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ORIGINAL INVESTIGATION

Detecting Cheating when Testing Vision: Variability in Acuity Measures Reveals Misrepresentation

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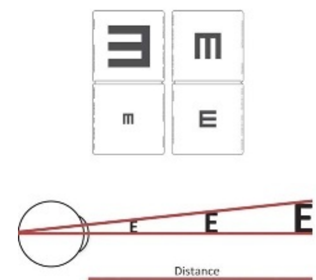
SIGNIFICANCE: In certain scenarios, it is advantageous to misrepresent one's ability and “cheat” on vision tests. Our findings suggest that increased variability when testing visual acuity holds promise as a novel means to help detect this cheating and may generalize to other subjective tests of visual function.

PURPOSE: People who cheat on vision tests generally do so to make their vision appear better than it actually is (e.g., for occupational or driving purposes). However, there are particular settings in which it is advantageous for their vision to appear to be worse than is the case (e.g., to qualify for benefits available to people with low vision). Therefore, a method to help detect cheating in these scenarios is desirable. The aim of this study was to investigate whether the intentional underrepresentation of vision could be detected when testing visual acuity.

METHODS: We tested the visual acuity of 13 participants with simulated vision impairment using the Berkeley Rudimentary Vision Test. Participants were tested in an honest condition when providing their best effort and in a cheating condition when attempting to make their visual acuity appear to be markedly worse. We also tested visual acuity of 17 participants with a wide range of vision impairments.

RESULTS: Participants were successfully able to “cheat” on the tests; however, their responses were significantly more variable when cheating ($P < .001$). Although the variability in visual acuity was larger in individuals with actual vision impairment compared with those providing honest answers with simulated impairment ($P < .01$), their responses remained significantly less variable than those for individuals in the cheating condition ($P = .01$).

CONCLUSIONS: The variability in the estimations of vision provides a promising novel means of detecting the intentional underrepresentation of vision and could help to minimize the chance of successfully cheating on tests of vision.



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It is not uncommon for people to cheat on tests of visual function. Cheating, or intentional misrepresentation, often occurs when people try to appear as though their vision is better than it actually is, for instance, in an effort to avoid losing their driver's license or to pass tests of occupational visual requirements (e.g., for pilots, commercial drivers, or the armed forces). However, the opposite scenario is increasingly common, with some attempting to underrepresent their level of vision so that it appears worse than it actually is. Anecdotally, the series of Harry Potter books and movies saw a marked rise in the number of children who attempted to underrepresent their vision in an attempt to convince their parents that they needed glasses. Of greater societal consequence, though, is the scenario where individuals attempt to underrepresent their vision to qualify for benefits available for people with disability as a result of vision impairment. These scenarios can be particularly challenging for a clinician because they are required to make a subjective judgment of whether the measured level of visual function is in line with what would be expected on the basis of the patient's medical condition. To help address this challenge in protecting the interests of those who truly have a vision impairment, in this study we sought to develop a new means of detecting the intentional misrepresentation of vision in people who deliberately underrepresent their vision.

The incentive for people to engage in the intentional misrepresentation of vision can be particularly high in scenarios where there are obvious benefits associated with being classified as having vision impairment. This is most apparent in the case of financial benefits, where a person with a mild impairment has an incentive to underrepresent his/her level of vision to meet the minimum level of impairment required to qualify for those benefits. Another potential incentive is the opportunity to take part in social opportunities designed for people with vision impairment, as is the case in Paralympic sport. In order to take part in Paralympic competition, a person must meet the minimum impairment criteria, currently requiring a visual acuity of 1.0 logMAR in most sports.[1] As the prestige and financial rewards associated with Paralympic sports grow,[2,3] so too does the motivation for athletes to underrepresent their vision to meet these criteria. Moreover, if an athlete qualifies to take part in a para-sport competition, they are generally placed into a sport class that is designed to ensure the athlete competes against others who possess a similar level of impairment.[1,4,5] Again, this provides some incentive for athletes to underrepresent their vision, because doing so might allow them to participate in a sport class designed for athletes with more severe impairment then theirs, increasing their chance of winning.

