An object-centered aftereffect of a latent material property: A squishiness visual aftereffect, not causality adaptation

Derek H. Arnold School of Psychology, The University of Queensland, Australia

Kirstie Petrie School of Psychology, The University of Queensland, Australia

Regan Gallagher School of Psychology, The University of Queensland, Australia

Kielan Yarrow Department of Psychology, City University London, UK

Visual aftereffects are characterized by a changed perceptual experience after exposure to a visual input. For instance, exposure to rightward motion can make a static input seem to drift leftward—the motion aftereffect. Such aftereffects have been integral to building our understanding of the neural mechanisms and computational processes that underlie perception. Increasingly complex characteristics have been found to be susceptible to visual aftereffects, such as the appearance of human faces, the apparent number of visual elements, and the glossiness of a surface. Here we report that the apparent elasticity, or squishiness, of an object is also subject to a visual aftereffect. This relationship can explain data previously interpreted in terms of a causality aftereffect.

Introduction

Visual aftereffects are characterized by people reporting systematic changes in perception after exposure to a particular input. After viewing a persistent direction of motion, for instance, a static stimulus can seem to move in the opposite direction—the motion aftereffect (see Nishida, 2011 for a review). Much of our knowledge concerning the neural mechanisms and computations underlying perception has been gained from studying this type of phenomenon.

The list of properties known to be susceptible to a visual aftereffect has been growing. For instance, we now know that an androgynous looking human face can seem more masculine after viewing a feminine face (or more feminine after viewing a masculine face, see Storrs & Arnold, 2012; Webster, Kaping, Mizokami, & Duhamel, 2004; Zhao, Seriès, Hancock, & Bednar, 2011). Similarly, the number of displayed objects can seem less numerous after looking at a display containing a greater number (Burr & Ross, 2008; Durgin, 1995). Here we report that object elasticity, or squishiness, is also subject to a visual aftereffect.

In Experiment 1, participants were asked to judge whether simulated bounces of a disc against a static wedge were "hard" (like a pool ball bouncing on concrete) or "soft" (like a squash ball bouncing). Judgments were made before and after adaptation, which simulated repeated collisions of either rigid or elastic objects. Adaptation suggesting repeated "rigid" collisions resulted in more "soft" bounces being reported, whereas adaptation suggesting repeated elastic object collisions resulted in more "hard" bounce reports—an object elasticity aftereffect. In Experiment 2 we explore the likely coordinate mapping of this type of effect, finding that it is linked to objects, as opposed to a position in external space or on the retinal surfaces.

Experiment 1: Soft / Hard Bounces

Methods

In describing our stimuli, it is necessary to switch repeatedly between similar sounding terms with different meanings. When referring to retinal image size, we

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will use the abbreviation "dva" to refer to degrees of visual angle subtended at the retina. When referring to angular degrees to describe revolution speed, we will use the abbreviation "degs." When we refer to polar coordinates to describe the placement of stimuli relative to fixation, we will use the ° symbol, with 0° designating a position to the right of fixation, and 90° up from fixation.

Apparatus

Visual stimuli were generated with a ViSaGe stimulus generator from Cambridge Research Systems (Rochester, United Kingdom), driven by custom software programmed in MATLAB 7.5, and displayed on a gamma-corrected 19-inch Sony Trinitron G420 monitor (Sony, Tokyo, Japan) at a resolution of 1024 × 768 pixels and a refresh rate of 120 Hz. Stimuli were viewed from 57 cm with the participant's head placed in a chin rest. Responses were given by pressing one of two mouse buttons. The display background was black.

Participants

There were 10 participants, including the first three authors, and seven participants who were naïve as to the purpose of the experiment. All had normal or corrected to normal visual acuity.

Stimuli

In the center of the display (see Figure 1a) there was a cross-hair, subtending 0.7 dva. This served as the fixation point. A white disc, subtending 0.7 dva and centered 3.5 dva from fixation, traversed a clockwise trajectory, centered on fixation, at a rate of 90°/s. The disc travelled toward a static wedge (i.e., a circular sector) with a height subtending 4 dva and a width of 9°. The static wedge pointed at fixation and was centered at a polar angle of 90°. The disc moved towards the wedge for 0.87 to 1.15 s (see the following material), then changed direction and rotated counterclockwise for 1.0 s. We jittered the disc's starting point (polar angles of 180° to 198°) to ensure participants could not accurately anticipate when the initial movement period would cease.

