Title:

Using online media to assess mirror self-recognition in domestic cats

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Abstract:

In the mirror test of visual self-recognition, if an animal responds to its reflection as its own, rather than as to a novel individual, the animal may have the capacity to recognize itself. Here we explore two permutations of the mirror test on cats by gleaning data from social media. We examine TikTok videos where pet owners show cats reflective images with augmented reality filters; and YouTube videos where cats interact with mirrors. Behavioral sequence analysis revealed little support that cats understand reflective images. Few TikTok cats responded to AR images, and those cats may have responded to other cues, such as human touch. In YouTube videos, cats fell into five behavioral clusters, two which were aggressive, and two which were curious. Even curious cats showed little evidence that they understood mirrors. We discuss whether distinct clusters indicate that cat personality influences how cats respond to their reflections.

Key words:

mirror self-recognition test, self-recognition, *Felis catus*, cat, social media, citizen science

Statements and Declarations

The authors have no competing financial or non-financial interests that are directly or indirectly related to this study.

Introduction

A classic test for visual self-recognition is the mirror self-recognition (**MSR**) test, which involves an animal's reaction to its reflection, and to its modified reflection, e.g., by putting a mark on an animal's face (Gallup 1970; see de Waal 2008; de Waal 2019). If animals recognize their reflections, they should not treat the reflection as another animal, e.g., by displaying aggressive or fearful behaviors, and they should respond to modifications to the reflection. Some species "pass" the mirror test, including chimps (Gallup 1970, Povinelli et al. 1997), dolphins (Reiss & Marino 2001), elephants (Plotnik et al. 2006), and magpies (Prior et al. 2008). Other species like dogs may use mirrors to acquire spatial information (Howell & Bennett 2011, Howell et al. 2013), and Rhesus monkeys show evidence of self-recognition after learning how mirrors work (Chang et al. 2017).

Interpreting the results of the mirror test can be challenging, and the relationship between passing the MSR test, self-recognition, self-awareness, theory of mind, and the evolution of cognition, is controversial and depends on species tested and the protocol (e.g., Gallup 1982; Povinelli et al. 1997; Heschl & Burkart 2006, de Waal 2008; Anderson & Gallup 2015; de Waal 2019; Kopp et al. 2021). Popular consensus is that domestic cats (*Felis catus*) do not demonstrate self-recognition; rather that they habituate to their reflections (e.g., Gallup 1982; de Waal 2019; see also Nosowitz 2013; Wetsman 2019). This claim seems perfectly reasonable. However, we are aware of little formal research on visual self-recognition in domestic cats. The entirety of one cited work is, "Dogs and cats, especially younger ones, have a brief interest in their reflection, in which they probably also think they see a congener. Dogs are often afraid of it, cats become curious and go look behind the mirror" (Kraus 1949). We know of no others.

Two types of videos on social media, TikTok (http://www.tiktok.com) and YouTube (www.youtube.com), provide analogues to the MSR test. A popular Instagram and TikTok trend 2019-2020 involved pet owners showing cats theirs and their cats' images in cellphone screens while using an augmented reality (**AR**) filter to change the owners' faces (Fig 1). Conveniently, cat owners simultaneously recorded their cat's reactions to the owners' AR filtered face. Separately, cat owners uploaded videos of felines' reactions to mirrors to YouTube. Although social media is comprised of largely *ad libitum* observations (Altmann 1974), and thus is prone to biases, it can be useful for recording uncommon occurrences (Nelson and Fijn 2013, e.g., Loong et al. 2021, Bungum et al. 2022) and events involving companion animals (e.g., Boydston et al 2018).

