Slow motion increases perceived intent

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Edited by Susan T. Fiske, Princeton University, Princeton, NJ, and approved May 17, 2016 (received for review March 9, 2016)

To determine the appropriate punishment for a harmful action, people must often make inferences about the transgressor's intent. In courtrooms and popular media, such inferences increasingly rely on video evidence, which is often played in "slow motion." Four experiments (n = 1,610) involving real surveillance footage from a murder or broadcast replays of violent contact in professional football demonstrate that viewing an action in slow motion, compared with regular speed, can cause viewers to perceive an action as more intentional. This slow motion intentionality bias occurred, in part, because slow motion video caused participants to feel like the actor had more time to act, even when they knew how much clock time had actually elapsed. Four additional experiments (n = 2,737) reveal that allowing viewers to see both regular speed and slow motion replay mitigates the bias, but does not eliminate it. We conclude that an empirical understanding of the effect of slow motion on mental state attribution should inform the life-or-death decisions that are currently based on tacit assumptions about the objectivity of human perception.

intent | time | slow motion | egocentrism | law

When harm has been observed, judgment generally follows. Even when someone has indisputably committed a guilty act, judgments of responsibility depend, in large part, on inferences about whether the actor did so with an intending mind. In everyday social judgments, perceptions of intent may mean the difference between concluding that an act was aggressive or calculated rather than clumsy or impulsive. In legal proceedings, it may mean the difference between lethal injection and a lesser sentence. A central concern of the courts, as well as of public opinion, is to adjudicate this mental state inference, and both are increasingly relying on video replay to do so.

With the continued spread of surveillance cameras in major cities and small towns, the growing adoption of "on-officer" recording systems by police forces around the world, and the billions of bystanders carrying fully operational cameras in their pockets, it is increasingly likely that any given behavior will be recorded on video. When that behavior causes harm, video replays may surface in the public via social media or be introduced in courtrooms as evidence. Because video affords repeated viewings, it can augment the limits of human attention, visual processing, and memory. Because video can be slowed down, it also provides the ostensible benefit of giving people "a better look" at real-time events that happened quickly or in a chaotic environment. Although slow motion replay may be intuitively appealing for this reason, we demonstrate that slow motion replay, compared with regular speed replay, produces systematic differences in judgments of intent.

The life-or-death consequences of these differences are exemplified in a case that appeared before the Supreme Court of Pennsylvania, stemming from a 2009 murder trial in which prosecutors presented slow motion surveillance video of John Lewis fatally shooting a Philadelphia police officer during an armed robbery. The prosecution's case convinced jurors that the shooting was premeditated, warranting a charge of first-degree murder and possible death by lethal injection, rather than reflexive, warranting a charge of second-degree murder and life in prison. On appeal, the defense argued that the slowed tape artificially stretched the relevant time period, creating a "false impression of premeditation." The prosecution responded that the jury saw both regular speed and slow motion video, and could not be biased because jurors were fully informed (by a superimposed digital display) that Lewis shot the officer approximately 2 s after seeing him at the door (1). (The Supreme Court of Pennsylvania affirmed the trial court's decision that slow motion was more probative than prejudicial, and denied Lewis's initial appeal. His June 18, 2014 execution date was stayed to allow for the exhaustion of appeals. At the time of this writing, Lewis is on death row.)

Weighing the admissibility of the slow motion video, one justice asked, "What can you see in this case only in the slower version that you couldn't see in the fast version?" (2). We suggest that what you can see only in the slower version is more time, or, more specifically, an actor who seems to have had more time to form and act on an intention. Two features of human judgment suggest that impressions of the duration over which real-time events unfolded are likely to be affected by the speed of video replay. First, duration estimations vary across people, situations, level of distraction, and estimation procedures (3), indicating that the mind's timing mechanisms are susceptible to the influence of incidental factors. Second, even when people are aware that an incidental factor (e.g., slow motion) has the potential to influence their judgment, they often do not correct sufficiently (4–7). We therefore predicted that slowing a video would cause people to perceive that the events in question unfolded over more time, making people more likely to infer that the actor had formulated and carried out an intentional action. To test this prediction, we used an experimental paradigm in which we showed viewers the same

Significance

When determining responsibility for harmful actions, people often consider whether the actor behaved intentionally. The spread of surveillance cameras, "on-officer" recording devices, and smart-phone video makes it increasingly likely that such judgments are aided by video replay. Yet, little is known about how different qualities of the video, such as replay speed, affect human judgment. We demonstrate that slow motion replay can systematically increase judgments of intent because it gives viewers the false impression that the actor had more time to premeditate before acting. In legal proceedings, these judgments of intent can mean the difference between life and death. Thus, any benefits of video replay should be weighed against its potentially biasing effects.

