatedly exposed to the same stimuli may stop responding [26]), checking how the calls-per-session count developed over time. Any effect was insignificant ($R$ = -0.5588, $p = 0.05938$, $p > 0.05$).

We also checked for any changes in the parrots' initiation behaviours as the playback phase progressed, reflecting that it might have taken a while for the birds to detect the nature of the new type of material. As a whole, the number of calls showed no change from session to session within this stage ($R$ = -0.0063, $p = 0.965654$, $p > 0.05$). It cannot be ruled out that the significant change evident in the number of calls is connected with the parrots' introduction to the pre-recorded videos during the 'meet & greet' step before exposure to the second condition.

In the interviews, many caregivers expressed a belief that the bird's awareness of the second phase's videos not being live had affected the parrot's calling behaviour – for instance, 'She approached the screen, and nothing happened' whereas '[I]f she vocalises and the other bird vocalises, there's a response for almost every single action. With the pre-recorded videos, she never got that' (P3) and 'This was just boring TV. She didn't get much out of it' (P7). This group-level pattern notwithstanding, the breakdown in Table 2 reveals variations among individual birds. For example, P6 and P7 initiated more playback condition than live calls (with an 8% increase each). Also, two caregivers of other parrots, stated that pre-recorded videos were more relaxing for the parrot, e.g., 'very relaxed, 24 hours after' (P2) and 'more relaxed [...] but don't know why' (P5).

### 6.2 Engagement in Video Calls

As for the duration of engagement in video calls, the parrots had access to the system for 600 seconds (i.e., 10 minutes, over 1–2 calls) in each of the 12 sessions (six live + six with playback). On average, they used the video-call system for 266 seconds per session in the live and 166 seconds in the pre-recorded-video phase. Table 3 presents each participant's total call time per session and mean values for both conditions, alongside the difference between the two. The figures highlight the significantly longer durations when the system offered live calls as opposed to pre-recorded videos ($Z$ = -2.2-37, $p = 0.0278$, $p < 0.05$). Per the qualitative material, caregivers sensed the bird's level of involvement with the video calls on the basis of movements (P2); mirroring of the other birds' behaviour, such as walking toward the tablet when the bird onscreen did (P1); observing the second parrot intently (P4); and engaging in preening, napping, etc. (P9). Part of the benefit that caregivers found in the

**Table 2: Numbers of parrot-placed calls during the live-call and the playback phase, with comparison between the two phases.**

| | Live phase | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Session ID** | **P1** | **P2** | **P3** | **P4** | **P5** | **P6** | **P7** | **P8** | **P9** |
| **S1** | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 |
| **S2** | 2 | 2 | 1 | 0 | 2 | 2 | 0 | 0 | 2 |
| **S3** | 2 | 2 | 1 | 0 | 1 | 2 | 0 | 1 | 0 |
| **S4** | 2 | 2 | 2 | 2 | 0 | 2 | 0 | 0 | 1 |
| **S5** | 0 | 0 | 2 | 0 | 0 | 2 | 2 | 1 | 0 |
| **S6** | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 |
| **Percentage of bird's calls (%)** | 75% | 83% | 75% | 42% | 58% | 92% | 33% | 33% | 50% |

| | Playback phase | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Session ID** | **P1** | **P2** | **P3** | **P4** | **P5** | **P6** | **P7** | **P8** | **P9** |
| **S7** | 0 | 2 | 0 | 0 | 0 | 2 | 1 | 0 | 0 |
| **S8** | 1 | 1 | 0 | 1 | 2 | 2 | 1 | 0 | 0 |
| **S9** | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 2 |
| **S10** | 0 | 1 | 0 | 0 | 2 | 2 | 1 | 0 | 0 |
| **S11** | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 0 | 0 |
| **S12** | 0 | 2 | 0 | 1 | 0 | 2 | 1 | 0 | 1 |
| **Percentage of bird's calls (%)** | 25% | 67% | 0% | 25% | 50% | 100% | 42% | 0% | 25% |
| **Live minus playback** | **-50%** | **-17%** | **-8%** | **-17%** | **-75%** | **+8%** | **+8%** | **-33%** | **-25%** |