We explore cats' reactions to reflective images, from videos gleaned from TikTok and YouTube, in the context of MSR tests, by describing cat behavioral sequences. In the AR filtered TikTok videos, we expect that, if cats understand the reflective nature of the phone screen, they should explore the differences between their reflections and some expectation, comparable to how a chimp or elephant reacts to a mark on its face. In the cats' case, we expect them to look at the phone screen, then look at the human in response to the AR filter. In the YouTube videos, we expect cats that recognize their own reflections would respond curiously. If cats in either kind of video respond with aggressive or fearful behaviors as they would to another cat – such as by charging the mirror, piloerection, displaying a bushy tail, or by trying to peer behind the mirror – we conclude that the cats are unlikely to have recognized their own reflection.

Methods

We found TikTok videos of cats reacting to AR filters by searching for terms like "cat face filter" (see Online Resource 1). We found appropriate YouTube videos by using search terms like "cat mirror" (see Online Resource 2). We analyzed 145 TikTok videos showing cats interacting with owners' AR filtered faces (posted 2019-2020) and 57 YouTube videos showing cats interacting with mirrors (posted 2012-2020). The search for each kind of video was exhaustive as of June 2020. From these videos we generated ethograms of cat behaviors (Online Resource 3, 4), which were largely concordant with the one from Stanton et al. (2015; see Online Resource 5 for notable behaviors). We described behavioral sequences in both TikTok and YouTube videos using BORIS v.7.9.8 (Friard & Gamba 2016; www.boris.unito.it), including only those behavioral transitions that occurred more frequently than chance ($p < 0.05$ from 10,000 permutations). We further grouped YouTube videos into clusters based on the frequencies of cat behaviors, using a correlation distance matrix and ClusterVis (Metsalu & Vilo 2015), a PCA-based clustering tool that incorporates several R packages (R Core Team 20221). We assessed the ability of clusters to explain variation in cat behaviors with the R package PERMANOVA (https://cran.r-project.org/package=PERMANOVA), using 1000 permutations. TikTok videos included relatively few behaviors per sequence and we therefore excluded them from cluster analysis.

Results

TikTok videos started with cats in one of three positions relative to humans (Fig 2, upper box), two of which involved human contact. Depending on the starting position, cats looked towards the phone image (Fig 2, **Eyes towards**) in 9.2 to 54.5% of TikTok videos. Cats responded to the phone image (Fig 2, **Head towards**, lower box) in 84/145 videos (57.9% total), and in 28.3% of those did the human AR appearance change (Fig 2, **Human mouth**). Overall, the AR appearance changed in 17/145 (11.7%) of videos. The cat reacted to the AR image with ear movement 32.0% of the time, but 14.6% of cat reactions to the AR image entailed the cat looking back at the human, i.e., **Human mouth → Eyes to human** (Fig 2). However we only saw the sequence, **Heads towards → Human mouth → Eyes to human**, where we can surmise that the cat reacted first to the phone, and then to the AR image by looking at its human, in 2/145 (1.4%) of videos.

No humans were visible in the YouTube videos where cats reacted to mirror reflections. Cats often responded fearfully or aggressively (Fig 3; **Snarl → Attack; Stalk → Charge → Bushytail → Piloerection → Sidestep**). However, some cats repeatedly reared and pawed the mirror, but not aggressively (Fig 3; **Rear → Paw**). And some cats would try look behind the mirror then back at it (Fig 3; **Look back → Turn towards**), in a sequence consistent with Kraus (1949). This latter sequence would sometimes switch to (12.9%) or from (54.5%) an aggressive sequence (Fig 3).

Including only significant behaviors revealed by sequential analysis, we found five likely clusters of cat behaviors among YouTube videos (Fig 4), Each cluster was characterized by high frequencies of one or a few behaviors (red bands in Fig 4); e.g., **Turn towards** (15/57), **Paw** (13/57**)**, **Charge** (11/57), **Sidestep** (15/57), and one other cluster that had no obvious high frequency behaviors (3/57). In two clusters, cats appeared curious (**Turn towards** and **Paw;** 49.1% of YouTube cats); cats approached their reflection and either tried to look behind the mirror or pawed at the mirror, without piloerection or other signs of aggression. Two clusters included aggressive behaviors (**Charge** and **Sidestep**; 45.6%). These five clusters explained 47.1% of the variation among significant YouTube cat behaviors (PERMANOVA $F_{4,52} = 11.57$, $p < 0.001$) and 39.6% of the variation among all YouTube cat behaviors (PERMANOVA $F_{4,52} = 8.51$, $p < 0.001$).