As the stakes are high for both patients and regulators of these initiatives designed for individuals with vision impairment, it is particularly important to be able to detect when someone is intentionally underrepresenting his/her level of vision. Governments typically have strong penalties in place for those found to be claiming benefits that they are not entitled to. And in the case of Paralympic sport, the International Paralympic Committee has harsh penalties in place for athletes who are caught engaging in intentional misrepresentation, with a lifetime ban from Paralympic competition being the ultimate punishment.[6] However, it remains challenging to prove that a person is being dishonest, and therefore it is difficult to enforce these penalties. Given the substantial consequences of labeling a person as a "cheat," a clinician must be very confident that intentional misrepresentation has occurred when making such a judgement. There thus is a need for valid and reliable methods to detect whether someone is giving his/her best effort on the tests of vision to help clinicians build evidence to support their judgement of someone's true level of visual function.

The accurate and reliable assessment of vision in people with low vision can present a significant challenge to clinicians. The ETDRS letter chart is typically considered to be the criterion standard for testing visual acuity; however, it is designed for testing people with visual acuities as low as 1.6 logMAR, but not those with even more severe impairment.[7] Historically, very simplistic methods have been used to assess low vision, often evaluating whether a person can count the clinician's fingers or if he/she can perceive light.[8] Recently, though, there has been a push toward the development of tests designed to more accurately evaluate vision in this population. One such test is the Berkeley Rudimentary Vision Test,[7,9] which has been adopted as the preferred test of visual acuity by organizations including the International Paralympic Committee[10] and the International Blind Sports Federation.[11] The Berkeley Rudimentary Vision Test determines visual acuity in logMAR units using single Tumbling E optotypes of four different sizes (25-, 40-, 63-, and 100-M letter size).[9] The Tumbling E targets can be presented at different distances (0.25 to 4.0 m) to find the threshold distance at which the optotypes can be resolved and can thereby identify visual acuities between 1.4 and 2.6 logMAR.[9] Crucially, in most cases, this provides the clinician with four measurements of visual acuity that should be similar or ideally identical for a given patient. For instance, if a person has a visual acuity of 1.6 logMAR, then he/she would be expected to provide responses that lead to a threshold distance of 2.5 m for the 100 M Tumbling E, 1.6 m for the 63 M Tumbling E, 1.0 m for the 40 M Tumbling E, and 63 cm for the 25 M Tumbling E.

The need to maintain consistency across the four Tumbling E sizes of the Berkeley Rudimentary Vision Test may present a significant challenge for people who attempt to cheat on the test because observers have been shown to be very inaccurate in judging object distances and sizes.[12] The variability of the four estimates of acuity might prove to be a potentially useful way to test for intentional misrepresentation, because increased variability might be expected in the presence of cheating when their task has now become to judge the angular distance of the Tumbling E they are being presented. A similar rationale has been used to test for maximal effort on tests of physical performance. Deuble et al.[13] sought to identify underperformance on tests of motor coordination using a task that required fast tapping between two different objects. They asked participants to perform a series of these reciprocal-tapping tasks, but manipulated the size of the targets and the distance between them so that the constraints changed while the level of task difficulty remained the same. According to Fitts's Law, the time taken to perform those tasks should not change, because the time should alter only with changes in difficulty.[14] Consistent with this hypothesis, the time taken to perform the tasks varied little when participants provided their best effort, but increased when they tried to be deliberately slower than what they were capable of (simulating physical impairment). This increased variability was found, even after a period of training designed to decrease the variability (see also Sindhu et al.[15] for a similar method in the assessment of grip strength). As a result, the measurement of variability across tests of similar difficulty levels might provide a valuable means of detecting whether someone is giving his/her best effort on a test.

Given the promise that a measure of consistency might hold as a marker of intentional misrepresentation, one potential concern with the Berkeley Rudimentary Vision Test is the predictability of the standard test procedure typically relied on when conducting the test. According to this procedure, a single optotype is presented and simply moved toward the viewer until it can be resolved, or moved away until it cannot. This is a logical and convenient procedure when testing people who are providing their best effort; however, the predictable nature of the movement could inadvertently help a person seeking to intentionally misrepresent his/her vision by providing cues as to when he/she should report that he/she can or cannot resolve each optotype. It could be that an alternate procedure that is less systematic would be more appropriate, for instance, a procedure that alternates between different optotype sizes and test distances in a less systematic fashion. Such an approach may render the test more likely to detect the deliberate underrepresentation of vision.