Author contributions: E.M.C., Z.C.B., and B.A.C. designed research, performed research, analyzed data, and wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

Freely available online through the PNAS open access option.

Data deposition: The data files and referenced video clips are available at the Open Science Framework repository, https://osf.io/uzs3a/.

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This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1603865113/-/DCSupplemental.

events at regular speed or in slow motion, and asked them to indicate how much time they felt the actor had to execute his actions and whether (or to what degree) they thought the action was intentional. We focus on the formulation of intentional action that is most relevant to the legal setting, namely, whether a given action was "willful, deliberate, and premeditated" (1).

Study 1

Study 1 modeled the legal context for judgments of intent. Participants imagined themselves as jurors in a criminal trial and saw real surveillance video (with an accurate digital display of elapsed time) depicting 5 s of an attempted robbery that ended with the assailant shooting a store clerk. Participants were randomly assigned to watch the clip at "regular speed" or "slow motion" (2.25 times slower than regular speed). [This rate is similar to the rate at which the video in the John Lewis trial was slowed (footnote 3 in ref. 1).] Participants then indicated whether the person with the gun shot "with the intention to kill the victim"; the extent to which the action was performed with willful, deliberate, and premeditated intent to kill; and how much time it felt like the shooter had to assess the situation before he fired (*SI Materials and Methods*).

As predicted, participants who saw the slow motion (vs. regular speed) video felt that the action was performed with more of a willful, deliberate, and premeditated intent to kill [$t(469.91) = 2.85$, $P = 0.005$, $d = 0.26$] and were more likely to conclude that the person with the gun shot with the intention to kill [$\chi^2(1, n = 489) = 6.60$, $P = 0.010$, $\varphi = 0.12$; Table 1]. The statistically significant increase in "yes" votes to the intentional killing question is also of practical significance. In bootstrapped simulations of 1,000 12-person juries (sampled from each condition of our data), 39 juries composed of participants who saw the video at regular speed would be unanimous in saying that the defendant shot with the intention to kill, compared with 150 juries composed of participants who saw the video in slow motion (odds ratio = 4.35). This simulation does not account for jury deliberation; however, *ceteris paribus*, slow motion video quadrupled the odds that jurors would begin the deliberation phase ready to convict. Slow motion viewers also felt the shooter had more time than did regular speed viewers [$t(480.67) = 5.54$, $P < 0.001$, $d = 0.50$], an increase that statistically accounts for the relationship between video speed and judgments of intent (indirect effect 95% confidence interval [CI; 0.16, 0.46]; *SI Materials and Methods*).

Study 2

Study 2 used a sports video to test whether this slow motion intentionality bias generalizes beyond rare and horrific criminal actions to more mundane transgressions. Participants watched a National Football League (NFL) player execute a prohibited "helmet-to-helmet" tackle. Although the tackle itself was clearly intentional, it was unclear whether the player intended to strike the opposing player's helmet with his own. Because legal definitions of intent (focusing on premeditation) are not necessarily the same as lay definitions [which typically incorporate components of desire, belief, intention, and awareness into assessments of intentionality (8)], we included face-valid measures of each to determine which aspects of intentionality are affected by video speed. In addition, study 2 aims to provide further insight into our proposed subjective-time mechanism. An artifact of comparing slow motion video with regular speed video is that slow motion viewers are exposed to the stimuli for more time. It is therefore possible that the slow motion bias results from the greater amount of time that perceivers have to make inferences about the actor's intent. To examine this alternative, study 2 included a "paused" condition that played the video at regular speed but with a still-frame pause inserted to equate its duration to the duration of the slow motion video.

Three key findings emerged from study 2. First, judgments of the various intentionality-related constructs were highly correlated (all dyadic $r \geq 0.57$, $P < 0.001$; Table S1) and produced similar effects when examined independently (Table S2), suggesting that observers do not finely differentiate these constructs when judging the intent behind a harmful action. We therefore collapsed these measures into an overall composite ($\alpha = 0.95$). Second, this composite replicated the findings from study 1: Participants felt that the action was more intentional if they saw it in slow motion than if they saw it at regular speed [$t(389.54) = 2.87$, $P = 0.004$, $d = 0.29$; Table 1], and this effect was mediated by perceptions that the actor had more time to assess the situation ($t(383.88) = 2.66$, $P = 0.008$, $d = 0.27$, indirect effect 95% CI [1.23, 7.73]). Third, increasing the duration of the video by pausing it did not have the same effect on intentionality judgments as did increasing the duration of the video by slowing it down: Participants felt that the action was marginally more intentional if they saw it in slow motion than if they saw it with an inserted pause [$t(378.10) = 1.93$, $P = 0.054$, $d = 0.20$].