Discussion

Behavioral sequence analyses offered little evidence that cats "pass" MSR tests. Only 1.4% of the TikTok videos included cats who first turned to the phone image, then apparently responded to the AR filter by turning to their owners, although a larger proportion already facing the phone turned to their owners. We urge caution with even these low frequencies for several reasons. Some videos seem to show cats responding to other cues, such as the owners' touch, e.g., when an owner's chin touched the cat's head. Owners could have encouraged cats with unconscious or surreptitious cues, i.e., they could have goosed their cats. In this way the TikTok videos may be subject to a Clever Hans effect (Sebok & Rosenthal 1981), where cats respond to other cues from their owners than to the phone screens, *per se* (but see Schmidjell et al. 2012). Because pet owners may be motivated to make videos that "go viral", the frequencies we report may over-represent interesting behaviors and sequences.

With these caveats in mind, we found clusters of cat behavior sequences in YouTube cat responses to mirrors. Nearly half the cats fell into clusters involving aggressive behaviors, which has not been reported previously. About half the cats fell into clusters involving exploratory behaviors, one of which, **Turn towards**, was consistent with the pattern described by Kraus (1949). Curiosity does not by itself mean cats exhibit self-recognition but it may warrant further study. The clustered nature of responses may suggest that cat personality, or something like it, influences how cats react to mirrors. Alternatively, clusters could reflect what cat owners find worthy of social media. Variation among cats in their responses to mirrors may simply be a confound or a correlate with demographic components, like prior exposure to mirrors, cat age, or cat sex. But individual variation among cats performing cognitive tasks might be worth investigating (Thornton & Lukas 2012). Our analysis cannot determine whether the clusters reported here correlate with measured cat personalities (Litchfield et al. 2017) or other categories of behavioral responses (e.g., Vitale et al. 2019).

Our analysis of data gleaned from the internet can be viewed as a "next-gen" natural history study (Tosa et al. 2021), in this case of cats on social media, where we extrapolate patterns from observable variation in cat behavioral responses. Because these TikTok and YouTube videos lack experimental treatments and controls, we cannot adequately test MSR hypotheses. We do not know, for example, how TikTok cats respond to an unmanipulated images, or whether aggressive or curious YouTube cats respond differently if they are marked. Although some cats on social media display behaviors that may be consistent with self-recognition, there are other explanations, including general curiosity about novel individuals or images. Indeed, the ways the curious cats investigated their reflections, by pawing at them or trying to peer behind the mirrors, indicate cats did not understand how mirrors work. But even humans can be prone to the “mirror fallacy” (Heschl & Burkart 2006); like Rufus T Firefly in the movie Duck Soup, we too sometimes explore what is – and is not – our own reflection (Shoemaker 1994; Zunshine 2018). Our observation of cats switching between behavioral patterns might indicate similar exploration.

Even with these limitations, this study analyzed over 200 cats, which points to the potential power of citizen cognitive science (e.g., Smith et al. 2021; Stewart et al. 2015). It also suggests a means of addressing MSR tests with cell phones, computer cameras, and AR filters, which could allow for very careful manipulation of reflective images, e.g., by placing any kind of mark on an animal’s image, and without the confounding effects of paint textures or anesthetization. And our study revealed distinct clusters of curious and aggressive cat responses, which may correlate to cat personalities, and which had not been previously reported.

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Figure Captions

Fig. 1 Screen captures of behavior sequence in video with cat and human with augmented reality filter. Notice the placement of the human's chin in the second (upper right) screen capture, and the movement of the human's mouth in the third and fourth (lower two) screen captures. After TikTok post by user @funny_goe 2019-11-11.