The aim of this study was to investigate whether the intentional underrepresentation of vision could be detected when performing a test of visual acuity. We did so by testing participants with simulated vision impairment on the Berkeley Rudimentary Vision Test, both while they gave honest responses and after teaching them to "cheat" to make it appear as though their vision was worse than it actually was. We also used the Berkeley Rudimentary Vision Test to test the acuity of individuals with actual vision impairment, because their responses on the test have previously been shown to be slightly more variable.[16] We hypothesized that cheating would increase the variability across the estimations of visual acuity produced during testing with the Berkeley Rudimentary Vision Test and therefore would prove to be a reliable method to detect whether participants were providing their best effort on the test whether they had a simulated or an actual vision impairment. Moreover, we sought to test whether cheating would be easier to detect when using a method that was less systematic than the test procedure typically relied on for the Berkeley Rudimentary Vision Test. We expected to find an increase in the variability of responses (i.e., poorer cheating) when administering the Berkeley Rudimentary Vision Test using the less systematic procedure.

METHODS

Participants

Thirteen participants with normal or corrected-to-normal vision took part in the experiment ($\text{mean}_{age} \pm SD = 33 \pm 18$ years; five males). During the experiment, participants were required to wear goggles that simulated mild vision impairment, and so those who required glasses for vision correction were excluded from participation (contact lenses were acceptable). In addition, 17 individuals with actual vision impairment (i.e., visual acuity ≥1.0 logMAR) were recruited at para-sport events and took part in the experiment. All participants provided informed consent to participate in the study, which was performed in association with the Declaration of Helsinki and approved by the faculty research ethics committee.

Design

Throughout the experiment, the normally sighted participants were fitted with a pair of modified swimming goggles that had four overlapping Bangerter occlusion foils (density 0.1) placed on the inside (Ryser Ophtalmologie, St. Gallen, Switzerland) that simulated a relatively mild level of vision impairment (logMAR ≈0.8). Swimming goggles were used to ensure that the peripheral visual field could be occluded. All testing was performed with only the right eye, with the left side of the goggles occluded using black tape.

Participants were tested on the Berkeley Rudimentary Vision Test a total of four times using a 2 (intention-to-cheat: honest, cheating) × 2 (test procedure: standard, modified) block design. In a first test block, participants took part in two conditions where they were asked to perform honestly (i.e., give their best effort) on the Berkeley Rudimentary Vision Test using either the standard or the modified test procedure. The order in which the two procedures were performed was randomized.

Following the first block, participants were taught how they could cheat on the test to make it appear as though their vision was worse than it actually was. Specifically, participants were taught three principles. The first principle was that accuracy on the test required consistency across the different combinations of letter size and test distance. Second, participants were taught a specific level of visual acuity that they should aim for during the tests (1.5 logMAR). Participants were shown one Tumbling E size at both the farthest distance at which they should be able to recognize that size (based on the results while providing their best effort) and then brought in to the farthest distance at which they would be able to recognize that Tumbling E if their visual acuity were to be 1.5 logMAR. Third, participants were shown one of the Tumbling E's over the full range of distances so they could practice to give the correct responses to fit with the visual acuity they were required to simulate.

After being taught how to cheat on the test, a second test block was conducted. Participants again performed the Berkeley Rudimentary Vision Test using both test procedures, but this time while attempting to cheat so that their visual acuity appeared to be 1.5 logMAR. The order of the two test procedures was again randomized.

The participants with actual vision impairment were tested only once on the Berkeley Rudimentary Vision Test using the standard test procedure without wearing any goggles simulating further impairment, in order to assess their habitual visual acuity and the variability across the visual acuity estimates collected using the test.

Procedures

Each of the four different Tumbling E sizes used in the Berkeley Rudimentary Vision Test (25, 40, 63, and 100 M) is printed on one side of a 25 × 25-cm white card. Optotypes are presented at a range of possible test distances (0.25, 0.32, 0.40, 0.50, 0.63, 0.8, 1.0, 1.25, 1.6, 2.0, 2.5, 3.2, and 4.0 m) to establish the maximum distance at which the letter can be resolved. For any given combination of optotype size and test distance, the Tumbling E is presented four times at one of the four randomly selected orientations. The task for participants is to indicate the direction of the arms of the letter E. A minimum of three correct responses is required for a determination that the optotype can be reliably resolved at that distance. The best level of acuity that can be determined using all four Tumbling E's in combination with one of these test distances is 1.4 logMAR.[7,9] Therefore, a standard ETDRS letter chart with Tumbling E's presented at a range of distances (1.0, 1.25, 1.6, 2.0, 2.5, 3.2, and 4.0 m) was used to test visual acuity when it was better than 1.4 logMAR.