Table 1. Means (SDs) in studies 1–4

Study	Condition	Clock time	Perceived time	Intent (continuous)	Intent (dichotomous)
Study 1 ($n = 489$)	Regular speed		55.11 (29.38)	73.81 (27.47)	77.3% (0.42)
	Slow motion		69.18 (26.73)	80.36 (23.13)	86.2% (0.35)
Study 2 ($n = 580$)	Regular speed		21.85 (21.19)	39.32 (25.49)	
	Paused		26.51 (23.41)	41.54 (27.54)	
	Slow motion		28.05 (25.04)	47.08 (28.38)	
Study 3 ($n = 410$)	Time nonsalient				
	Regular speed	3.70 (1.73)	52.25 (29.23)	72.94 (28.37)	76.0% (0.43)
	Slow motion	5.25 (2.22)	67.77 (28.51)	83.99 (22.43)	82.0% (0.39)
	Time salient				
	Regular speed	3.11 (1.04)	54.83 (29.81)	77.97 (25.82)	72.2% (0.45)
	Slow motion	3.36 (0.93)	62.15 (26.54)	83.37 (23.70)	83.0% (0.38)
Study 4 ($n = 905$)	Regular speed		56.01 (27.98)	72.57 (28.92)	70.7% (0.46)
	Both speeds		63.92 (27.46)	76.17 (26.51)	71.9% (0.45)
	Slow motion		67.97 (24.52)	77.51 (24.26)	76.5% (0.43)

Clock time is estimated number of seconds. Perceived time and Intent (continuous) are on 0–100 scales. Intent (dichotomous) is the percentage indicating that the action was intentional as opposed to unintentional (study 1) or the percentage indicating a verdict of first-degree murder as opposed to second-degree murder (studies 3 and 4).

Study 3

Study 3 further investigated the underlying mechanism of this effect by testing whether perceived time, and its subsequent effect on judgments of intent, could be debiased by highlighting the actual amount of clock time that the actor had. An objectivist account of the bias we have demonstrated presumes that viewers have some objective cognitive knowledge about what can occur in a given window of clock time and that any threat of a slow motion bias would be eliminated by ensuring accurate clock-time estimates. This account appears to be the one that the court had in mind after hearing the Lewis appeal when it ruled that slow motion could not have biased the jury because "the time that transpired was displayed on the tape and was repeatedly pointed out to the jury" (1). In contrast, our proposed subjectivist account recognizes that the same amount of clock time can feel shorter or longer under different conditions (3) and predicts that viewers will be more likely to infer intent when they feel like an actor had more time rather than less time, even when they are fully aware of (and can accurately estimate) the objective amount of time that the actor had. We therefore directly measured estimates of objective clock time in addition to subjective perceptions of time.

To test between the objectivist and subjectivist accounts, study 3 added a time salience manipulation to the study 1 procedure. In the "time nonsalient" conditions that replicate study 1, the clock time (via a digital time stamp on the video) was present but not highlighted. In the new "time salient" conditions, participants were repeatedly reminded that they could "see from the digital time stamp" that "approximately three seconds elapsed." We predicted that the difference in the amount of time it felt like the actor had, and hence the slow motion intentionality bias, would persist even when the actual amount of time was highlighted. To increase ecological validity further, we changed the dichotomous measure (from study 1) to ask outright whether participants would convict the actor of first- or second-degree murder if they were jurors in this trial.

Results revealed an interaction between video speed and time salience on clock-time estimates [$F(1, 406) = 16.79$, $P < 0.001$, $\eta_p^2 = 0.040$]. When clock time was available but not made salient, participants in the slow motion (vs. regular speed) condition estimated that more clock time had elapsed [$F(1, 406) = 48.89$, $P < 0.001$, $\eta_p^2 = 0.107$]. In contrast, when clock time was made salient, clock-time estimates in the two conditions did not differ significantly [$F(1, 406) = 1.28$, $P = 0.258$, $\eta_p^2 = 0.003$; Table 1]. Although making clock time salient successfully decreased the bias in estimates of clock time, it did not significantly affect the difference in estimates of the time it felt like the shooter had. Consistent with the subjectivist account, participants in the slow motion (vs. regular speed) conditions felt like the shooter had more time to assess the situation before he fired [$F(1, 406) = 16.11$, $P < 0.001$, $\eta_p^2 = 0.038$]; the interaction with time salience was not significant [interaction $F(1, 406) = 2.08$, $P = 0.150$, $\eta_p^2 = 0.005$].