**Table 3: Parrot-specific and overall average use of the video-call system (in seconds of call time), with comparison between the phases.**

| | Live video calls | | | | | | | Video calls using playback | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **S1** | **S2** | **S3** | **S4** | **S5** | **S6** | **Mean** | **S7** | **S8** | **S9** | **S10** | **S11** | **S12** | **Mean** | **Difference** |
| **P1** | 480 | 142 | 381 | 487 | 0 | 175 | 278 | 0 | 300 | 600 | 0 | 0 | 0 | 150 | -128 |
| **P2** | 540 | 300 | 360 | 600 | 0 | 382 | 364 | 468 | 18 | 48 | 92 | 0 | 108 | 122 | -241 |
| **P3** | 274 | 165 | 160 | 360 | 600 | 600 | 360 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -360 |
| **P4** | 300 | 0 | 0 | 310 | 0 | 600 | 202 | 0 | 300 | 0 | 0 | 300 | 300 | 150 | -52 |
| **P5** | 600 | 600 | 300 | 0 | 0 | 600 | 350 | 0 | 600 | 600 | 600 | 0 | 0 | 300 | -50 |
| **P6** | 300 | 390 | 600 | 600 | 360 | 600 | 475 | 600 | 210 | 563 | 600 | 515 | 600 | 515 | +40 |
| **P7** | 0 | 0 | 0 | 0 | 70 | 40 | 18 | 150 | 185 | 0 | 136 | 81 | 186 | 123 | +105 |
| **P8** | 58 | 0 | 120 | 0 | 96 | 0 | 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -46 |
| **P9** | 300 | 600 | 0 | 300 | 0 | 600 | 300 | 0 | 0 | 600 | 0 | 0 | 190 | 132 | -168 |
| **Mean** | **317** | **244** | **213** | **295** | **125** | **400** | | **135** | **179** | **268** | **159** | **100** | **154** | | **-100** |

**Table 4: Average time before parrots triggered a call, to the nearest minute. N/A signifies that data is not available, as no calls were made.**

| Participant | Live calls | Calls using playback | Difference |
|---|---|---|---|
| **P1** | 12 | 50 | +38 |
| **P2** | 50 | 27 | -23 |
| **P3** | 45 | N/A | N/A |
| **P4** | 58 | 37 | 21 |
| **P5** | 79 | 45 | -34 |
| **P6** | 34 | 67 | +33 |
| **P7** | 70 | 43 | -27 |
| **P8** | 43 | N/A | N/A |
| **P9** | 43 | 71 | +28 |
| **Group mean** | **45** | **49** | -5 |

experience lay in learning more about the bird, as P1 articulated in describing it as 'amazing to watch [parrot's name] move closer when the other bird had moved'.

## 6.3 Motives for Initiating Video Calls

We also examined how far into a session the parrots triggered a call, to measure the parrots' eagerness to use the system. That is, we measured how soon a parrot made the first call once the system became available. On average, 45 minutes elapsed in the live-call condition and 50 minutes in the playback one (see Table 4), which represents an insignificant difference in swiftness between the two phases ($Z$ = 0.03359, $P$ = 0.36393). Neither did the time before session-specific initiation of a call change significantly as either phase progressed ($R$ = -0.0721, $P$ = 0.565629).

## 6.4 The Familiarity Aspect of the Pre-recorded Videos

With so few calls being made in the second phase, only three birds watched the same videos on multiple occasions (P2 and P6 as many as four times each and P5 up to three times). The amount of time spent with a given pre-recorded video from our library did not correlate with the number of times the parrot had previously watched it

**Table 5: Caregiver responses in the end-of-study survey about their and the birds' experiences.**

| | Overall experience | | Did the parrot engage? | | Did live-caregiver | Did live-caregiver | Preferred content | |
|---|---|---|---|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 1 | Phase 2 | presence affect calls? | absence affect calls? | For the parrot | For the caregiver |
| **P1** | Positive | Positive | Yes | Yes | I don't know | I don't know | No pref. | No pref. |
| **P2** | Positive | Positive | Yes | Yes | Yes | No | Live | Pre-recorded |
| **P3** | Positive | I don't know | Sometimes | No | Yes | Yes | I don't know | No pref. |
| **P4** | Neutral | Positive | Yes | Yes | Yes | I don't know | Live | Pre-recorded |
| **P5** | Positive | Positive | Sometimes | Yes | I don't know | No | Live | Pre-recorded |
| **P6** | Neutral | Negative | Yes | Yes | No | No | Live | Pre-recorded |
| **P7** | Positive | Positive | Sometimes | No | I don't know | No | Pre-recorded | Pre-recorded |
| **P8** | Positive | Positive | Yes | No | I don't know | I don't know | Live | Pre-recorded |
| **P9** | Positive | Positive | Yes | Yes | Yes | Maybe | I don't know | Live |

(non-significant relationship: $F = 0.03199$, $P = 0.8620$). These results imply that video novelty did not affect the duration of engagement, though more data would be needed for robust evidence.