In the standard test procedure condition, we followed the recommended test procedure for the Berkeley Rudimentary Vision Test (Fig. 1). Specifically, this requires the tester to systematically move in toward the participant with a single optotype until it can be resolved (or away until it can no longer be resolved). In the case of the ETDRS chart, the participant systematically moves down the rows on the letter chart at each of four distances. In the modified test procedure condition, we designed an alternate procedure that we presumed to be less predictable. Using this procedure, single Tumbling E's (for the Berkeley Rudimentary Vision Test) or single lines (for the letter chart) were presented at individual distances, with each of the combinations of letter size and test distance presented in a randomized fashion. The tester thus often needed to switch Tumbling E cards between presentations. The standard and modified Berkeley Rudimentary Vision Test procedures are described in Fig. 1.

Outcome Measures

In all test conditions, the four logMAR values for visual acuity were used to calculate the average (mean logMAR) along with the SD (logMAR SD) and the range (logMAR range) of those values in each condition. The mean logMAR in the honest condition provided a measure of the participant's actual visual acuity while wearing the goggles. In the cheating condition, the mean logMAR established whether participants were able to achieve the targeted level of visual acuity (1.5 logMAR). Both the logMAR SD and logMAR range provided a measure of how consistent participants were when performing each test.

Statistical Analyses

A 2 (intention-to-cheat: honest, cheating) × 2 (test procedure: standard, modified) ANOVA was performed to examine for differences in the (i) mean logMAR, (ii) logMAR SD, and (iii) logMAR range across the different test conditions. Paired-sample *t* tests were conducted to perform follow-up testing where necessary. An α level of 0.05 was considered significant for all tests. Effect sizes were reported as partial η_p^2 or Cohen *d* values where appropriate. In addition, unpaired *t* tests were conducted to compare participants with actual vision impairment against participants with simulated impairment in both the honest and the cheating conditions when using the standard procedure of the Berkeley Rudimentary Vision Test.

RESULTS

Ability to Misrepresent Visual Acuity

Participants were successfully able to misrepresent their level of acuity on the Berkeley Rudimentary Vision Test, with a significantly higher mean logMAR found when participants were cheating rather than providing their best effort (honest vs. cheating = 0.77 [95% confidence interval {CI}, 0.72 to 0.83] vs. 1.71 [95% CI, 1.67 to 1.74] logMAR; $F_{1,12} = 1558$, $P < .001$, $\eta_p^2 = .99$; Fig. 2). The manner in which the test was conducted did not alter the measured level of visual acuity, with no difference in the mean logMAR found