Critically, subjective perceptions of time, not estimated clock time, drove judgments of intent. Participants in the slow motion (vs. regular speed) conditions felt that the action was performed with more of a willful, deliberate, and premeditated intent to kill [$F(1, 405) = 10.80$, $P = 0.001$, $\eta_p^2 = 0.026$], and more slow motion viewers than regular speed viewers returned a verdict of first-degree murder [$F(1, 406) = 4.14$, $P = 0.043$, $\eta_p^2 = 0.010$]. The interaction with time salience was not significant for the continuous measure of intent [interaction $F(1, 405) = 1.28$, $P = 0.259$, $\eta_p^2 = 0.003$] or the dichotomous measure of intent [interaction $F(1, 406) = 0.35$, $P = 0.556$, $\eta_p^2 = 0.001$]. Subjective perceptions of time mediated the effect of slow motion on first-degree murder verdicts, even when controlling for clock-time estimates (indirect effect 95% CI [0.04, 0.54]).

Study 4

Studies 1 and 3 were designed to reflect judgments routinely made by real jurors, but a notable divergence is that jurors may see multiple versions of a video at different playback speeds, whereas our participants saw one speed exclusively. In fact, in evaluating the potentially prejudicial impact of slow motion in the Lewis case, the justices cited the presentation of both video speeds as a mitigating influence (1). To approximate further the actual evidence a jury is likely to see during trial, and, by extension, to examine another potential bias-reduction strategy, study 4 added a "both speeds" condition in which participants first saw the regular speed version, followed by the slow speed version. We predicted that responses from those individuals who saw both video speeds would fall between the (relatively lower) responses of those individuals who saw only the regular speed and the (relatively higher) responses of those individuals who saw only the slow speed.

To test this prediction, we ran linear and quadratic contrasts. The linear trend was significant for the perceived time measure [$t(584.24) = 5.56$, $P < 0.001$] and the willful, deliberate, and premeditated intent to kill measure [$t(574.51) = 2.26$, $P = 0.024$]; it was not significant for the first- vs. second-degree murder measure [$t(592.49) = 1.61$, $P = 0.109$; Table 1]. None of the quadratic contrasts was significant, which supports the evidence for a linear trend (*SI Materials and Methods*). Although these patterns are generally in line with our prediction, Table 1 reveals some variation in the effect across measures, whereby viewing both speeds is closer to the slow speed condition on the continuous measure of intent, closer to the regular speed condition on the binary measure of intent, and between the two on the measure of perceived time (results of all pairwise comparisons are provided in *SI Materials and Methods*).

To clarify the mixed evidence from study 4, we ran three additional studies to isolate the comparison for the practical question of interest, namely, whether seeing the video at both speeds results in more perceived intent than seeing the video only at regular speed. The first experiment was an exact replication of study 4 (omitting the slow motion condition), and the other two experiments were variants on study 1 (replacing the slow motion condition with the both speeds condition). In a meta-analysis that included results from study 4 and these three follow-ups, the both speeds condition led to significantly higher judgments than the regular speed condition on the measure of perceived time (mean effect size = 0.270, SE = 0.041, $Z = 6.62$, $P < 0.001$) and the continuous measure of intent (mean effect size = 0.090, SE = 0.041, $Z = 2.21$, $P = 0.027$) and to marginally higher judgments on the dichotomous measure of intent (mean effect size = 0.165, SE = 0.099, $Z = 1.66$, $P = 0.096$). Perceived time consistently mediated the effect of viewing condition on both judgments of intent (*SI Materials and Methods*).

Empirical Summary

To gauge the practical magnitude of the effect of viewing condition on the dichotomous measure of intent, and the potential bias-reducing impact of seeing both regular and slow versions, we performed separate meta-analyses on (*i*) regular speed vs. slow motion conditions and (*ii*) regular speed vs. both speeds (i.e., regular and then slow) conditions. A bootstrap analysis (based on the meta-analytic effect size) revealed that, compared with simulated juries who saw only the regular speed video, the odds of a unanimous first-degree murder verdict were 3.42-fold higher among juries who saw only the slow version, and 1.55-fold higher among juries who saw both versions. These results demonstrate that giving viewers the opportunity to view both speeds reduces the intentionality bias, but does not eliminate it.