## 6.5 Caregivers' Preferences and Speculations on Future Use

The interview questions, dealt with in Table 5, probed caregivers' experiences of using the video-call system with the parrot for six months in the home. Among the comments were that it was 'fun to see [the bird] learn and engage' (P8) and that the system aided in 'learning what [the birds'] needs are' (P1). When asked whether they sensed that the parrot was immersed with the system, six of the caregivers identified general engagement with the live-call system while three found the bird sometimes engaged. The total percentage remained the same with the pre-recorded content, but a third of caregivers regarded the birds as no longer actively engaging with it (there were no 'Sometimes' responses for the latter phase). Among the associated reflections were that parrot P7 'didn't go to the screen as much; she seemed like she always wanted to do something else [...] she definitely seemed less interested' than in the live calls.

Concerning the live calls, four of caregivers indicated that the second caregiver's presence influenced the bird's involvement. For example, caregivers believed that live calls worked well when the other human's way of addressing the bird matched their own (e.g., in the case of P2) and when the other caregiver said the bird's name, to the point that 'in the meet & greet, I think [P3] was a little confused not to hear her name in the video'. Also, when asked whether it mattered whether a human was live during the parrot's video calls, only one of the caregivers believed that a live human not being there on some occasions influenced the bird. The other caregiver's presence apparently influenced the human experience too, with P6's caregiver saying, with regard to the live calls, that it was 'more fun, for me, to meet other people and birds'. In contrast, when asked about our choice to include a caregiver in the pre-recorded videos, a third of the caregivers would have preferred not showing one. With regard to this condition, P5's caregiver explained that 'she doesn't like the talking; we need to give them their time', stating that the system was just for her bird.

When asked which of the two modes they would prefer in their home for the bird, five opted for the live version, a third were indifferent or deemed them the same, and only one felt that pre-recorded videos were better for the parrot (again, the table provides a summary). Caregivers who preferred interactive calls connected this preference with how the bird when interacting in live calls 'seemed more motivated' while with 'pre-recorded ones he wasn't that interested' (P1) or pointed to 'less engagement' with videos while the bird 'showed more energetic [moods] or happiness with live calls' (P4). Caregivers also regarded the playback interaction as 'view[ing] it as TV with a show going on' (P5). When musing on which system was better for themselves, however, six of the caregivers favoured pre-recorded video, one opted for live calls, and two expressed no preference. Favouring a playback system over live calls was connected primarily with the burden of scheduling live calls with other people (cited in the cases of P1, P4, P5, P6, and P8). For instance, P4's caregiver commented: 'My favorite part of the study was the flexibility' of the playback condition. One caregiver (P9's), though, found the burden of the second phase greater, since one had to find the right video. Of course, both conditions involved overheads, characterised in P5's case as 'finding the time to do it': setting up the equipment and being there when the bird wanted to place a call were a constant factor. Whatever their personal preferences might be, many caregivers stated that the bird's wishes are more important; e.g., with P1, it should be '[l]ess about pleasing me and more about what he wanted'.

Looking toward the future, eight of caregivers hoped to keep using pre-recorded videos for the bird's enrichment, with some caregivers (of P1, P2, and P5) requesting permission to retain the study's videos to this end while others (P3 in particular) referred to plans to utilise online parrot videos. Caregivers also articulated a desire to continue with the system to induce calm behaviour (for P2) and to provide enrichment (for P5) and enjoyment (for P5 and P7) and even cited a need to modify the system (such that P6 can call people).