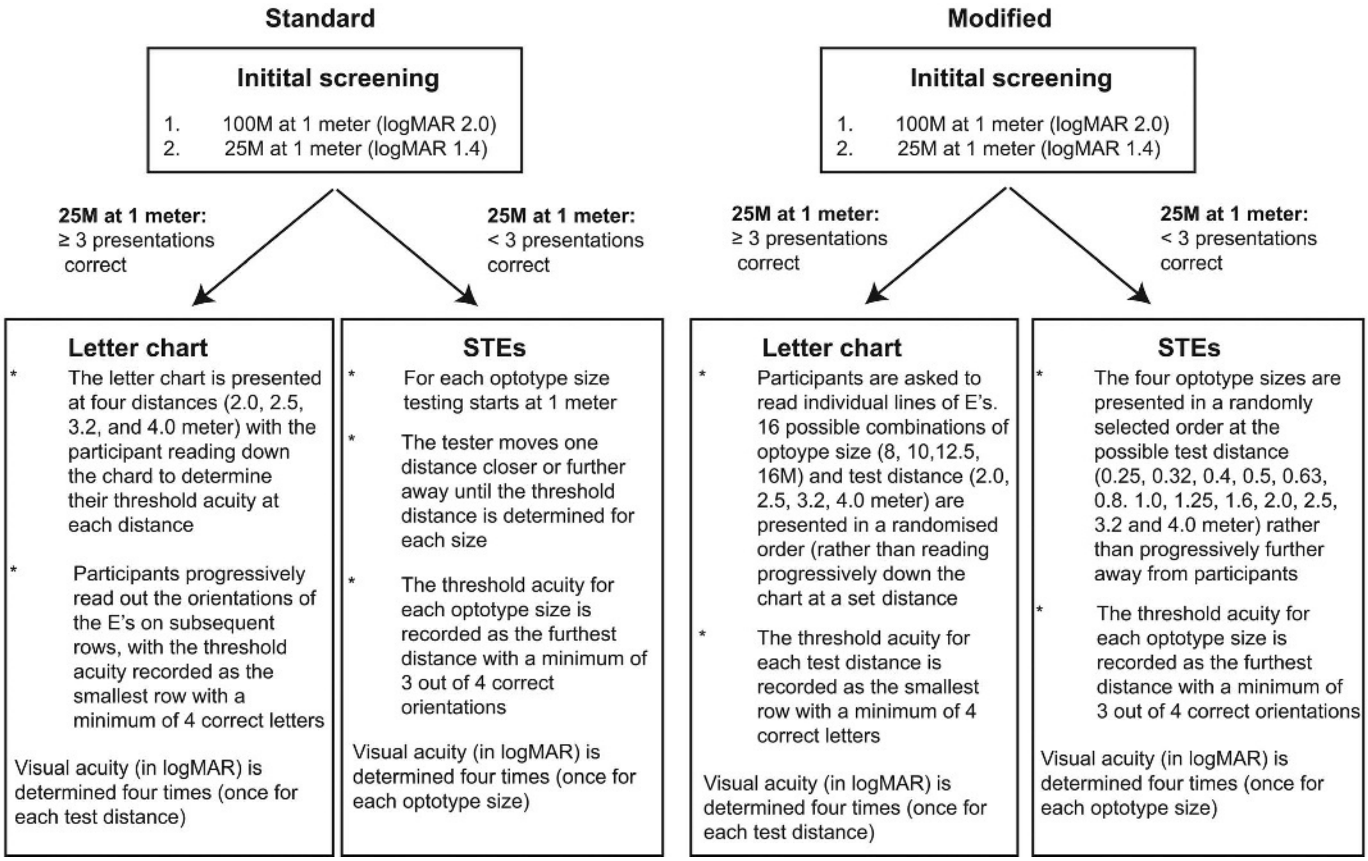

FIGURE 1. Description of the standard and modified Berkeley Rudimentary Vision Test procedures.

across the two procedures (standard vs. modified = 1.23 [95% CI, 1.20 to 1.27] vs. 1.25 [95% CI, 1.20 to 1.30] logMAR; $F_{1,12} = 0.38$, $P = .55$, $\eta_p^2 = .03$; Fig. 2). However, a significant interaction between the intention-to-cheat and test procedure ($F_{1,12} = 8.92$, $P = .01$, $\eta_p^2 = .43$) revealed that the increase in mean logMAR when cheating was slightly smaller using the standard test procedure than it was when using the modified procedure (ΔlogMAR standard vs. modified = 0.88 [95% CI, 0.78 to 0.99] vs. 0.98 [95% CI, 0.87 to 1.09]; $P = .01$, $d = 0.83$).

Ability to Consistently Misrepresent Visual Acuity

The variability in logMAR values was significantly higher when participants were cheating than when they provided genuine responses (Fig. 3). Significant main effects for cheating were found for both logMAR SD (honest vs. cheating = 0.05 [95% CI, 0.04 to 0.07] vs. 0.12 [95% CI, 0.10 to 0.14 ± 0.01]; $F_{1,12} = 62.3$, $P < .001$, $\eta_p^2 = .84$) and logMAR range (honest vs. cheating = 0.11 [95% CI, 0.08 to 0.15] vs. 0.26 [95% CI, 0.22 to 0.31]; $F_{1,12} = 58.5$, $P < .001$, $\eta_p^2 = .83$), indicating that participants were not able to maintain their usual level of consistency when cheating.