During a run of trials, the duration of the initial revolution period (disregarding trial-by-trial random additions) was manipulated according to a two-interleaved one-up-one-down staircase procedure, thereby adjusting the disc's reversal point. For visualization purposes, note that it took approximately 127 ms for a disc to traverse a distance equal to its diameter. One staircase was initialized at a prereversal revolution period of 0.87 s (the low staircase, with the disc reversing direction 32 ms *before* making contact with the static wedge), whereas the other was initialized at a prereversal revolution period of 0.95 s (the high staircase, with the disc reversing 49 ms *after* having made contact with, and beginning to move into, the static wedge). For each staircase "Hard Bounce" and "Soft Bounce" responses resulted in initial revolution periods being increased or decreased by 17 ms, up to limits corresponding with initial staircase values. After the first reversal (i.e., the participant had reported a "Soft Bounce" on this trial but a "Hard Bounce" on the last trial, or vice versa) each staircase was reset to its original value (to ensure some sampling at extremely short and protracted initial revolution periods). After rests the standard reversal rule was adopted. A run of trials persisted until 10 reversals were recorded for each staircase.

On each trial the initial revolution period was recorded, along with the participant's "Hard Bounce" (scored as 0) / "Soft Bounce" (scored as 1) response. These data were collated across the two staircases, and a cumulative Gaussian function was fitted, with "Soft Bounce" responses expressed in proportion to the number of trials for that initial rotation period. We took 50% points on fitted functions as estimates of the "Hard" / "Soft" bounce categorical boundary.

Adaptation

All participants first completed a baseline run of trials, wherein tests were presented without prior adaptation. During subsequent adaptation runs of trials, tests were preceded by six sequential adaptation presentations, which took the form of a contact-launch scenario (see Michotte, 1963) wherein we modulated the spatial overlap at the time of the "launch" to create different impressions concerning object rigidity.

Adaptation presentations involved two white discs, each subtending 0.7 dva and centered 3.5 dva from fixation (see Figure 1b). One of these was initially static, positioned at a polar coordinate of 180° relative to fixation. The other revolved clockwise about fixation at an angular velocity of 90°/s for 0.8 s before stopping. The starting position of the initially moving disc was such that it either stopped 33 ms *before* making contact (to simulate a collision of rigid objects) or 83 ms *after* making contact (to simulate a collision of elastic objects). When the first disc stopped, the second, initially static, disc would begin moving along the same trajectory—i.e., the "launch." After launch, the initially static disc revolved for 0.4 s before both discs disappeared. The start/stop positions for the initially moving disc during adaptation were based on preliminary testing, wherein we determined estimates of the minimal and maximal trajectory for the initially moving disc that participants would still construe as a