# 7 LIMITATIONS AND FUTURE WORK

The grand vision behind our endeavours is to grasp how we can technologically support animals and the people who care for them in captive environments. Accordingly, we embarked on an iterative process of analysing how animals behave with and might benefit from technology. This lens facilitates creating technology designed with animals to support them in species-appropriate ways. While representing a solid step toward this goal, our research faced some limitations also. The design was susceptible to an ordering effect, since we always offered live and then pre-recorded content. Although we did not find a significant change in engagement (as indicated by call frequency or duration) over time, this is still a factor. Secondly, the live phase's reciprocity (i.e., receiving calls from other parrots) might have influenced the use of the system. When Kleinberger et al. [32] deployed their system letting parrots

video call each other, the birds seemed to be affected by a social aspect to the calls: in essence, the more calls they received, the more they were likely to make. To investigate the reciprocity factor, future ACI work with pre-recorded videos could could simulate the situation of being called. Manifesting another relevant phenomenon of note, African grey parrots in behaviour studies have been observed aligning their responses with experimenters' behavioural cues [17, 51]. While we aimed for a standard caretaker script and uniform study steps between the two phases, the humans' implicit/explicit body language and knowledge of the key differences (live *versus* pre-recorded content) could have biased the birds' behaviours. Likewise, variables related to the video medium, as mentioned above, could have affected engagement differentially. Whereas such issues inevitably accompany study designs such as ours (oriented toward in-home support), research in more controlled environments could attend more specifically to these facets of human presence and video. We are only beginning to tease out the ways in which parrots may benefit from social calls, so far more work is needed before we fully comprehend the nuances of how the affordances, presentation, and features of such systems affect parrots' engagements with technology.

# 8 DISCUSSION

The emergence of the so-called animal Internet has sparked considerable interest in recent years, as it may open new avenues to enriching the social life of animals across the board. With this paper, we have begun delving into what a 'connected parrot' might be, by looking at the differences we uncovered in their engagement between live and pre-recorded video calls involving other birds.

## 8.1 The Role of the Human

The study raises questions about the role of the human–animal relationship in shaping animals' online presence. Caregivers saw other caregivers as an integral part of the parrot-to-parrot interactions, which added new dynamics and complexities to the landscape of measuring and modelling inter-species online interaction. Our results support the contention that humans are invariably woven into the picture when developing communication technologies for animals in the home.

During the pre-recorded-video phase, some caregivers expressed some concerns about the bird's well-being as use of the system declined. While we supported them throughout and reassured them that this was entirely up to the parrots – and, moreover, precisely the choice we were studying – these worries highlight the challenges of creating interactive systems for pets' voluntary use. To some extent, a 'black box' looms large when the pets targeted opt not to engage. The paucity of calls left many caregivers wondering which aspect of the pre-recorded video the bird disliked. Some projected that the bird did not like the counterpart in the video (e.g., P5 'has told me that she doesn't like [bird B]'), the other bird's colour (apparently, P8 'was never drawn to white birds' and P5 'loves brightly coloured birds'), that bird's manner of movement (the bird in the video 'wasn't moving as much'), or the other birds' size ('smaller birds [...] one similar to' P8). All these factors, from colouration to compatibility of personalities, are valid considerations and worthy of research in their own right.

Simultaneously, caregivers questioned their skills. For instance, P8's caregiver commented on the low number of calls that sometimes there was 'a challenge' since 'my training skills weren't as high as other people's'. While not always simple, keeping the humans intimately involved in the process and supporting them are pivotal for successful animal video-call systems.

## 8.2 Ethics and Philosophical Issues with Parrot Video Calls

Our results pave the way for further development of animal technology by identifying video-call systems' potential to support and enhance the welfare of parrots in ways that mesh well with the caregiver and parrot context in the home. While we found that parrots initiated live calls significantly more often than playback of pre-recorded videos and maintained the connection longer, individuals differed greatly in this respect. That implies that ACI developers should factor in animals' unique perspectives and preferences – for live or pre-recorded videos etc.

While a tendency to prefer real-time interaction points to some fundamental difference from playing pre-recorded material, we do not know what aspect of being 'live' influences the animals' subjective experience and their understanding of being online with each other. For insight, we can turn to HCI advances in machine simulation of humans: computers in that domain focus on the mouth, gaze, and facial expression, along with general posture and body movement, as critical components of what we consider natural human expression integral to everyday interaction [41]. When these aspects are considered as a whole, much literature attending to live-streamed vs. pre-recorded videos in humans has focused on the need for social-influence cues – signals of social presence and synchrony – as underpinnings for authentic experiences [1]. Our findings are consistent with this emphasis in that caregivers hinted that responsiveness and mirroring behaviours (of parrots and humans alike) influenced the parrots' experiences. What constitutes 'authentic experiences' for parrots online, however, is a much larger question.