Fig. 2 Behavioral sequences of cats and owners in TikTok videos. Human behaviors (filled ovals) include contact, hug, and moving the mouth such that the AR filtered image changes ("Human mouth"). Cat behaviors (open ovals) include flicking ears ("Ears flinch") flattening ears ("Ears back"); looking away from ("Eyes away") or towards ("Eyes towards") the phone screen; turning head towards the screen ("Head towards") or moving gaze towards the human ("Eyes to human"). See ethogram (Online Resource 3) for details.

Fig. 3 Behavioral sequences of cats exposed to mirrors in YouTube videos. Sequences are coloured according to clusters in Fig. 4. See Online Resource 4 for ethogram and Online Resource 5 for notable behaviors.

Fig. 4 Heatmap of cat behaviors. Cats fell into five clusters, each typified by high frequencies of some behaviors. Labels under heatmap refer to individual videos (see Online Resource 2). See Online Resource 4 for ethogram and Online Resource 5 for notable behaviors.

Online Resource Captions

Online Resource 1 TikTok videos analyzed. We first used the search terms "cat face" and "cat face filter," and were able to locate the original viral video posted (2019-11-11) by user @funny_goe, which received over 8M views and 736.6k likes (as of Jan 2022). After clicking on its audio, titled "original sound (untitled)," we were able to find 67.8k related videos. We went down this list of videos with descending popularity as the order and only chose the videos that included cats and the cat face filter on a human. As we traverse down the list of videos, they became increasingly irrelevant to the cat face trend and we stopped data gleaning after 150 videos, 145 of which were exclusively cat videos. https://doi.org/10.6084/m9.figshare.21080818

Online Resource 2 YouTube videos analyzed. We first used the search terms "cat mirror", using "Relevance" as a filter. After exhausting the list of videos that consisted of cats reacting to mirrors (no human involved), we then changed the filter to "Upload date." We then went down the list, gleaning videos that were novel from the results of our first search. We stopped searching after reaching videos posted in 2012. This search yielded 57 separate instances of cats reacting to mirrors. https://doi.org/10.6084/m9.figshare.21080929

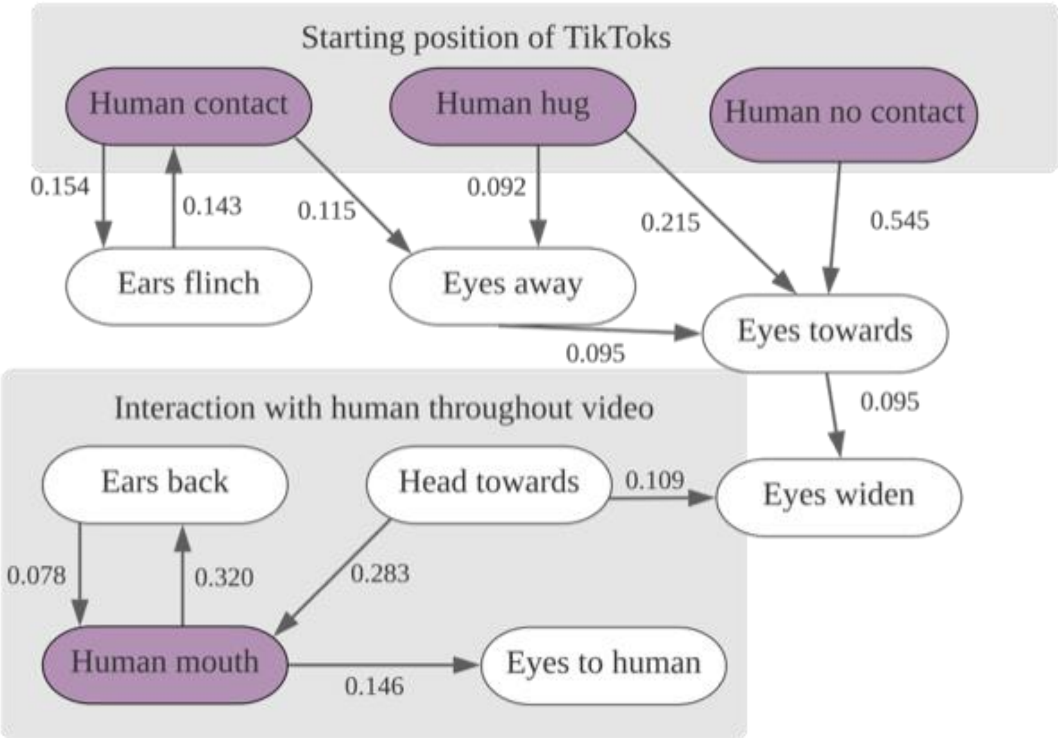
Online Resource 3 Ethogram used to analyze TikTok videos. Names and descriptions of 32 events, including 4 human behaviors, 24 cat behaviors, and 4 events related to the video itself.