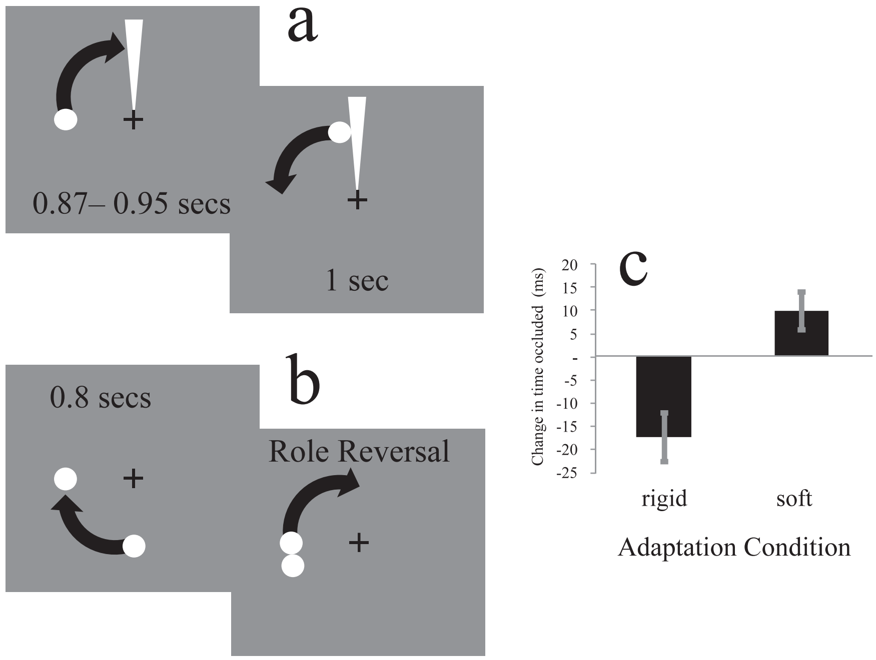

Figure 1. (a) Depiction of test protocol. A disc moves toward a static sector, and then reverses. The initial revolution period was varied, such that the disc could just contact the static sector, or pass into the static sector and become partially occluded. Participants judged if the simulated bounce had been "hard" or "soft." (b) Depiction of adaptation protocol. One of two discs (starting position polar 270°) revolved for a time, then stopped. A second disc, positioned at polar 180°, was static during this period. When the first disc stopped the second started revolving toward polar 90°. Participants judged if the first disc had contacted the second, launching it into motion, or if it had stopped short or passed through into the initially static disc. (c) Adaptation-induced changes in the hard-soft bounce category boundary. Error bars show ±1 *SEM*.

contact-launch scenario (as opposed to the initially moving disc having seemed to stop short of the static disc, or as having passed through into it).

The cross-hair fixation point during adaptation presentations was white. It turned red before test presentations to alert the participant that a hard / soft bounce judgment would soon commence, and they would be required to make a judgment of the object's properties. There was a 0.4-s interstimulus interval (ISI) in between successive adaptation presentations. Participants completed two adaptation blocks of trials, one with adaptation suggesting a collision of "rigid" objects, and another suggesting a collision of "elastic" objects. The order in which the two runs of adaptation trials were completed was counterbalanced across participants.

Results

For each participant we calculated difference scores between estimates of the Hard / Soft Bounce category boundary from baseline (moving disc partially occluded by wedge for 91± 6 ms) and adaptation trials. Negative values signify that more occlusion was needed to reach the category boundary relative to baseline, and positive values less occlusion.

The placement of the hard/soft bounce category boundary varied as a function of experimental condition repeated-measures ANOVA, $F(2, 18) = 12.8$, $p < 0.001$, $n_p^2 = 0.59$. Contrasting conditions revealed that adaptation suggesting repeated collisions of rigid objects made people more likely to judge subsequent bounces as *soft,* i.e., relative to baseline people were less tolerant of a disc becoming partially occluded by the static sector, more often judging this as a soft rather than as a hard bounce; $F(1, 9) = 16.5$, $p = 0.003$, $n_p^2 = 0.65$. Adaptation suggesting repeated collisions of elastic objects had the opposite effect, with people becoming more likely to judge bounces as *hard,* $F(1, 9) = 10.7$, $p = 0.01$, $n_p^2 = 0.54$; see Figure 1c. These data show that adapting to different types of "collision" can shape subsequent elasticity-dependent judgments, specifically of whether a simulated bounce had been hard or soft.

Discussion

Our data suggest that object elasticity is subject to a visual aftereffect. Adaptation suggesting repeated rigid object collisions decreased tolerance to partial occlusion when judging if simulated bounces had been "hard." Adaptation suggesting repeated elastic object collisions had the opposite effect. We interpret these data in terms of how recent experience shapes a perceptual expectation concerning how an object will behave in a collision. Any discrepancy between expected and actual input results in an exaggerated perceptual experience, in this case pertaining to object elasticity. This adds a new type of material property, elasticity, to the growing list of characteristics known to be subject to a visual aftereffect. Other susceptible material properties include surface glossiness (Motoyoshi, Nishida, Sharan, & Edelson, 2007), texture (Durgin, 1995), and translucency (Motoyoshi, 2012).