Discussion

With more moments of our lives being caught on video comes the increasing likelihood that retrospective judgments of those moments, in courts of public opinion and courts of law, will be influenced by video replays. In courts of law, whether an accused party had "time enough so that the defendant can and does fully form an intent to kill and is conscious of that intention" (9) is a question of fact that juries are responsible for determining. In the cases that we studied, perceived time was indeed at the crux of participants' inferences about this fact. For example, once the store clerk appeared, did the shooter have time for forethought or did he fire reflexively? Although timing will be irrelevant or uncontroversial in some behavioral sequences submitted for the court's inspection, the question of whether an actor had a "long enough" window to assess and prepare to inflict the harm is likely to be central in many disputes.

The present investigation cannot determine whether slow motion replay makes viewers more or less accurate in judging premeditation in these situations, but it does demonstrate that slow motion can systematically increase perceptions of premeditation itself. Considering that viewers' inferences about intentions were sensitive to the amount of time they felt the actor had, we suspect that slow motion is one of many ways in which the temporal dynamics of an event could be modulated. From a lawyer's narrative pacing to the selection, arrangement, and timing of still photographs presented to a jury, many processes in a trial could potentially affect perceptions of how much time elapsed and, consequently, could affect the perceived intent of an actor. If jurors perceive video as a particularly "objective" representation of true events, its biasing potential may be especially pernicious.

In the case of video, our results do offer some initial insight into how to mitigate the bias that results from the artificial distortion of temporal dynamics. Contrary to the intuition of the justices in the Lewis appeal, reminding viewers of the actual elapsed time was not sufficient (in our studies) to prevent them from feeling that the actor had more time to act, and hence inferring that his action was more intentional and more deserving of a first-degree murder conviction (study 3). However, consistent with the intuition of the justices, showing the action at both regular speed and in slow motion was somewhat, albeit not completely, effective in reducing the impact of slow motion on first-degree murder convictions (study 4).

In its decision on the Lewis appeal, the court acknowledged that, "In a sense, all slow motion and freeze frame video distorts reality," and that "such distortion may enhance the jury's understanding or it may do the opposite" (1, citing ref. 10). Therefore, in determining whether, and under what conditions, slow motion evidence should be admissible in court, its potential benefits must be weighed against its potential costs. Although we agree that slow motion may enhance the jury's understanding of the actions in question, including the *actus reus* and any mitigating or aggravating contextual events, our results underscore that under some conditions it may "do the opposite" for the jury's understanding of actors' mental states (*mens rea*). The relative impact of this tradeoff under various potentially moderating conditions, including the number, order, and exact speed of replays, remains open for investigation, but even the possibility of such a tradeoff demands empirical attention. For instance, at a certain point of "superslow motion," actors may appear to be moving at nonhumanly slow speeds and seem less likely to possess any mental states, including intentions (11). It seems imperative that an empirical understanding of the factors that contribute to assessments of intent inform the life-or-death decisions that are currently based, in part, on the intuitions of lawmakers and their tacit assumptions about the objectivity of human perception.

Materials and Methods

Ethics Statement. All studies were approved by the Institutional Review Board at The University of Chicago or Northwestern University. All participants read and provided informed consent before completing the studies.

Open Science Statement. The original study materials that participants saw, and the raw data from all studies, are available at the Open Science Framework repository (https://osf.io/uzs3a/). We determined all sample sizes in advance and, for each study, did not run any analyses until after the entire sample was collected.

Recruitment, Participants, and Exclusions. We recruited participants from all experiments using Amazon Mechanical Turk (limited to the United States) and paid either \$0.50 (studies 1 and 2) or \$0.60 (studies 3 and 4) in exchange for their participation. Across the four main studies, 2,384 participants met our criteria for inclusion [study 1: $n = 489$, mean age (M_{age}) = 31.9 y (9.5), 323 male, 166 female; study 2: $n = 580$, $M_{age} = 33.0$ y (10.0), 336 male, 244 female; study 3: $n = 410$, $M_{age} = 34.6$ y (11.6), 231 male, 179 female; study 4: $n = 905$, $M_{age} = 35.8$ y (11.6), 461 male, 444 female]. We set screening criteria to disallow access to anyone who had completed any previous study in this line of work or whose browser was incapable of playing the video (full details are provided in *SI Materials and Methods*).