In contrast to expectations, the manner in which the test was conducted did not alter the consistency of the measurements and therefore the ability to detect cheating. The consistency of responses was comparable across the standard and the modified test procedure, both in terms of logMAR SD (standard vs. modified = 0.09 [95% CI, 0.07 to 0.11] vs. 0.09 [95% CI, 0.07 to 0.10 ± 0.01]; $F_{1,12} = .13$, $P = .72$, $\eta_p^2 = .01$) and logMAR range (standard vs. modified = 0.19 [95% CI, 0.14 to 0.24] vs. 0.19 [95% CI, 0.15 to 0.22]; $F_{1,12} = .04$, $P = .85$, $\eta_p^2 = .003$). Crucially, a lack of interaction between the intention-to-cheat and test procedure reveals that the modified test procedure was no better in detecting cheating than was the standard procedure when using either the logMAR SD ($F_{1,12} = 2.33$, $P = .15$, $\eta_p^2 = .16$) or logMAR range ($F_{1,12} = 1.55$, $P = .24$, $\eta_p^2 = .11$).

Control Experiment: Simulating the Higher Level of Impairment Achieved While Cheating

The results of our main experiment suggest that participants were able to deliberately misrepresent their visual acuity but that it may be possible to detect this through higher test variability. However, it is possible that the increased variability could be a characteristic of poorer logMAR values in general, in particular because of the closer proximity of the successive test distances, rather than the variability being a result of the cheating itself. Moreover, visual acuity was typically tested in the honest condition using the ETDRS chart, but using the Tumbling E's when cheating. It could be that the two tests themselves have different levels of variability that explain the differences we found. To exclude these possible explanations for our findings, we conducted a control experiment with an additional group of 13 participants matched for age and gender with those in the main experiment ($mean_{age} \pm SD = 33 \pm 10$ years; five males). The control experiment largely replicated the main experiment, with the exception that instead of cheating in the second block of tests participants performed to the best of their ability but

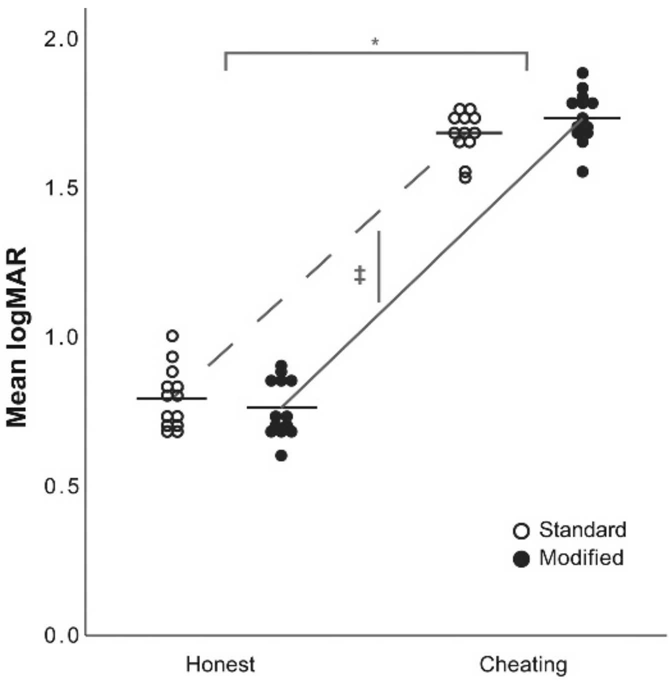

FIGURE 2. Mean logMAR values for visual acuity as a function of intention-to-cheat and test procedure. Participants managed to increase the logMAR value on the Berkeley Rudimentary Vision Test in both cheating conditions compared with the honest conditions. This increase was slightly smaller when tested using the standard procedure compared with the modified procedure. *Significant effect of intention-to-cheat. ‡Significant interaction effect between intention-to-cheat and test procedure ($P < .05$). The solid and dashed diagonal lines represent the interaction effect.

while wearing stronger filters (Bangerter foil <0.1) that impaired vision to a level similar to what they were asked to cheat to in the main experiment. This meant that we were able to compare this *honest with high simulated impairment* condition with the *cheating with low simulated impairment* condition performed in the main experiment to test for other explanations for the increased variability when cheating. The first testing block was identical to that used in the first experiment to control for any fatigue and/or learning accrued when testing the second block and was otherwise of no experimental interest. The findings from this first block replicated what was found in the main experiment and are therefore not reported again.