Our adaptation protocol, watching repeated collision-launch scenarios, is similar to one recently used by Rolfs, Dambacher, and Cavanagh (2013) to distort causality judgments. These authors found that, after an adaptation protocol consistent with viewing repeated rigid object collisions, people were *less likely* to report collision-launches, particularly when the two discs were overlapping at launch. This was interpreted in terms of an adaptation of mechanisms that encode causality, resulting in subsequent events being *less likely* to be seen as causally related (Rolfs et al., 2013). As this effect was reduced when tests were presented in an unadapted location, except when eye movements brought that location into retinotopic alignment with adaptors, the authors further suggested that these mechanisms have retinally localized visual receptive fields (Rolfs et al., 2013). Our findings are somewhat similar, in that participants became *less* tolerant of partial overlap post adaptation. In our data this was expressed by an increase in the number of reported "soft" bounces. We attribute this to changes in apparent object elasticity, rather than to an adaptation of mechanisms that encode causality. A couple of important differences encouraged this interpretation.

One important difference between data from Experiment 1, and that reported by Rolfs et al. (2013), is that we did not test for the impact of adaptation in the adapted location. This motivated us to consider a more object-centered explanation. A second difference is that in addition to adapting to a contact-launch scenario, wherein two discs seemed to just contact, we also adapted people to a scenario wherein the two discs seemed to become partially superimposed, and this resulted in an *opposite* bias. So, instead of a process that simply reduces the probability of a quality being encoded, as suggested by Rolfs et al. (2013), we were motivated to consider a process that can result in opposite perceptual biases. Given these discrepancies, between our data and the former study (Rolfs et al., 2013), we decided to replicate the experimental conditions reported by Rolfs et al. (2013) to see if the consequences of such adaptation were mapped onto positions on the retinal surfaces, or were object centered.

Experiment 2: Coordinate mapping for hard and soft collision adaptation

To facilitate comparison between our data, and that reported by Rolfs et al. (2013), we changed our test protocol to match that of the previous study.

Methods

Details for Experiment 2 were as for Experiment 1, with the following exceptions.

Participants

There were seven participants, including the first two authors, and five participants who were naïve as to the purpose of the experiment. All had normal, or corrected to normal, visual acuity.

Stimuli

The display consisted of a white fixation cross-hair, subtending 0.75 dva at the retina, and white discs that subtended 1.25 dva and were centered 4 dva from the contemporary fixation point. When moving, discs translated linearly at a speed of 10°/s (see Figure 2).

Procedure

All trials began with the fixation point being positioned 4 dva to the left of the display center. During this time participants viewed a sequence of 16 "collisions" between two discs offset to the right of fixation. These involved eight individual presentations, each involving two sequential collisions. For these sequences the trajectory of motion along which discs translated varied randomly, from presentation to presentation, within a range ±45° from vertical, broadly upward, or downward. This restricted range of possible test directions avoided moving discs from impinging on fixation. For each sequence one of the two discs was initially static for 80 to 150 ms, and the other disc translated toward it, then stopped. The initially static disc then moved for 480 to 900 ms, half the time away from and then back toward its initial position, where it too stopped. The other disc then began moving away from the now static disc, back