Online Resource 4 Ethogram used to analyze YouTube videos. Names and descriptions of 23 cat behaviors.

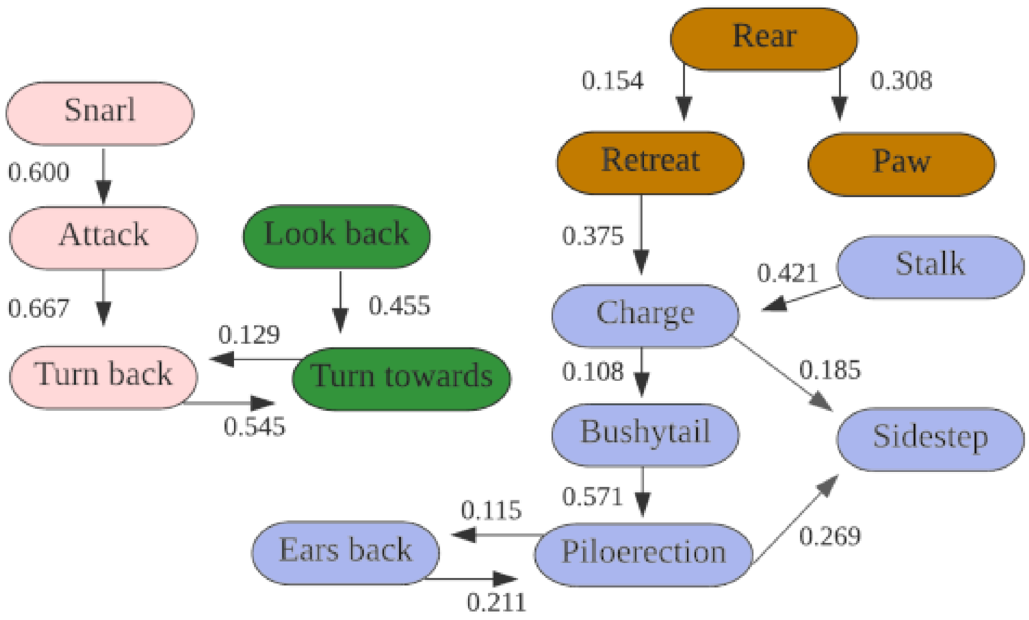
Online Resource 5 Diagram of notable cat behaviors in YouTube videos whose descriptions might not do them justice (see Online Resource 4).