After consenting to the study, participants were warned of the potentially graphic nature of the video they would watch (in studies 1, 3, 4, and the follow-up experiments) and reminded that they could terminate the study at any time by closing their browser. After completing the dependent measures, participants indicated their age, ethnicity, and sex. Finally, we included attention filters that allowed for self-exclusion, asked if participants experienced any technical difficulties, and (in studies 3 and 4) asked if they were eligible to serve on a jury in the United States. Across these four studies, 271 (10.2%) unique participants who completed the survey were excluded for having seen the video in the study before, failing the attention filters, reporting technical difficulties, or not being jury-eligible (*SI Materials and Methods*). Of those participants who were not excluded, one participant in study 2 failed to answer all measures of intentionality, and one participant in study 3 and in study 4 failed to answer the willful, deliberate, and premeditated measure; these participants were not included in the analysis of the measures they failed to complete, which accounts for the different degrees of freedom reported in the results.

Statistical Results. Levene's test indicated unequal variances on (*i*) the perceived time and continuous intent measures in study 1, so degrees of freedom were adjusted down from 487; (*ii*) the perceived time measure and intentionality composite in study 2, so degrees of freedom were adjusted down from 395; and (*iii*) all three dependent measures in study 4, so degrees of freedom were adjusted down from 902.

Study 1.

Procedure. Participants watched surveillance footage from an incident outside a convenience store. They read that, after seeing the clip once to get a feel for it, they would see it again and answer a few questions about the events that unfolded and the shooter's intent.

We presented the slow motion version of the video at a speed 2.25 times slower than the regular speed version of the video. This rate is similar to the rate at which the video in the John Lewis trial was slowed. As noted in the court's denial of appeal, the defense counsel estimated that the crucial 2 s of the tape (i.e., from the time the defendant recognized the officer at the door to the time he fired) took about 4 to 6 s in the slow motion videotape (footnote 3 in ref. 1) (Movies S1 and S2). (Warning: The video contains graphic imagery that some viewers may find disturbing.)

After their first viewing, participants read instructions that directed their attention to specific parts of the scene and received factual information about the outcome of the incident (that the victim died as a result of the gunshot). This information was included to mimic closely the judgment context of a criminal trial, in which jurors would have known that the victim died.

Participants then watched the video two more times at the speed determined by their condition, and then responded to the following questions (each on a separate page; response options appear in parentheses):

i) Did the person with the gun shoot with the intention to kill the victim? (Yes or No)

ii) In determining whether the person is guilty of homicide, it is important to determine if an action was performed with the willful, deliberate, and premeditated intent to kill. To what extent would you say the

PSYCHOLOGICAL AND COGNITIVE SCIENCES

person's actions during this incident satisfy those three criteria? (Responses were given on a slider scale with end points labeled "Not at all" to "Completely," and were coded on a 0–100 scale.)

iii) How much time did it feel like the person with the gun had to assess the situation before he fired? (Responses were given on a slider scale with end points labeled "Almost no time at all" to "Quite a lot of time," and were coded on a 0–100 scale.)

Jury bootstrap analysis. We generated separate randomly selected "juries" from each of the two experimental conditions. For each jury, 12 participants from the condition were selected at random, without replacement. This process was repeated 1,000 times, replacing all participants between each jury selection. We then used these 12 participants' responses to determine how the jury would have voted.

This method is nearly equivalent in the limit (as the number of juries approaches infinity) to using the probability mass function for a binomial distribution. Using this method, the probability of a "yes" vote is 0.773 in the regular speed condition, meaning that in 1,000 juries, ≈46 juries will have 12 of 12 members vote "yes." The probability of a "yes" vote is 0.862 in the slow motion condition, meaning that in 1,000 juries, ≈168 juries will have 12 of 12 members vote "yes."

The differences between the bootstrap analysis and the calculation are due to a combination of random sampling and sampling the juries without replacement. The binomial distribution considers each draw to be independent (and has a fixed probability), whereas when sampling the juries from the data, the selection of a jury member who will vote "yes" decreases the probability that a subsequently selected juror will also vote "yes."

Study 2.

Pilot. We conducted a pilot test using this paradigm with just regular speed and slow motion conditions. Results were comparable to the main study. A full description of the method is provided in *SI Materials and Methods*, and a summary of results is provided in Table S3.

Procedure. Participants viewed a video of a helmet-to-helmet collision from an NFL game. The clip featured NFL linebacker, James Harrison, tackling a player from the opposing team in such a way that their helmets were the first points of contact. Whereas it is clear that the action of tackling is intentional, it is unclear whether Harrison intended to strike the other player's helmet with his own, which was the focus of our questioning. Helmet-to-helmet contact has been a topic of concern in the NFL. This concern has led to rule changes that restrict such contact, made such tackles subject to review by league officials following the game, and imposed monetary fines on players who are judged to have engaged in intentional helmet-to-helmet contact.