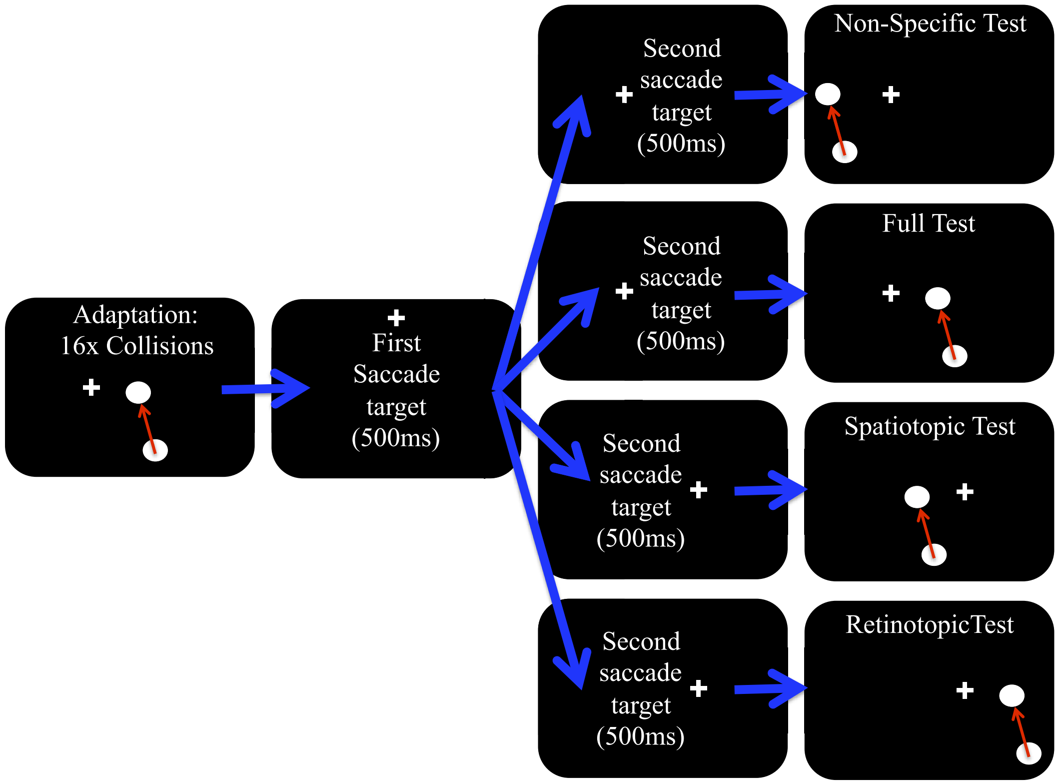

Figure 2. Depiction of trial sequences for Experiment 2. All trials began with participants fixating a position on the left of the display (left panel). In adaptation blocks of trials, during this period participants viewed repeated Elastic or Rigid collisions (see main text for an explanation of these terms) to the right of this fixation point in the middle of the display. In all trials, participants then made a saccade to fixate a target positioned above the center of the display (second from left panel). Participants then made a saccade to fixate a final target, either again positioned on the left of the display (top two panels, second from right) or on the right (bottom two panels, second from right). Then a test was presented, either to the left of a fixation point on the left of the display (Nonspecific test, top panel on right), to the right of a fixation point on the left of the display (Full test, panel second from top on right), to the left of a fixation point on the right of the display (Spatiotopic test, panel second from bottom on right), or to the right of a fixation point on the right of the display (Retinotopic test, bottom panel on right).

along its initial trajectory for 80 to 150 ms. There was a 500-ms interval between individual presentations. In sum, this constituted the adaptation sequence.

There were two types of adaptation sequences, simulating Rigid and Elastic collisions. For Rigid collisions, one disc stopped, and the other started moving, as soon as they made contact. For Elastic collisions, one disc stopped, and the other started moving, when the initially moving disc had traversed 40% into the diameter of the initially static disc. On all adaptation trials the point of contact between the two discs was 2 dva to the right of fixation.

Tests involved two sequential saccades before a test animation was shown. On all trials the first saccade target was centered 4 dva above the center of the display, and was shown for 500 ms. The second saccade target was then presented for 500 ms, positioned either 4dva to the left of the display center (the initial fixation position), or 4 dva to the right of the display center.

Test animations were similar to the first half of an individual adaptation presentation—they involved a single contact between two discs. During a block of trials the extent of overlap, at the point when the initially moving disc stopped and the initially static disc started moving, was manipulated according to staircase procedures. At minimum the two discs just made contact (with no overlap) and at maximum there was complete overlap. After each test presentation the participant indicated if the initially moving disc had seemed to launch the initially static disc into motion—a contact launch response, or if the initially moving disc had seemed to stream through the initially static disc—a stream response. The former response resulted in a 5% increase in the extent to which the initially moving disc would traverse into the initially static disc on the next trial for that staircase, and the latter response a 5% decrease. In both cases the minimum and maximum conditions were enforced, so in the unlikely event of a contact-launch response after the two discs had completely overlapped, the next trial for that staircase would also involve a complete overlap, and vice versa for the minimal condition and stream responses.

