

Timescale Bias in the Attribution of Mind

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In this research, the authors found that people use speed of movement to infer the presence of mind and mental attributes such as intention, consciousness, thought, and intelligence in other persons, animals, and objects. Participants in 4 studies exhibited timescale bias—perceiving human and nonhuman targets (animals, robots, and animations) as more likely to possess mental states when those targets moved at speeds similar to the speed of natural human movement, compared with when targets performed actions at speeds faster or slower than the speed of natural human movement.

Keywords: attribution, mind, movement, speed, theory of mind

Ever notice that anyone going slower than you is an idiot, but anyone going faster than you is a maniac?—George Carlin

What has a mind? Although criteria for deciding on the existence of other minds have been debated by philosophers for centuries, each of us makes rough-and-ready decisions about mental properties on a regular basis, deciding that one entity has a desire or a thought (this dog wants my sandwich), for example, or that another does not (the sandwich is not all that interested in the dog). In attributing mind to any entity, people seem to base their judgments in part on anthropocentric features, such as whether the entity looks human or seems to have human perceptions or behaviors. One particularly subtle cue is whether an entity moves at a tempo like that of a human. In this research, we examined whether mind perception is influenced by timescale bias—the degree to which targets are perceived to move at a human pace.

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We gratefully acknowledge research Grant MH 49127 from the National Institute of Mental Health to Daniel M. Wegner and the Harvard Institute for Quantitative Social Science Dissertation Fellowship and Graduate Society of Fellows Merit Fellowship to Carey K. Morewedge. We thank Michael Clear, Leanne Gaffney, Dina Gohar, Dana Graef, Tessa Johung, Jennifer Lee, Kathleen Lee, Rebecca Levine, Christine Mathieson, Gregory McBroom, Kristian Myrseth, Xi Wang, and Lisa Xu for their help with the execution of these experiments and Kevin Lahoda for animations.

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Mind Perception

The interpretation of other minds is an activity that people engage in frequently, for example, in reading facial expressions (Ekman, Friesen, & Ellsworth, 1972; Marsh, Adams, & Kleck, 2005), detecting deception (Kassin & Fong, 1999), inferring intentions and goals (Hassin, Aarts, & Ferguson, 2005; Malle & Knobe, 1997), and managing interpersonal relations (Baron-Cohen, 1995). Mind perception is a psychological process that occurs with the attribution of mental states such as desire, thought, emotion, planning, reasoning, or consciousness to target objects (Baron-Cohen, 1995; Premack & Woodruff, 1978). Viewing the behavior of entities in terms of mental states has great benefits to the observer. Knowledge of others' goals or desires helps inform a person how to best direct his or her actions in relation to these other agents (Byrne & Russon, 1998; Tomasello, Carpenter, Call, Behne, & Moll, 2005), for instance, leading the person to protect sandwiches from hungry dogs rather than to protect dogs from sandwiches. Human and nonhuman perceivers regularly rely on mind perception to predict and interpret others' beliefs (Hare, Brown, Williamson, & Tomasello, 2002; Nickerson, 1999), desires (Epley, Morewedge, & Keysar, 2004; Keysar, Barr, Balin, & Brauner, 2000), and behaviors (Epley, Caruso, & Bazerman, 2006; Kozak, Marsh, & Wegner, 2006).

Making judgments about the contents of other entities' minds requires one to first ascribe mental states to other entities. In evaluating the surrounding environment, a sharp distinction is made between animate agents (e.g., humans, other animals, artificial life) and inanimate objects (e.g., mannequins, rocks, furniture). Guthrie (1993) noted there are strong evolutionary pressures to be able to detect other agents in the environment to determine who might be a potential ally, enemy, predator, prey, or mate. Unlike objects, agents are seen as potential prime movers, or first causes—they can act without being

acted on (Dennett, 1987; Michotte, 1946/1963). Agents tend to be mentalized (endowed with thoughts and desires that guide their actions), but objects are assumed to be governed only by simple physics (Molina, Van de Walle, Condry, & Spelke, 2004; Wegner, 2002). Perceiving an inner mental life in agents provides useful shortcuts when anticipating future behavior. If a dog is treated as an entity with beliefs ("This sandwich is food."), desires ("I want to eat food."), and goals ("I want to eat the sandwich!"), it is easier to predict how the dog might behave at a picnic than if one attempts to create a mathematical model to predict the dog's behavior that accounts for all external stimuli. Mind perception is therefore a special kind of causal inference that appeals to mental states as an explanation or prediction. Like other kinds of causal inferences, mind perception occurs effortlessly and spontaneously (Hassin, Bargh, & Uleman, 2005). Without appealing to an agent's mental states, the actions of others would seem entirely random and unpredictable (Baron-Cohen, 1995; Sacks, 1995).

Attributions of mind may begin with the inference that the "lights are on" inside the agent, but the extent to which those lights are bright or dim is a different matter. Though all agents may hold the basic property of animacy, they vary in the psychological agency that includes properties of consciousness and sentience (Opfer, 2002). In other words, the perception of mind is not perceived as a dichotomy between discrete categories but rather is perceived along a graduated scale (Gray, Gray, & Wegner, 2007). Agents on the low end of the mind scale possess very limited capacities of thought or awareness, and agents on the high end possess a rich experience of mind with complex emotions and elaborate thought. Observations of the exact same action might be interpreted in either mechanistic or mentalistic terms (Wegner & Vallacher, 1986), depending on where the agent is perceived to be on this scale (Kozak et al., 2006; Vallacher & Wegner, 1987). For instance, shooting a gun could be identified as pulling a trigger, when performed by a 6-year-old child, or as committing murder, when performed by a 35-year-old man. Special status is given to humans in this hierarchy, who are endowed with greater consciousness than other animals. Some mental experiences are presumed to be reserved only for humans—for example, abstract emotions such as hope and nostalgia (Demoulin et al., 2004) or complex traits such as insecurity or imaginativeness (Haslam, Bain, Douge, Lee, & Bastian, 2005).