We used the video clip from the original live broadcast footage of the game, but we did not include sound or any graphics from the broadcast superimposed on the screen. The clip was edited in a way to direct participants' attention to the focal action: The periphery of the screen was subtly dimmed partway through the clip, giving the impression of a brighter circle around the focal action. We presented the slow motion version of the video at a speed two times slower than the regular speed version of the video, a rate that is roughly equivalent to typical slow motion replays in football broadcasts. For the paused version, we inserted a pause approximately halfway between the beginning of the video and the time when Harrison's helmet hit the other player's. The paused image remained on the screen for 3 s, such that the total length of the paused clip was equivalent to the total length of the slow motion clip.

Participants watched the video once, "just to get a feel for it," and then were instructed to focus particularly on the helmet-to-helmet contact. After two additional viewings, participants responded to the following five questions, presented in randomized order:

i) To what extent was the player trying to hit the other player in the helmet?

ii) To what extent did the player plan to hit the other player in the helmet?

iii) To what extent did the player have the ability to avoid hitting the other player in the helmet?

iv) To what extent was this action intentional?

v) To what extent was the player's action willful, deliberate, and premeditated?

All responses were made on separate slider scales labeled "Not at all" to "Very much," and were coded on a 0–100 scale. The five measures of intentionality were highly correlated (Cronbach's $\alpha = 0.95$). The complete correlation matrix is provided in Table S1.

Following the intentionality questions, participants answered the following question: How much time did it feel like the player had to assess the situation before making contact with the other player? (Responses were given on a slider scale with end points labeled "Almost no time at all" to "Quite a lot of time," and were coded on a 0–100 scale.)

Study 3. Participants were randomly assigned to one of four conditions in a 2 (video speed: regular vs. slow motion) × 2 (time salient: yes vs. no) between-participants design. All imagined they were members of a jury in a case where the defendant shot and killed a store clerk during an armed robbery. They were told that the prosecution and defense both agreed that the defendant killed the victim while committing a felony (in this case, a robbery) and acting with malice, but disagreed on whether the killing constituted first-degree murder or second-degree murder. They were provided with legal definitions of how to make that distinction (full details are provided in *SI Materials and Methods*), and then watched the video used in study 1 at the speed determined by their experimental condition.

After their first viewing, participants read instructions that reiterated their charge as jurors. In addition to the instructions given to all participants, those participants in the time salient conditions read the following: "As you will see from the digital time stamp displayed on the video, approximately three seconds elapsed from the time that the defendant let go of the store clerk's arm until the time he fired. The sequence of the defendant's actions in that time is relevant to the issue of whether the defendant possessed the intent to kill." After their second viewing, participants were reminded of their task, with time salience participants receiving an additional instruction to keep in mind that the crucial portion of the defendant's actions encompassed approximately 3 s.

After their third viewing, all participants responded to the following question: After letting go of the store clerk's arm, how many seconds did the person with the gun actually have (in real time) to assess the situation before he fired? (Responses were given on a slider scale labeled "Time in Seconds," ranging from 0.0 to 10.0, and were measured to one decimal place.)

Participants then answered (on separate pages) the amount of time it felt like the person had to assess the situation before he fired and the extent to which his actions were performed with the willful, deliberate, and premeditated intent to kill (from study 1).

The final measure directly assessed the relevant legal question of whether the action should be considered first-degree or second-degree murder. The question was modeled after Commonwealth of Pennsylvania jury instructions given in the Lewis case and ended with the following: "... In other words, first-degree murder is an intentional killing that is a willful, deliberate, and premeditated act. What is your verdict?" The responses available to participants were "first-degree murder" and "second-degree murder."

Participants completed demographic questions similar to those questions in previous studies, and then indicated whether they were currently eligible to serve on a jury in the United States.

Study 4. The methods used were nearly identical to study 3, but time salience was not manipulated (all participants were in the standard, time nonsalient condition). We added a both speeds condition to compare with the regular speed and slow motion conditions. Because participants in the regular speed and slow motion conditions of studies 1 and 3 each saw the video three times, we had participants in the both speeds condition first watch the regular speed version and then watch the slow motion version twice (to equate the total number of viewings across the conditions). Participants then completed the same dependent measures as in study 3, with the exception of the clock-time measure. In between these measures and the demographic questions, we assessed whether participants were clear on the facts of the case by having them read five separate statements and indicate whether the defense and prosecution agreed or disagreed on each issue based on the information they read in the case.