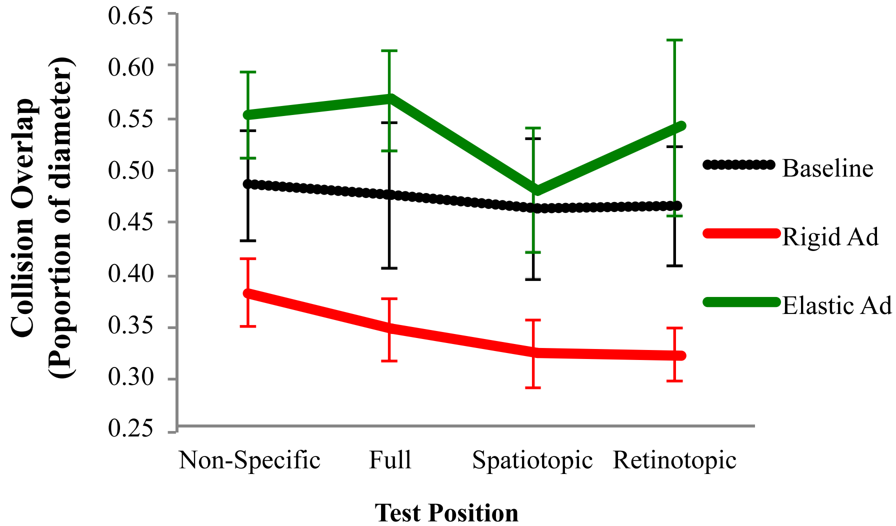

Figure 3. Plot depicting Contact-launch / Stream category boundary estimates, expressed in terms of the proportion of the static disc's diameter the initially moving disc traversed before stopping. Estimates are shown from baseline blocks of trials (black), from Elastic adaptation blocks of trials (green), and from Rigid adaptation blocks of trials (red). Data are also shown for each of the four test types. Error bars depict ±1 *SEM*.

There were four types of test (see Figure 2). Nonspecific: the test was neither presented to the same retinal region nor to the same position on the physical display as the adaptor. Full: the test was presented to the same retinal region and to the same position on the physical display as the adaptor. Retinotopic: the test was presented to the same retinal region, but to a different spatial position on the physical display as the adaptor. Spatiotopic: the test was presented to a different retinal region, but to the same position on the physical display as the adaptor. In Nonspecific and Full conditions, the second saccade target was in the same position on the physical display as the initial fixation point. In Retinotopic and Spatiotopic conditions, the second saccade target was positioned 4 dva to the right of the initial fixation point. In Full and Retinotopic conditions, points of contact were 2 dva to the right of the second saccade target. In Nonspecific and Spatiotopic conditions, points of contact were 2 dva to the left of the second saccade target.

Two staircase procedures were conducted for each of the four types of tests, one beginning with a minimum test condition, the other with a maximum test condition. Overall eight staircase procedures were conducted, all interleaved in random order. A block of trials involved 25 trials for each staircase, for a total of 200 individual trials. After the 100^{th} trial, each staircase was reset to the initial value, to ensure extreme test conditions were sampled at least twice in each staircase procedure. Data from the two staircase procedures conducted for each test type were collated, and a logistic function fitted to the proportion of stream responses for each magnitude of overlap sampled. The 50% points on fitted functions were taken as an estimate of the category boundary, separating contact launches from stream responses.

Blocks of trials were conducted in the absence of adaptation (baseline), or after adapting to "Rigid" or "Elastic" collisions. Baseline blocks of trial were conducted first, four participants then completed Rigid adaptation, and three participants then completed Elastic adaptation, with all participants then completing the remaining adaptation condition.

Results

Overlap magnitudes coinciding with the Contact-launch / Stream category boundary are depicted in Figure 3. A repeated-measures ANOVA on these data revealed a significant main effect of adaptation, $F(2, 12) = 12.91$, $p = 0.001$, Eta Sq $= 0.683$), but no effect of test position, $F(3, 18) = 1.96$, $p = 0.157$, Eta Sq $= 0.246$, nor was there evidence for an interaction between adaptation and test position, $F(6, 36) = 0.99$, $p = 0.447$, Eta Sq $= 0.142$.

As the ANOVA had revealed a significant effect of adaptation, but neither a main effect for test position, nor an interaction between test condition and adaptation, we calculated average aftereffects for Rigid and Elastic adaptation for each participant. We did so by subtracting each participant's average Contact-launch / Stream category boundary estimate from the baseline block of trials from the average category boundary estimate from the relevant adaptation block of trials. Aftereffects, averaged across participants, are depicted in Figure 4. Single sample t tests revealed that people were *less* likely to report contact-launches after