Minds and Motion

Given the importance of anticipating agents' behavior, it is not surprising that a strong cue to the presence of mind is the appearance of self-propelled movement (Leslie, 1994; Premack, 1990). Inferences of mind tend to be made from biological motion, the easily recognized dynamics of movement first noted in Johansson's (1973) studies of point-light displays of walking figures. For example, point lights attached to dancers' joints can convey emotions such as fear, anger, grief, joy, surprise, and disgust without any other visual information about the actor's physical appearance (Dittrich, Troscianko, Lea, & Morgan, 1996). People can also recognize the identity of a person in motion by their idiosyncratic walking style (Troje, Westhoff, & Lavrov, 2005) and readily recognize the gender of walking humans (Kozlowski & Cutting, 1977), cued by differences in the velocity of shoulder and hip dots (Mather & Murdoch, 1994).

Yet motion does not necessarily have to appear lifelike to garner attributions of agency. In the classic study of Heider and Simmel (1944), people attributed mental states such as desires and emotions to moving geometrical figures when the shapes moved at a human pace and performed recognizable actions. Research since then has established that the perception of targets as animate is commonly based on the targets' pattern and timing of motion (for a review, see Rakison & Poulin-Dubois, 2001). Even more rudimentary movements, such as changes in movement direction or dynamics without physical cause, can induce perceptions of animacy for infants and adults (Bassili, 1976; Michotte, 1946/1963; Rochat, Morgan, & Carpenter, 1998; Scholl & Tremoulet, 2000; Tremoulet & Feldman, 2000). If a target's movement appears to achieve a goal or occurs in spatiotemporal synchrony with the movement of an object, perceivers also infer that the target possesses mental states (Csibra, Gergely, Biro, Koos, & Brockbank, 1999; Johnson, 2003; Meltzoff, 1995). Movement dynamics provide a rich set of cues for the perception of minds.

Timescale Bias

One potentially important influence of motion on mind perception is the speed of motion. In particular, an entity that moves at a humanlike pace might be more likely to draw attributions of mind (Dennett, 1996). At the slow extreme, of course, targets that move almost imperceptibly are sometimes not recognized as agents. Young children may fail to identify plants as alive because of their apparent lack of movement (Carey, 1988; Piaget, 1929). Although plants move in a self-serving way (i.e., when orienting toward light), they move so slowly that few would attribute such movements to acts of a mind. If one were to view plants' movement in a time-lapse film, however, it might seem to observers that plants want to grow toward sunlight because they desire sunlight.

At the opposite extreme, when an entity is moving very quickly, agency and mind might also be difficult to appreciate. When actions occur very rapidly in sports on television, for example, it may be difficult to understand the intentions of actors without the aid of slow-motion replays. So, rather than mind perception increasing linearly as the speed of action increases, there may instead be a curvilinear relation between speed of motion and the likelihood that the motion will be perceived as having been generated by an intelligent entity. As Dennett (1996) has suggested, the inflection point in this curve could be the speed of human motion—targets moving at human tempo may be especially likely to garner attributions of mind, whereas those moving slower or faster may be less likely to be viewed as having minds.

Preferential attributions of mind to agents moving at one's own pace suggests a functional approach to mind attribution. A perceiver gains little reading the mind of a target moving much faster than the self. Such a target cannot be avoided or caught, so there is no use in speculating about its mental states in order to predict its actions. Instead, it is better to respond to such agents by some fixed rule (e.g., "Play dead!" or "Run away!"). There is also not much use in examining the thoughts or motives of targets that are sluggish, such as rocks or plants. Perceivers do not need to predict such targets' behavior in advance as they can easily be outmaneuvered. Indeed, mind perception is often prompted when the prediction of targets' mental states

confers some specific benefit (Gallup, Marino, & Eddy, 1997; Haselton & Buss, 2000; Maner et al., 2005).

We hypothesized that perceptions of mind are influenced by a timescale bias—behaviors are more likely to appear to be the intentional acts of conscious beings when they occur at speeds similar to human movement speeds. We tested this by assessing whether perceivers' attribution of mental states to a target depends on the target's speed relative to human motion. In Study 1, we examined the relation between mind attribution and movement speed in the perception of a variety of familiar natural agents and objects. In further studies, we held targets constant—all participants judged the mental states of the same targets, but we manipulated the targets' apparent speed of movement (Studies 2 and 4) or actual speed of movement (Study 3). Unfamiliar nonhuman targets' apparent speed was manipulated in Study 2 by changing the frame rate of videos presented. Human targets' actual walking speed was directly manipulated in Study 3. In Study 4, we examined whether attributions depend on a target's absolute speed of movement or speed of movement relative to human speed. In an animated film, the apparent movement speed of a nonhuman target (i.e., a purple blob) was manipulated by changing the apparent motion speed of animated humans in the background.

Study 1: Natural Agents and Objects

Timescale bias in mind perception may stem from evolutionary selection pressures involved in dealing with other species. The

degree to which we attribute mind to any particular species may depend on whether it is useful to be able to infer intentions and goals from observations of their behavior. Therefore, the general assessment of mind for members of species may be related to their motion speed relative to human motion speed. In Study 1, we examined the relation between people's assessment of motion speed and mind of various targets. Participants judged 22 targets (including animals, plants, and an inanimate object) on their speed and the extent to which each appeared to have a mind. We expected participants to preferentially endow mind upon entities that move at speeds similar to speed of human movement.

Method

Participants. There were 240 participants in three samples who volunteered to complete a short survey. Sample A consisted of 91 undergraduates (40 females, 38 males, and 13 not reporting sex, $M_{\text{age}} = 20.6$ years, $SD = 2.9$). Sample B consisted of 55 pedestrians in Cambridge, Massachusetts (25 females, 26 males, and 4 not reporting sex, $M_{\text{age}} = 38.1$ years, $SD = 18.7$). Sample C consisted of 94 undergraduates (40 females, 35 males, and 19 not reporting sex, $M_{\text{age}} = 19.6$ years, $SD = 1.8$).