Figure 1

Figure 2

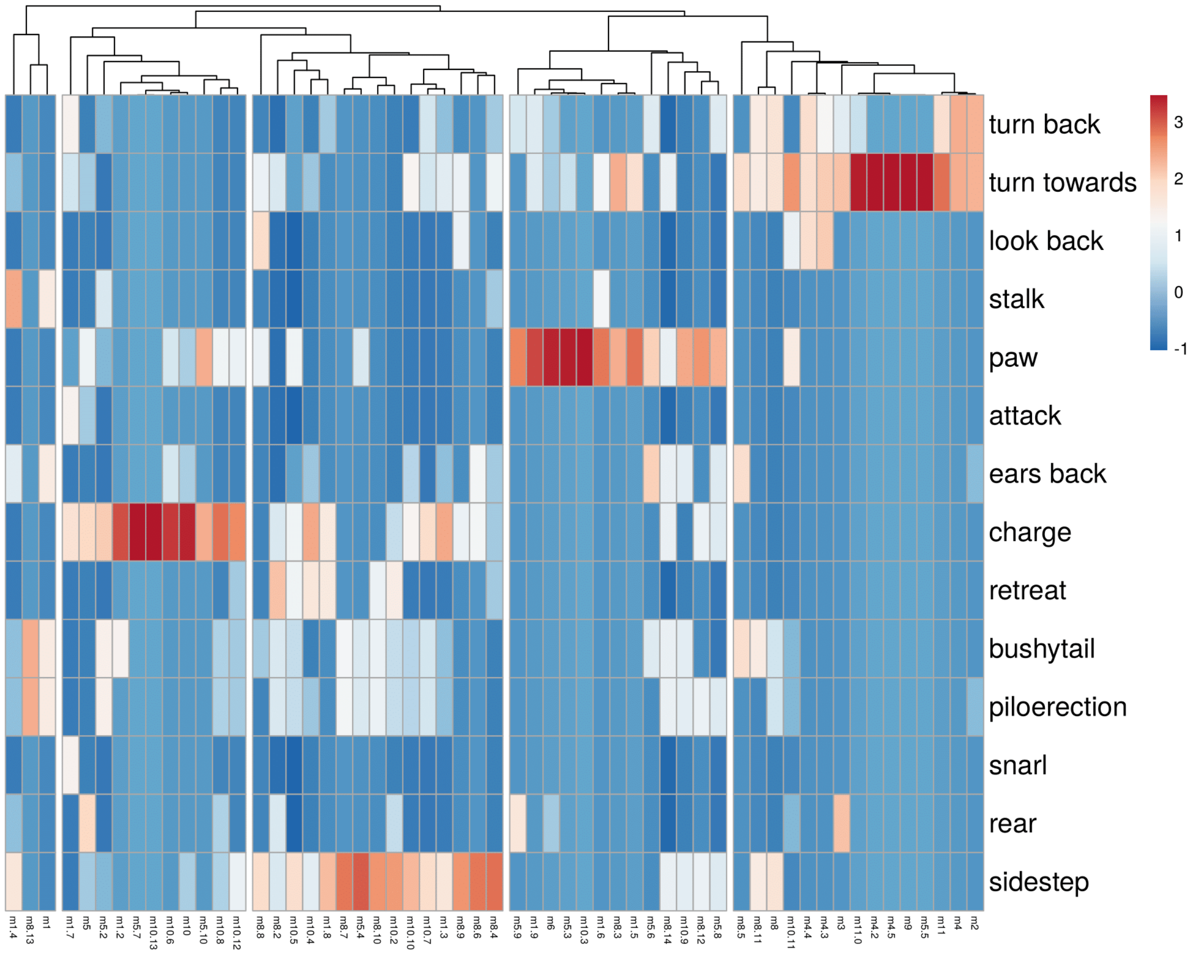

Starting position of TikToks
Human contact
Human hug
Human no contact
0.154
0.143
0.115
0.092
0.215
0.545
Ears flinch
Eyes away
Eyes towards
0.095
Interaction with human throughout video
0.095
Ears back
Head towards
0.109
Eyes widen
0.078
0.320
0.283
Human mouth
Eyes to human
0.146

318 **Figure 3**



319

Figure 4


turn back
turn towards
look back
stalk
paw
attack
ears back
charge
retreat
bushytail
piloerection
snarl
rear
sidestep
3
2
1
0
-1
m1.4
m8.13
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m1.7
m5
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