What it means for animals to use online video calls is entwined with several philosophical and ethics issues related to what animals make of being 'online' for social benefit. Animals are thought to show awareness of social functions, typically assessed in terms of whether their behaviours point to cognitive states reflecting a social architecture similar to humans' [68]. This has directed measurement efforts toward focusing on perception and representation of objects, humans, and each other, as a window to how they conceive of the world. Research into what animals make of humans and one another (which, paralleling human-focused investigations, has concentrated on the mouth, gaze, and posture [52], plus auditory cues [11]) has supplied evidence that birds can discriminate among members of their species by relying on auditory and visual discrimination alone [6]. For example, songbirds are able to recognise each other's song systems [5], and jays recognise individuals, memorising this information across time [48]. Many now regard birds as manifesting complex communication and social interaction, with rich behaviour repertoires [6]. Our increasing awareness that birds operate with subjective experiences of the world could prompt us to ask whether the above-mentioned methods centred on visual

and auditory cues are truly appropriate for measuring how birds perceive and evaluate online social experiences – especially over time and concerning selfhood. For parrots viewing each other online, is it the beak, gaze, pose/posture, auditory cues, a mix of these, or something else entirely that forms the core of the complex interplay? Further reflection on our study reveals how little we know about the role we play in parrots making sense of each other in the digital realm. What makes a parrot distinct as a parrot is even harder to answer. As humans, we are in many ways locked out of other species' understanding and interpretations, standing across deep inter-species divides [44].

If restricting ourselves to what **is** visible, we find evidence that the system in our study does confer benefits: quantitative data (from the birds) and qualitative feedback (from caregivers) attest to parrots' continuing engagement with these devices, with especially strong involvement occurring in cases of live parrot-to-parrot interaction. This brings us back to the problem of ascertaining how/why parrots interpret interactive and playback-based systems differently or what features are distinctive of each from the bird's standpoint. It is entirely possible that some element of authenticity inherent to the animals' social presence to others of their species but not comprehensible to us gets exchanged in their online experiences. Branching out into various manipulations of auditory and visual features (analogous to current HCI simulation efforts) could shed light on birds' view of others and self. Such work, alongside more general observation of how parrots interact with other birds through video-call systems, could accord us new insight into parrots' identity, social behaviours, and dynamics, thereby shedding light on multifaceted communicative narratives.

Our contribution represents a step forward in speaking to the welfare and other needs of parrots, and their human companions, via in-home and other support. Notwithstanding visions of a promising future for animals using technology in specific contexts, though, we must be mindful that animal (and human) consciousness has its limits, as does our understanding of it. The ethics implications of our actions also merit careful consideration. Still, for the broad context of animal Internet research, our work attests that it might be possible for animals' interaction to cross physical boundaries genuinely via technologies. We hope our work in this direction guides others in the search for ways to develop animal-Internet systems and highlights critical future paths for exploring how birds engage in video calls.

## 9 CONCLUDING REMARKS

As the online realm expands to encompass animals, we cannot ignore the perennial question of what animals make of other animals in video calls. This issue created much of our motivation for investigating how parrots differ in their interactions online with other parrots and their viewing of pre-recorded videos of other parrots using the system. The patterns revealed by engagement data and by caregiver feedback (from our interviews and questionnaires) are encouraging in that all parrots used our video-call system and caregivers found their relationship with their parrot stronger through learning about their bird. Our key finding that, at group level, parrots triggered and remained engaged in live calls significantly more extensively relative to video playback leaves us with important questions as to what aspect of the live calls prompted parrots in our study to engage more strongly with the video-call system. Hence, various philosophical and ethics aspect of measuring selfhood and communication via technologies deserve deeper study. We hope we have pointed to key future directions in this regard. Simultaneously, practice can benefit from our work even today, thanks partly to the concrete feedback from caregivers. For instance, their preference for pre-recorded video calls crystallised the value of not needing to schedule appointments with another parrot, though at the same time they recognised the live calls as holding greater value for the bird. More broadly, our study underscores the potential for technology to collapse spaces between animals, for decisive progress toward grasping what it signifies for animals to connect in video calls.

## ACKNOWLEDGMENTS

We wish to thank all the birds and their humans for their participation.

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