Procedure. Participants who volunteered to complete a survey on how different entities appeared to them assessed the mind and movement of a total of 22 targets (see Figure 1), by drawing an X through 115 mm continuous scales with the endpoints *does not appear to have a mind* versus *definitely appears to have a mind*

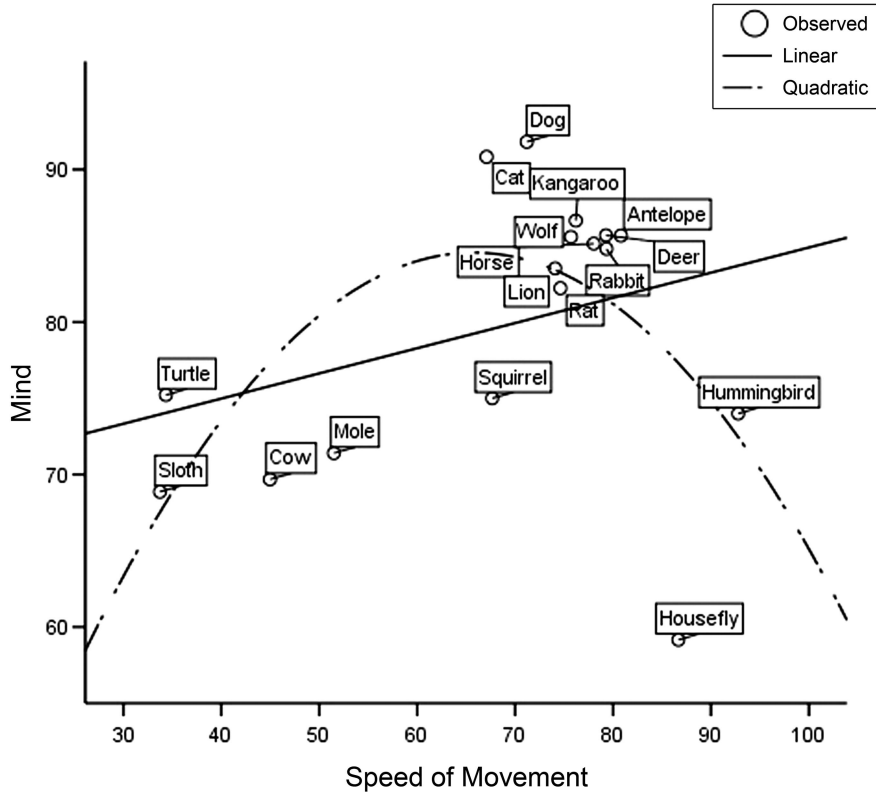


Figure 1. Mind attributions to nonhuman animals by their perceived speed of movement in Study 1 are shown. (Other mean scores: $M_{\text{human movement}} = 68$, $M_{\text{human mind}} = 108$; $M_{\text{flytrap movement}} = 40$, $M_{\text{flytrap mind}} = 32$; $M_{\text{sunflower movement}} = 23$, $M_{\text{sunflower mind}} = 11$; $M_{\text{vine movement}} = 20$, $M_{\text{vine mind}} = 18$; $M_{\text{rock movement}} = 13$, $M_{\text{rock mind}} = 6$).

and *does not move at all* versus *moves faster than the eye can see*. Participants in Sample A assessed the mind and movement of 10 targets—humans, hummingbirds, lions, rocks, sloths, sunflowers, turtles, venus flytraps, vines, and wolves. These judgments were made by participants in Sample B for antelope, deer, houseflies, humans, kangaroos, hummingbirds, rabbits, rats, rocks, sloths, and vines and by those in Sample C for cats, cows, dogs, horses, humans, hummingbirds, moles, rocks, sloths, squirrels, and vines.

Results and Discussion

To determine whether human movement speed was used in judging targets' minds, we computed the absolute value of the difference between each participant's human movement rating and movement ratings of each other target. Targets' mind scores and absolute deviation from human movement were correlated in Sample A, Sample B, and Sample C; mean within-subjects correlations ($r = -.50$, $r = -.44$, and $r = -.63$) differed significantly from zero, $t(89) = 12.18$, $p < .001$; $t(54) = 8.43$, $p < .001$; and $t(93) = 21.17$, $p < .001$, respectively (for means, see Figure 1).

The reliability of ratings of the five targets rated by all samples was high, with interclass correlation $r = .99$, $F(2, 460) = 1,148.54$, $p < .001$, so further analyses were used to examine averaged ratings of all targets rated by any sample. For these analyses, we looked at targets for which mind was a plausible attribution (i.e., not rocks or plants), examining ratings of targets that possess brains. For these targets, a curve-fitting regression yielded a significant quadratic model ($R^2 = .37$), $F(2, 14) = 5.06$, $p < .05$, in which mind attribution varied as an inverse quadratic function of speed of motion ($\beta = -3.93$), $t(16) = 2.42$, $p = .03$, but did not fit a linear model ($R^2 = .06$), $F(1, 16) = 1.08$, $p = .32$. We considered that this result may be due to some relation between speed of motion and brain weight (Jokisch, Midford, & Troje, 2001). But it is important that the brain weight of nonhuman animals ($N = 17$) did not predict those targets' mind scores as either a linear function ($R^2 = .05$), $F(1, 15) = 0.78$, $p = .39$, or a quadratic function ($R^2 = .11$), $F(2, 14) = 0.92$, $p = .42$. A linear regression on nonhuman animal targets, including both targets' absolute derivations from human movement and brain weights, $R^2 = .78$, $F(2, 14) = 6.09$, $p = .01$, revealed that the targets' absolute deviations from human movement predicted the targets' mean mind scores, $\beta = -0.54$, $t(16) = 3.30$, $p = .005$, whereas the targets' average brain weights did not, $\beta = 0.01$, $t(16) = 0.66$, $p = .52$.¹

In the perception of known animals and plants, then, and in the perception of animals alone, the greater the similarity between human movement speed and a target's apparent movement speed, the more the target appeared to have a mind.