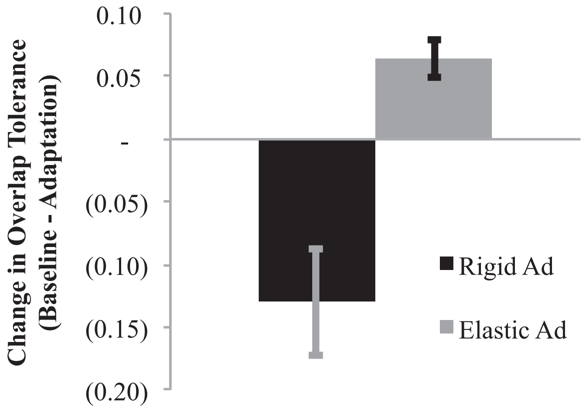

Figure 4. Bar graph depicting shifts in the contact-launch / stream category boundary after adaptation to "Rigid" and "Elastic" simulated collisions. Data are averaged across test positions for each participant, and then averaged across participants. Error bars depict ±1 *SEM*.

adapting to Rigid collisions ($t_6 = 3.06$, $p = 0.022$), and *more* likely to report contact-launches after adapting to Elastic collisions ($t_6 = 4.36$, $p = 0.005$).

General Discussion

Data from both of our experiments are consistent with object elasticity being subject to a visual aftereffect. In both experiments adaptation suggesting repeated rigid object collisions *decreased* tolerance to partial occlusion when characterising the nature of subsequent simulated bounces. In Experiment 1 this took the form of an increased propensity to categorize simulated bounces as "soft," whereas in Experiment 2 this resulted in an increased propensity not to categorize such events as bounces. Most important, however, is that adaptation suggesting repeated elastic collisions had opposite effects. Such adaptation brought about an increased propensity to categorize simulated bounces as "Hard" in Experiment 1, and in an increased propensity to report contact-launches in Experiment 2. We believe these data are explicable in terms of how recent experience shapes perceptual expectations concerning how objects will behave in a collision scenario.

Our data are inconsistent with a purely negative aftereffect, wherein an adapted quality seems reduced, such as when movement seems slowed post adaptation (Thompson, 1981), or when color seems faded (Webster & Mollon, 1991). Instead, our data are more consistent with a process that exaggerates differences between the adapted and other inputs, such as when a line seems tilted away from an adapted orientation (Mitchell & Muir, 1976). Our data are thus inconsistent with the suggestion that adaptation to repeated simulated collisions will bring about a negative aftereffect, wherein objects are *less* likely to be encoded as being causally related (Rolfs et al., 2013). From a functional perspective, this hypothesis seems unlikely as we would expect repeated exposure to a situation wherein two objects seem causally related to result in an *increased* subsequent propensity to see the same objects as causally related, not the opposite.

Our data suggest that the object elasticity aftereffect is object centered. There was no evidence that this effect was modulated if tests were presented in a different position, either on the retina or in external space, relative to adaptation (see Experiment 2). These data therefore conflict with a prior report, wherein data were interpreted in terms of a negative aftereffect impacting causality detectors with retinotopically-mapped receptive fields. From a conceptual perspective this suggestion seems surprising, as people will readily infer a causal relationship between two events when those events are widely separated either in space or time. For instance, people may report the sensation that their own footfall has caused a distant light to turn on/off if the two events happen to coincide in time. Alternatively, people readily report that a bolt of lightning has caused subsequent thunder, which might not be heard until seconds later. Such a malleable approach to inferring causality does not sit comfortably with the suggestion that mechanisms that detect such relationships are located at low-levels of the visual hierarchy, and have retinotopically-mapped receptive fields (Rolfs et al., 2013).

We believe the data we have presented here, and similar effects, are best construed in terms of a modulation of an expectation concerning how an object will behave in contact. We are mindful, however, that it is possible to modulate high-level effects, such as one's sense of agency over events, via adaptation protocols (Arnold, Nancarrow, & Yarrow, 2012; Haggard, Clark, & Kalogeras, 2002; Kawabe, Roseboom, & Nishida, 2013; Stetson, Cui, Montague, & Eagleman, 2006; Yarrow, Sverdrup-Stueland, Roseboom, & Arnold, 2013). For instance, if people are adapted to a delay separating button presses from consequent flashes, when that delay is removed one can have a compelling sensation that the flash caused by pressing a button actually preceded the button press (Stetson et al., 2006). This type of aftereffect might similarly illustrate how adapting to a basic stimulus property (in this case timing) can have a cascading influence on higher-level inferences (such as agency). Compare this to our finding here, where adaptation to a timing contingency seems to have resulted in changed perceptions of squishiness, which in turn appears to influence causality inferences. We suspect that both aftereffects are caused by a modulation of a perceptual expectation, or decisional criterion, rather than by a neural adaptation that impacts sensory encoding. Some of the authors have previously made similar suggestions regarding an aftereffect that affects audio-visual timing judgments (see Yarrow et al., 2011).