Follow-Up Studies.

Procedure. We ran two replication studies that were similar to study 1 (with additional instructions to participants in the both speeds condition to avoid any confusion about seeing the video at different speeds) and one replication study that was identical to study 4 (omitting the slow motion-only condition). A full description of the method is provided in *SI Materials and Methods*, and a summary of results is provided in Table S4.

Meta-analyses. We analyzed the dependent measures from study 4 and the three follow-up studies together using meta-analytic techniques (12). A full description of the method is provided in *SI Materials and Methods*, and a detailed summary of results is provided in Tables S5 and S6.

Mediation analyses. We used the PROCESS procedure (13) to test mediation models with video condition as the independent variable, the continuous or dichotomous measure of intent as the dependent variable, and perceived

time as the mediator. Across the four studies, we find robust evidence of mediation via perceived time on the continuous measure (mean effect size = 2.59, SE = 0.509, $Z = 5.08$, $P < 0.0001$) and on the dichotomous measure (mean effect size = 0.241, SE = 0.041, $Z = 5.85$, $P < 0.0001$). A full description of the method is provided in *SI Materials and Methods*, and a detailed summary of results is provided in Tables S7–S9.

Additional Analyses. We used a variation on the jury bootstrapping simulation described in study 1 to illustrate the practical impact of slow motion video on judgments of intent across all of our studies (except study 2). A full description of the method and results is provided in *SI Materials and Methods*, and a detailed summary of results is provided in Tables S5, S6, S10, and S11.

ACKNOWLEDGMENTS. We thank Jessica Bregant, Nicholas Epley, Reid Hastie, Emir Kamenica, Jonathan Masur, Joseph Noel, Joshua Plotkin, Adam Waytz, and Timothy Wilson for providing insightful feedback on this work; Morgan Britt, Michael Kardas, and David Levari for their assistance; and the Office of the Court Reporter (First Judicial District of Pennsylvania) for providing excerpts of the transcripts from the Lewis trial.

1. LEAGLE (2013) Com v. Jordan, 65 A.3d 318 (2013). Denial of appeal. Available at www.leagle.com/decision/In%20PACO%2020130424856/COM.%20v.%20JORDAN. Accessed July 8, 2016.
2. Passarella G (2011) Pa. Justices Mull Showing Jury Slow-Motion Video of Murder. *The Legal Intelligencer.* Available at www.thelegalintelligencer.com/id=1202514497888&slreturn=1. Accessed July 8, 2016.
3. Block RA, Hancock PA, Zakay D (2010) How cognitive load affects duration judgments: A meta-analytic review. *Acta Psychol (Amst)* 134(3):330–343.
4. Tversky A, Kahneman D (1974) Judgment under uncertainty: Heuristics and biases. *Science* 185(4157):1124–1131.
5. Van Boven L, Loewenstein G (2003) Social projection of transient drive states. *Pers Soc Psychol Bull* 29(9):1159–1168.
6. Gilbert DT (1989) Thinking lightly about others: Automatic components of the social inference process. *Unintended Thought*, eds Uleman JS, Bargh JH (Guilford Press, New York), pp 189–211.
7. Epley N, Keysar B, Van Boven L, Gilovich T (2004) Perspective taking as egocentric anchoring and adjustment. *J Pers Soc Psychol* 87(3):327–339.
8. Malle BF, Knobe J (1997) The folk concept of intentionality. *J Exp Soc Psychol* 33(2): 101–121.
9. Pennsylvania Bar Institute (2005) *Pennsylvania Suggested Standard Criminal Jury Instructions* (Pennsylvania Bar Institute, Mechanicsburg, PA), 2nd Ed, Vol. I-II, PBI No. 3470.
10. LEAGLE (1993) Com. v. Hindi, 631 A.2d 1341. Available at www.leagle.com/decision/1993598429PaSuper169_1585/COM.%20v.%20HINDI. Accessed July 8, 2016.
11. Morewedge CK, Preston J, Wegner DM (2007) Timescale bias in the attribution of mind. *J Pers Soc Psychol* 93(1):1–11.
12. Lipsey MW, Wilson DB (2001) *Practical Meta-Analysis* (Sage Publications, Thousand Oaks, CA), Vol 49.
13. Hayes AF (2013) *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach* (Guilford, New York).
14. Ames DL, Fiske ST (2015) Perceived intent motivates people to magnify observed harms. *Proc Natl Acad Sci USA* 112(12):3599–3605.
15. Gray K, Wegner DM (2008) The sting of intentional pain. *Psychol Sci* 19(12): 1260–1262.