Study 2: Novel Targets

In Study 1, we found initial evidence for a timescale bias. However, that study was limited by the fact that in it, we examined correlations and judgments of familiar targets that may have been influenced by unrelated preexisting beliefs. In Study 2, we examined whether participants would use movement speed to infer the presence and abundance of mental states in novel nonbiological targets (i.e., robots, animations, and action figures). Though the attribution of mind to nonbiological targets may seem strange,

people anthropomorphize objects with some regularity. People perceive unreliable computers and cars as having a mind of their own (Morewedge, 2006), and people often respond to robot and computer behavior in the same way people respond to similar human behavior (Reeves & Nass, 1996). Furthermore, Study 2 addressed problems that may have resulted from the idiosyncratic selection of targets in Study 1 by having all participants rate the same targets and manipulating the apparent motion speed of those targets. We predicted that participants would exhibit a timescale bias in the attribution of mental states, preferentially ascribing mental states to novel nonhuman targets when those targets moved at speeds similar to human speed, compared with when those targets moved at speeds slower or faster than human speed.

Method

Participants. Participants were 63 undergraduates (19 males and 44 females, $M_{\text{age}} = 20.8$ years, $SD = 4.7$) who received \$5 or course credit.

Stimuli. Stimuli consisted of nine films presented at three film speeds. We used three films of robots from laboratory demonstrations (MIT Robotics Labs, 2000); films of a fourth robot and an animation were from a PBS film (Sims, 2000). The robots ran, jumped, pounded in a nail, or navigated terrain (i.e., a furnished apartment or a rocky plateau). In the animated film, a rectangle and a circle moved so that the rectangle appeared to be following the circle. Four stop-action films of action figures were shot one frame at a time and edited with Adobe Premier (Version 6.5). Action figures such as an adjustable plastic Godzilla performed various actions, including walking, dancing, and interacting with other objects and action figures.

All films were presented at slow, medium, and fast speeds. Medium speed animations were created to approximate an adult human gait frequency of 40–65 strides/min (Davis, 2001); slow and fast versions showed these movements at $0.07\times$ – $0.45\times$ and $2.50\times$ – $8.00\times$ medium speed, respectively. For the stop-action videos shot frame-by-frame, slow films were presented at 1 frame per s (fps); $0.07\times$ – $0.14\times$ medium speed), medium films at 6.60–11.60 fps, and fast clips at 16.60–50.00 fps ($2.50\times$ – $6.00\times$ medium speed). Films ranged in duration from 1 s to 186 s ($M_{\text{faster speed}} = 3.00$ s, $SD = 2.27$; $M_{\text{medium speed}} = 25.89$ s, $SD = 28.93$; $M_{\text{slower speed}} = 88.00$ s, $SD = 56.84$). All actions were recognizable at all speeds.

Procedure. Participants in an object perception study watched nine films of targets performing various actions. Each participant viewed three slow, three medium, and three fast films—each film depicting a different target. After watching each film, participants assessed the extent to which each target appeared to possess consciousness, how intentional the behavior appeared, how much

¹ When domesticated animals are excluded (i.e., animals in Sample C), all reported analyses yielded the same results (i.e., significant and nonsignificant) reported here. Mind score varied according to a curvilinear pattern with respect to speed of motion, $F(2, 8) = 4.38$, $p = .05$, but not according to a linear pattern, $F(1, 9) = 0.61$, $p = .46$ (see Figure 1). It is interesting that a regression analysis of all the nonhuman items ($n = 21$) revealed that items' mean movement metric scores predicted the items' mean mind score better than items' mean brain weight did ($\beta = -1.39$), $t(20) = 7.33$, $p < .001$, and ($\beta = 0.02$), $t(20) = .69$, $p = .50$.

the target appeared to think about the action, and how intelligent the target's behavior appeared on 7-point scales with endpoints such as *not at all* (1) and *very intentional* (7). Film order and condition were randomly assigned in this and further studies. Participants in this and further studies were debriefed and compensated after participation.

Results and Discussion

The responses of 5 participants to one film were lost because of computer error and were not included in the analyses. To compare responses across films (as individual targets may have moved at slightly different action speeds), each scale response was Z transformed across participants. Participants' responses to the four mind perception items were significantly intercorrelated within target (all Cronbach's $\alpha > .74$, $M = .86$) and were averaged within each action to create a general index of mind attribution for each target. Each participant's mind rating for each action was then averaged with the other two actions observed at the same speed to create a mind score for each action speed (slower, similar-to-human speed, faster). A repeated-measures analysis of variance (ANOVA) with 3 levels of speed and 3 levels of order revealed that action speed influenced mind attribution to the animated targets, $F(1, 60) = 10.65$, $p = .002$, $h^2 = .15$ (for means, see Figure 2), and polynomial contrasts indicated that mind attribution varied as an inverse quadratic function of film speed, $F(1, 60) = 8.73$, $p = .004$, $h^2 = .13$; with linear contrast, $F(1, 60) = 12.16$, $p = .001$, $h^2 = .17$. The particular clips participants viewed at each respective speed did not influence participants' attribution of mind ($F < 1$).

In sum, perceivers appear to be more likely to attribute mental states to novel targets moving at speeds similar to human speeds than to novel targets moving at faster or slower speeds. Timescale bias extended not only to those familiar agents in the natural environment but to novel artificial agents as well. It is interesting that a significant linear contrast revealed that participants were particularly reluctant to attribute mental states to the fastest moving nonhuman agents. Whereas the slow movements of the novel robots and animations may have led participants to infer that targets possessed lesser mental abilities than movements approximating human speeds of movement, it is possible that the fastest movements led participants to infer that the targets were automated and thus incapable of possessing any form of consciousness or thought.

Study 3: Human Movement Speed

In Study 3, we altered the speed of human actors' movement to determine whether timescale bias could influence the ascription of mental states to other humans. Participants watched three film clips of people walking on a populated city street. For each film, people made judgments of mind about one particular person walking among the other pedestrians. To control for the possibility that participants in previous studies simply judged targets by comparison with the other targets they assessed, in this study all participants first watched and rated one film of a human target moving at one of three speeds (i.e., Target A) before watching and rating two other human targets (i.e., Targets B and C). Thus, judgments of all three targets (A, B, and C) could be compared within participants and judgments of the first target judged (Target A) could be compared between participants. We expected participants to preferentially ascribe mental states to human targets when those targets moved at speeds closest to normal human walking speed in Cambridge, Massachusetts, compared with human targets moving at faster or slower speeds.