While we are skeptical about the suggestion that causality detectors are located at low-levels of the visual hierarchy, have retinotopically-mapped receptive fields, and are subject to a fatigue-like aftereffect, we cannot dismiss these possibilities. Our own data are more consistent with an object-centered effect, which generates contrastive aftereffects. These data, however, conflict with those resulting from an earlier very similar experiment (Rolfs et al., 2013). We can see no obvious reason for the discrepancy, and thus suggest that either our data in part reflect a type 1 statistical error, or that the previous report reflects a type 2 statistical error. We would therefore encourage other researchers to re-examine these issues independently.

Perhaps the simplest way to interpret our own data is that they result from a high-level multichannel coding scheme that generates a contrastive aftereffect—in a conceptually similar fashion to lower-level analyses that result in the tilt and direction aftereffects (Barlow & Hill, 1963; Blakemore & Campbell, 1969; Clifford, Wenderoth, & Spehar, 2000). We prefer a more convoluted interpretation. We think these data are consistent with repeated exposures to an adaptor generating a perceptual expectation, or prior (Chopin & Mamassian, 2012; Kording, 2007), concerning how an object will behave in a collision. In uncertain conditions, wherein there is no obvious difference between adaptor and test, such an expectation can bring about a bias to report that tests were *similar* to the adaptor—the opposite scenario compared to the bias we report. We suggest that a different scenario might ensue when there is an obvious discrepancy between adaptor and test. In such circumstances, if people have accepted the repeated adaptor as an exemplar of one type of scenario, they might come to reliably classify the obviously different test as an opposite thing—in this case as an elastic or rigid object. This could happen even if the participant did not classify such tests reliably prior to adaptation.

Note that in this context we have used the term adaptation purely to denote a scenario wherein a participant is repeatedly exposed to one type of input before exposure to tests, and the term aftereffect to describe an effect that happens after repeated exposures to a systematic input. We are not committed to any bias reflected in our data being a consequence of neural adaptation that impacts sensory encoding. Rather, we believe that response biases resulting from this type of scenario could be mediated at decision levels of analysis. We suspect this is true in this context, and also for many phenomena regarded as instances of a high-level perceptual aftereffect (for similar suggestions, see Morgan, Melmoth, & Solomon, 2013; Storrs & Arnold, 2012; and Yarrow et al., 2011).

One final point readers should note is that the description of our data as having quantified a "squishiness" aftereffect is an interpretation. Our data reflect modulations in forced choice categorization behavior, induced by systematically changing the degree of overlap between two discs when one stops and the other starts moving during an adaptation protocol. In Experiment 1 participants were explicitly asked to judge if simulated bounces had seemed "hard" or "soft," and we determined when these categorizations switched from predominantly "hard" to predominantly "soft." Because of these explicit instructions, which reflected our personal impressions of stimuli when doing and conducting the experiment, and because of the systematic judgment biases our protocol produced, we feel justified in describing our results in terms of object elasticity, or squishiness. It is possible, however, that some participants never regarded our stimuli as elastic, just as rigid objects that became more or less overlapped with other input (a similar caveat could be made about peoples' inclination to classify static inputs as moving post motion adaptation). This would make the systematic biases we observed mysterious. We therefore believe that most, if not all, participants regarded our test stimuli as intended—as objects that could become transiently deformed when in contact. We acknowledge, however, that this is interpretive. Future experiments could make use of more realistic looking objects that conform more closely to physical laws, to see how far the systematic biases we have observed will generalize.

Keywords: visual aftereffect, elasticity

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Corresponding author: Derek Henry Arnold.
Email: d.arnold@psy.uq.edu.au.
Address: School of Psychology, The University of Queensland, Australia.

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