Method

Participants. Participants were 49 undergraduates in Cambridge, Massachusetts (22 males and 27 females, $M_{\text{age}} = 20.1$ years, $SD = 1.6$) who received \$3.

Stimuli. Participants watched three films of three different human targets, each walking at one speed (i.e., slower-than-average walking speed, average walking speed, and faster-than-average walking speed) filmed from a mean distance of 12.5 m. All films were shot along the same segment of a city street and presented at the same frame rate (44.1 fps). Nontarget humans (pedestrians not involved in the experiment) walking in front of and behind the actor were visible in all films. Films ranged from 6 s to 38 s in length ($M_{\text{slower-than-average speed}} = 31.30$ s, $SD = 9.07$; $M_{\text{average speed}} = 12.30$ s, $SD = 1.53$; $M_{\text{faster-than-average speed}} = 7.33$ s, $SD = 1.53$).

Procedure. Participants were informed that in the experiment, we were investigating first impressions of people walking on a street in their city. Before watching each film, participants were shown one still frame from the film that identified the target person they would evaluate. Participants were instructed to watch the target identified at the beginning of each film because they would be asked to make a few judgments about that person. First, par-

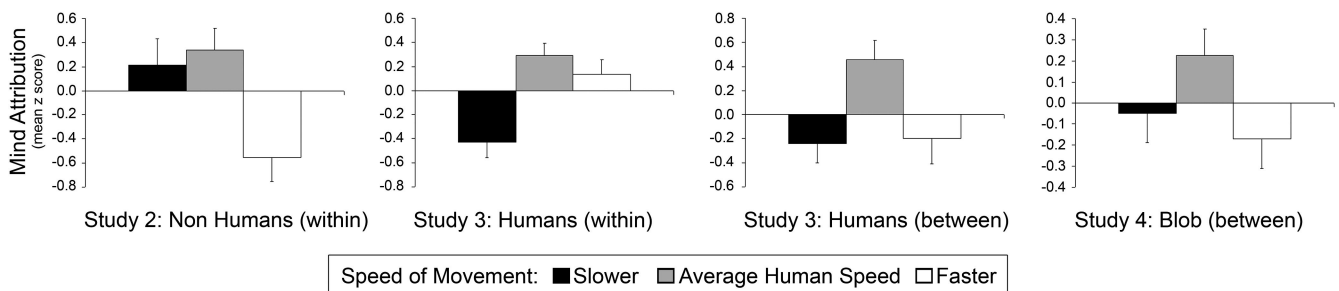


Figure 2. Mind attributions by movement speed in within-subject (Studies 2 and 3) and between-subjects (Studies 3 and 4) experiments are shown. Error bars indicate ± 1 standard error above and below the mean.

ticipants watched Target A walking on a city street at one of three speeds ($M_{\text{slower}} = 0.67$ m/s, $M_{\text{average}} = 1.35$ m/s, $M_{\text{faster}} = 2.03$ m/s), with the middle value matched to the average walking speed (1.34 m/s) in a city in northeastern America with a population size similar to Cambridge, Massachusetts (population 101,355; Bornstein & Bornstein, 1976). Then, in different films, participants watched two other people at the other speeds (Targets B and C; their walking speeds differed slightly from Target A; $M_{\text{slower}} = 0.46$ m/s, $M_{\text{average}} = 1.43$ m/s, $M_{\text{faster}} = 2.23$ m/s), presented in random order, yielding six orders. After watching each film, participants assessed the degree to which each target appeared to be competent, to be intelligent, to be smart, and to have a mind, on four 7-point Likert scales with the endpoints *not at all/does not appear to have a mind* (1) and *very competent/intelligent/smart/definitely appears to have a mind* (7), in addition to rating each target on several filler items, such as, "Do you think this person is a pet owner?"

Results

Each scale response was Z transformed across participants. Participants' responses on the four scales were significantly intercorrelated within each target (mean Cronbach's $\alpha = .85$) and were averaged to create a general mind attribution score for each target.

Within-subjects analysis. A 3 within (speed) $\times$ 6 between (order) ANOVA revealed a significant main effect of target speed, $F(1, 43) = 15.01$, $p < .001$, $h^2 = .26$, with no significant main or interactive effect of order ($F_s < 1$; see Figure 2). Polynomial contrasts showed that mind attributions varied by walking speed as an inverse quadratic function, $F(1, 43) = 18.42$, $p < .001$, $h^2 = .30$; with linear contrast, $F(1, 43) = 13.04$, $p = .001$, $h^2 = .23$. Although all films in this study were shot and presented at the same film speed, participants were more likely to attribute mental states to targets moving at normal human walking speeds than to targets walking at faster or slower speeds.

Between-subjects analysis. To further control for potential comparative judgments between the three targets, an ANOVA was performed solely on participants' ratings of Target A, the target first assessed by all participants. This analysis revealed a significant main effect of speed, $F(2, 46) = 5.17$, $p = .009$, $h^2 = .18$ (see Figure 2). Polynomial contrasts showed that participants' attributions of mental states to Target A varied by speed as an inverse quadratic function, $F(2, 46) = 10.15$, $p = .003$, not as a linear function ($F < 1$). In short, participants' judgments of mind appeared to be influenced by actual walking speed, not by comparison with other targets.²

Discussion

In this study, we found that attributions of mind to other humans was impacted by a timescale bias, with slower and faster humans appearing to have less mind than humans moving at an average human speed. The results of the between-subjects analysis suggest that the timescale bias exhibited by participants in Study 2 was not simply due to the comparison between targets. The results of the within-subjects analysis suggest that the timescale bias exhibited by participants in Study 2 was not simply due to any abnormalities in targets' apparent movement that may have been caused by the manipulation of film frame rates. Interestingly, in contradiction to

the linear contrast found in Study 2, a linear contrast in within-subjects judgments was found in Study 3, which revealed that participants were particularly reluctant to attribute mental states to the slowest moving human agents. Although a linear trend was not found in participants' between-subjects judgments, it is possible that the slowest movements led participants to infer that those human targets were inept because they required more time to perform simple tasks, like walking, than did the other human targets.

This timescale bias exhibited in judgments of other humans may have important implications for interpersonal and intergroup judgments. As differences exist within and between cultures with regard to the pace of living (Bornstein & Bornstein, 1976; Levine & Norenzayan, 1999; Levine, West, & Reis, 1980), groups and cultures with different tempos (e.g., teenagers and senior citizens) may have difficulty discerning the motivations behind each other's behavior and, as a result, may make uncharitable assessments of each other's mental capacity.

Study 4: The Blob

The results of the first three studies suggest that perceivers are more likely to attribute mental states to targets when the targets move at speeds similar to the speed of human movement. Study 4 was designed to determine whether perceivers attribute mental states according to a target's absolute movement speed or the target's movement speed relative to normal human movement speed. In other words, is there a particular range of movement speeds that is most indicative of the presence of mental states, or is speed of movement indicative of mental states only when it is perceived to be similar to human movement speed?

For this study, we presented participants with an animation in which the absolute speed of a nonhuman target was held constant but the movement speed of nearby human agents' actions varied across conditions. Participants watched an animated purple blob moving down a city street. Human actors' movement speed was varied behind the blob, so that the blob appeared to move slower than, the same speed as, or faster than the human actors' speed. If perceivers are influenced by targets' absolute speed of movement when attributing mental states, participants should be equally likely to ascribe mental states to the blob regardless of the animated humans' speed of movement. If perceivers are influenced by the relative similarity of the target's speed of movement and humans' speed of movement when attributing mental states, par-

² Asking one to judge the extent to which another person appears to have a mind may seem peculiar, but removing that specific response item from the analysis of attributions to all three targets yields a similar main effect of speed, $F(1, 43) = 14.87$, $p < .001$, $h^2 = .26$; quadratic contrast, $F(1, 43) = 19.67$, $p < .001$, $h^2 = .31$, as do analyses of attributions to Target A, $F(2, 46) = 4.21$, $p = .02$, $h^2 = .16$. Polynomial contrasts showed that participants' attributions of mental states to Target A varied by speed as an inverse quadratic function, $F(1, 46) = 8.38$, $p = .006$. Similarly, although competence may in some ways be considered to be distinct from mental abilities, excluding that assessment from the analyses in Study 3 yields similar results: $F_{\text{between subjects}}(1, 46) = 2.62$, $p = .08$, and $F_{\text{within subjects}}(1, 48) = 12.73$, $p = .001$; inverse quadratic functions of targets' speed: $F_{\text{between subjects}}(1, 46) = 5.25$, $p = .03$, and $F_{\text{within subjects}}(1, 48) = 13.40$, $p = .001$.

ticipants should be more likely to ascribe mental states to the blob when it appears to move at a speed similar to the speed of the animated humans.

Method

Participants. Participants were 94 undergraduates (31 males and 63 females, $M_{\text{age}} = 20.9$ years, $SD = 4.7$) who received \$5 or course credit.

Stimuli. Stimuli consisted of a silent animated film of a purple blob eating three inanimate objects—a stop sign, a car, and a bicycle—while oozing down a city street (44.1 fps, 35 s in length). In each film, animated humans performed activities—walking a dog, jogging, and smoking a cigarette. In all three films, the blob maintained the same speed of movement and goal completion (e.g., eating the car). In the similar-to-human-speed film, the humans moved at the same speed as the blob did. In the fast-blob film, the humans' movement speed was 1/3 of their movement speed in the similar speed film. The humans' movement speeds in the slow-blob film was $3.3\times$ their movement speeds in the similar film. All animated humans were sped up or slowed down equally within condition.³

Procedure. Participants each watched one animated film of a blob devouring objects while oozing along a city street. In the foreground, the blob's movement and mastication speed were held constant across conditions. In the background, the animated humans' movement speed was varied between conditions, affecting the relative speed of the blob's movement. In a between-subjects design, each participant watched one of three films in which the action speed of the city's human inhabitants was faster than, the same speed as, or slower than the blob's. Afterward, participants rated whether the blob was conscious, intelligent, thought about its actions, and exhibited intention on four 7-point scales with endpoints *not at all* (1) and *very conscious/intelligent/much/intentional* (7).

Results and Discussion

Participants' ratings were standardized and averaged to create a composite mind attribution score (Cronbach's $\alpha = .80$). The speed of the humans in the background influenced participants' attribution of mind to the blob according to a quadratic pattern, between-subjects contrast, $F(1, 91) = 3.85$, $p = .05$, $h^2 = .04$, but not according to a linear pattern ($F < 1$; for means, see Figure 2). Though the blob moved at the same speed in all three films, participants who observed the blob moving at a speed similar to the speed of the animated humans were more likely to perceive the blob to have a mind than participants who observed the blob moving at speeds faster or slower than the animated humans.

The perceived speed of a target relative to humans who are present can apparently override absolute speed in contributing to timescale anthropocentrism. Furthermore, these findings render doubtful two alternative interpretations for our results. First, timescale bias is not due to the time lapse between action initiation and completion that might cue goal directedness (Haggard, 2005). The actions of the blob in this study were constant, and the bias was introduced here by variations in perceived human speed. Second, timescale bias is not a function of capacity to process information or pay attention to action, either because it takes too long to hold

interest or occurs too quickly to appreciate. The constancy of the blob as stimulus suggests that influences of timescale on the perceiver's processing of the information in the movements is not critical for the production of the timescale bias.

General Discussion

In four studies, we found that people preferentially attributed mind to targets whose movement speeds were similar to human movement speed. Attributions of mind to targets increased as the difference between targets' movement speeds and average human speed decreased, rather than according to a sheer increase in the targets' speed. This timescale bias was found for a wide range of target agents, including nonhuman animals, robots, animations, and other humans.

In Study 1, a quadratic relation was found between judgments of mind and judgments of speed for other species. Animals that moved close to human speeds were thought to be more conscious than those that were judged to be faster or slower than humans. This was found regardless of whether domestic animals were included in the analysis.

In Study 2, we found a timescale bias for the movement speed of novel nonbiological targets (i.e., robots and animations) lacking brains and nervous systems. Timescale bias was shown to apply to perceptions of other humans as well, as target persons in Study 3 were ascribed greater intelligence, competence, and mind when they moved at the same speed as other humans rather than when they moved at faster or slower speeds. Timescale bias still occurred when controlling for other perceptual elements, such as the duration of the targets' action. In Study 4, the speed of the target (an animated blob) was held constant across conditions, whereas only the speed of other targets varied. Again, the target was attributed with the most mind when it moved at a tempo consistent with the human action, suggesting that timescale bias is a function of the targets' speed relative to the apparent speed of human movement rather than solely by the targets' absolute speed of movement.

³ In a pilot study, 32 participants (10 males and 22 females, $M_{\text{age}} = 27.2$ years, $SD = 7.9$) assessed the appearance of the animated human actors in the three different films in which the human actors appeared to move faster than, slower than, or the same speed as the blob in an online video pretest. Each participant assessed how normal the movement of the animated human actors appeared on a 5-point scale marked with the endpoints *not at all normal* (0) and *extremely normal* (4). Participants next assessed the extent to which the animated human actors appeared to have a mind and how quickly the human actors appeared on 7-point scales marked with the endpoints *definitely do not appear to have a mind/extremely slowly* (1) and *definitely appear to have a mind/extremely quickly* (7). Participants also assessed the film on several filler items, such as, "How colorful was the film?" A between-subjects ANOVA with three levels of film speed (slow, medium, and fast) revealed that the movements of the animated human actors appeared equally normal and the animated humans were attributed equal degrees of mind in all three films ($F_s < 1$) but that the motion speed of the human actors did appear different in the three films, $F(2, 28) = 5.45$, $p = .01$, $h^2 = .28$. A linear contrast revealed that the motion speed of human actors appeared slowest in the slow human actors film and fastest in the fast human actors film ($M_{\text{slow}} = 2.70$, $SD = 1.16$; $M_{\text{medium}} = 3.91$, $SD = 0.83$; $M_{\text{fast}} = 4.10$, $SD = 1.1$), $F(1, 28) = 9.80$, $p = .005$.

Issues and Limitations

Considered individually, each study reported was subject to particular limitations. Those particular limitations, however, were addressed and controlled for in the other studies that are reported in the present research. In Study 1, the targets were idiosyncratically selected by the experimenters to ensure that the targets were recognizable, were familiar, and included several species known to move at very slow and fast tempos (e.g., sloth, hummingbirds)—as a random sample of all species would be likely to include rare or uncommon animals whose speed of movement was unfamiliar to participants. Unfortunately, this idiosyncratic selection method may have yielded an (unintentionally) biased sample of targets. We addressed this potential limitation in Studies 2, 3, and 4 by asking participants to evaluate the same targets after observing targets moving at one of three different movement speeds.

In Study 2, the apparent speed of novel targets was manipulated by simply slowing down or speeding up the frame rate of each film—a manipulation that could have also impacted the apparent fluidity of the targets' movement. This issue was addressed in subsequent studies by manipulating the targets' actual speed of movement (Study 3) and by holding a target's speed constant while manipulating the speed of human actors moving behind the target (Study 4). Studies 2 and 3 shared a common limitation—the targets' speed of action was confounded with the duration of films participants saw. This problem was addressed in the final study by manipulating the relative speed of the animated nonhuman target in relation to animated human agents. In other words, all participants saw the same target (i.e., a blob) move and masticate at the same speed for the same duration, but the speed of humans moving in the background varied between conditions.

Finally, significant linear trends were found in Studies 2 and 3. However, the directions of these linear trends were inconsistent, as the fastest moving targets were least likely to garner attributions of mind in Study 2, whereas the slowest moving targets were least likely to garner attributions of mind in Study 3. Interestingly, participants did not exhibit a linear pattern of mind attribution in the study with the largest number of targets (Study 1) and in between-subjects analyses (Studies 3 and 4). More important, across all studies, the greatest attributions of mind were consistently ascribed to targets moving closest to a human tempo (see Figures 1 and 2). The linear trends observed in Studies 2 and 3 could be indicative of real effects, in that there may also be an overall tendency to ascribe mind to entities moving quickly or slowly. The fact that these linear trends are contradictory between studies suggests, however, that these linear trends may be artifacts of the range of values of relative tempo tested in these experiments. A curvilinear pattern that is measured closer to the middle at one end than the other could yield the artifactual appearance of a linear trend when the extreme values are compared.

Across four studies—each involving a unique manipulation—participants preferentially endowed a variety of targets with mental states when those targets were perceived to move at speeds similar to the average speed of humans. Although each study had particular limitations, each limitation was carefully controlled for in other studies yielding similar results. Considered together, the consistent results of the four studies provide strong evidence for a timescale bias in the attribution of mind.

Why Timescale Bias?

The fact that mind attribution did not increase with the absolute speed of motion may be somewhat surprising, given that the detection of self-propelled movement itself is an important cue to agency (Rakison & Poulin-Dubois, 2001). One account of timescale bias is that actions occurring within a particular spatiotemporal relation to some goal are more likely to be perceived as intentional—and therefore are more likely to be seen as directed by a conscious agent. However this cannot fully account for findings of Study 4. Because the duration of the blob's action was held constant across conditions and only the relative timing of the action to other agents varied, effects observed in Study 4 cannot be a function of the particular spatiotemporal relations between the blob's actions and the completion of its apparent goals. These findings also counter another explanation of timescale bias—that human tempo enhances mind perception because it allows action representations to arise in the perceiver (Prinz, 1997) to facilitate the processing of information relevant to the goals or effects of the action. Again, because the speed of the blob's actions was held constant, there were no differences in the observer's ability to perceive its actions.

Why then would attributions of mind be anchored on the speed of human action? There are two possible reasons that were touched on briefly in the introduction. First, inferences of mental states have been shown to be more likely when the attribution serves some adaptive function (Maner et al., 2005). For example, perceptions of potential mates' sexual interest are proportional to the cost of sexual reproduction to the perceiver—heterosexual men more often perceive potential mates' behavior as indicative of sexual interest than heterosexual women do (Haselton & Buss, 2000). The evolutionary advantages conferred by these systematically distorted attributions support a functional account of mind perception—that one should be particularly likely to attribute mental states to targets when mind perception improves one's ability to respond to targets' behavior. Second, watching other agents perform actions at a speed that is within one's own capability allows action representations to arise in the perceiver and consequently facilitates learning through other agents' imitation (Aarts, Gollwitzer, & Hassin, 2004; Chartrand & Bargh, 1999). In the present research, participants were more likely to attribute complex mental states and intention to targets that moved at speeds similar to the speed of human movement, precisely when mental state attributions would be most useful when predicting or attempting to imitate targets' behavior.

Although timescale bias may have evolved because of the particular benefits in attributing mind to agents moving at the same speed, the tendency is likely to be reinforced by general egocentrism. Simply put, people are more likely to perceive minds in targets that are similar to the self. People credit themselves with a richer experience of mind than they credit others with, for the simple reason that they have more experience and insight into their own thoughts and feelings. When trying to infer the content of others' minds, people will often use the self as reference point (Epley, Keysar, Van Boven, & Gilovich, 2004; Nickerson, 1999). Others close to the self are also generally given more mental credit than are strangers (Kozak et al., 2006), and people tend to judge members of their own ingroup to be more intelligent and credit them with more complex emotions (Vaes, Paladino, Castelli, Ley-

ens, & Giovanazzi, 2003). This extends to a more general anthropocentric bias that colors the perception of nonhuman agents in terms of human attributes (Barrett & Keil, 1996; Eddy, Gallup, & Povinelli, 1993).

Timescale bias is a simple perceptual cue that can assist people in discerning agents from nonagents. Being a relative measure of mind, it may often lead to inaccurate, anthropomorphic, and egocentric assessments of others, with implications for important and everyday social interactions. Drivers may judge other drivers moving faster or slower than they are moving to be less competent. Discrimination against older people, a group stereotyped as both mentally deficient and physically weak, may be exacerbated by observations of their slower locomotion. And visitors to a city may believe its residents to be obtuse or thoughtless if that city's human traffic and transactions move at a pace to which visitors are unaccustomed (Bornstein & Bornstein, 1976; Levine & Norenzayan, 1999; Levine et al., 1980). It might be that courts use such timescale differences to determine the mental states and sentences of those who break the law.

Future Directions

The present research suggests that timescale bias is affected by targets' relative rather than absolute speed of movement. Targets that appeared to move at speeds similar to the average speed of human movement were more likely to garner attributions of mind than targets appearing to move at speeds faster or slower than the average speed of human movement. This was true whether the targets' speed of movement was subjectively (Study 1), objectively (Studies 2 and 3), or relatively inferred (Study 4). Indeed, even human targets walking more slowly or quickly than other humans appeared to possess inferior mental capacities (Study 3).

What is left for future research to determine is what speed perceivers consider to be the average speed of human movement. One possibility is that perceivers simply exhibit an anthropocentric bias, comparing the speed of targets with the speed of all humans' movement. This is unlikely, as the participants in Study 4 would have then been less sensitive to the local norms of human movement when attributing mental states to the blob. It is more likely that contextual cues determine what perceivers consider to be normative, comparatively fast, and comparatively slow. Accordingly, timescale bias is likely to be influenced by local norms—such as a perceiver's ingroup (e.g., older people or young people) and situation. Indeed, what is considered normal for humans is generally skewed by an egocentric perspective, as perceivers expect others to think and act like they do (Nickerson, 1999). For instance, perceivers in a rush may consider sluggish individuals obstructing their movement to be mindless, whereas tired perceivers may consider individuals attempting to speed past them to seem equally rude and idiotic. Of course, in unfamiliar and peculiar instances, normative speeds may be judged according to others' speed of movement. If a cashier is working more slowly than other cashiers, his or her competency may quickly be called into question. And if perceivers feel their speed is dissimilar to that of an average human—as in the case of a debilitating injury—perceivers' normative speeds may be considerably less egocentric (Stapel & Winkielman, 1998). More generally, attributions of mind may also be exempt from timescale bias when targets are engaged in stereotypically reflective behavior such as meditation.

However, the extent to which the timescale bias varies according to factors such as context, absolute speed, and egocentric bias remains an open question.

Another question to be systematically addressed by future research on timescale bias is discerning what kinds of movement perceivers are most sensitive to when inferring mind from speed of motion. All targets assessed in Studies 2, 3, and 4 performed relatively complex movements. Just as patterns of motion that vary are particularly likely to garner attributions of mind (Heider & Simmel, 1944; Mandler, 1992; Michotte, 1946/1963), it is possible that perceivers are most likely to infer that targets possess mental states when targets are engaged in discontinuous rather than linear movements. In other words, timescale bias may be most pronounced when perceivers observe targets whose movement speed changes while executing an action (assuming that the target remains within the range of possible speeds of human motion) and least pronounced when targets move at one constant speed while performing different motions.

Conclusion

Perceivers exhibit a timescale bias in the attribution of mental states to other agents, whereby agents who move at speeds similar to human movement speeds are preferentially endowed with mental states, compared with faster and slower agents. This bias appears to reflect the agents' speed relative to the perceived speed of human movement rather than agents' absolute speed of movement and extends not only to other species observed in the natural environment but also to humans and artificial agents. Indeed, this timescale bias may be a potent cue used to infer the degree to which movements of any target are likely to be explained in terms of the target's mental life.

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Received September 18, 2006

Revision received December 19, 2006

Accepted December 21, 2006 ■