The results of the control experiment revealed that the increased variability when cheating was truly an effect of cheating. When using the standard test protocol to conduct the test, there was no difference in the mean logMAR values when providing honest responses (with high simulated impairment) and when cheating (with low impairment) (1.63 [95% CI, 1.61 to 1.66] vs. 1.68 [95% CI, 1.63 to 1.72], respectively; $P = .15$, $d = 0.73$; Fig. 4A). However, the variability of the logMAR scores was significantly lower when honest responses were given, both for the logMAR SD (0.05 [95% CI, 0.03 to 0.06] vs. 0.13 [95% CI, 0.10 to 0.16]; $P < .001$, $d = 2.4$; Fig. 4B) and the logMAR range (0.09 [95% CI, 0.06 to 0.12] vs. 0.28 [95% CI, 0.22 to 0.24]; $P < .001$, $d = 2.3$; Fig. 4C).

Ability to Discriminate between Those Who Cheated and Those with Actual Vision Impairment

When testing visual acuity in vision impairment participants, it was not always possible to acquire estimates using all four optotype sizes of the Berkeley Rudimentary Vision Test because for those with very poor visual acuity the threshold distance for the smallest optotype would be extremely small. Therefore, for all vision

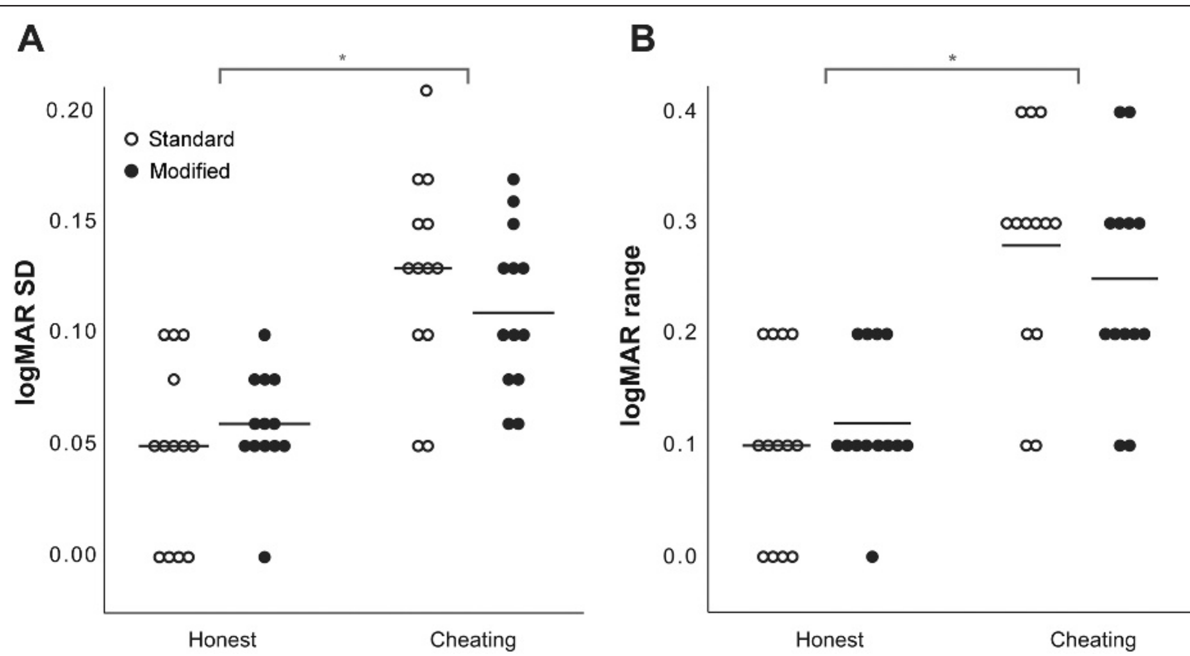

FIGURE 3. Consistency in logMAR values of visual acuity as a function of intention-to-cheat and test procedure. (A) The SD of the logMAR values for visual acuity by intention-to-cheat and test procedure. (B) The range in the logMAR values by intention-to-cheat and test procedure. Participants showed greater variability in their logMAR values in the cheating condition, but the increase in variability was not influenced by the test procedure (standard vs. modified). *Significant effect of intention-to-cheat ($P < .05$).

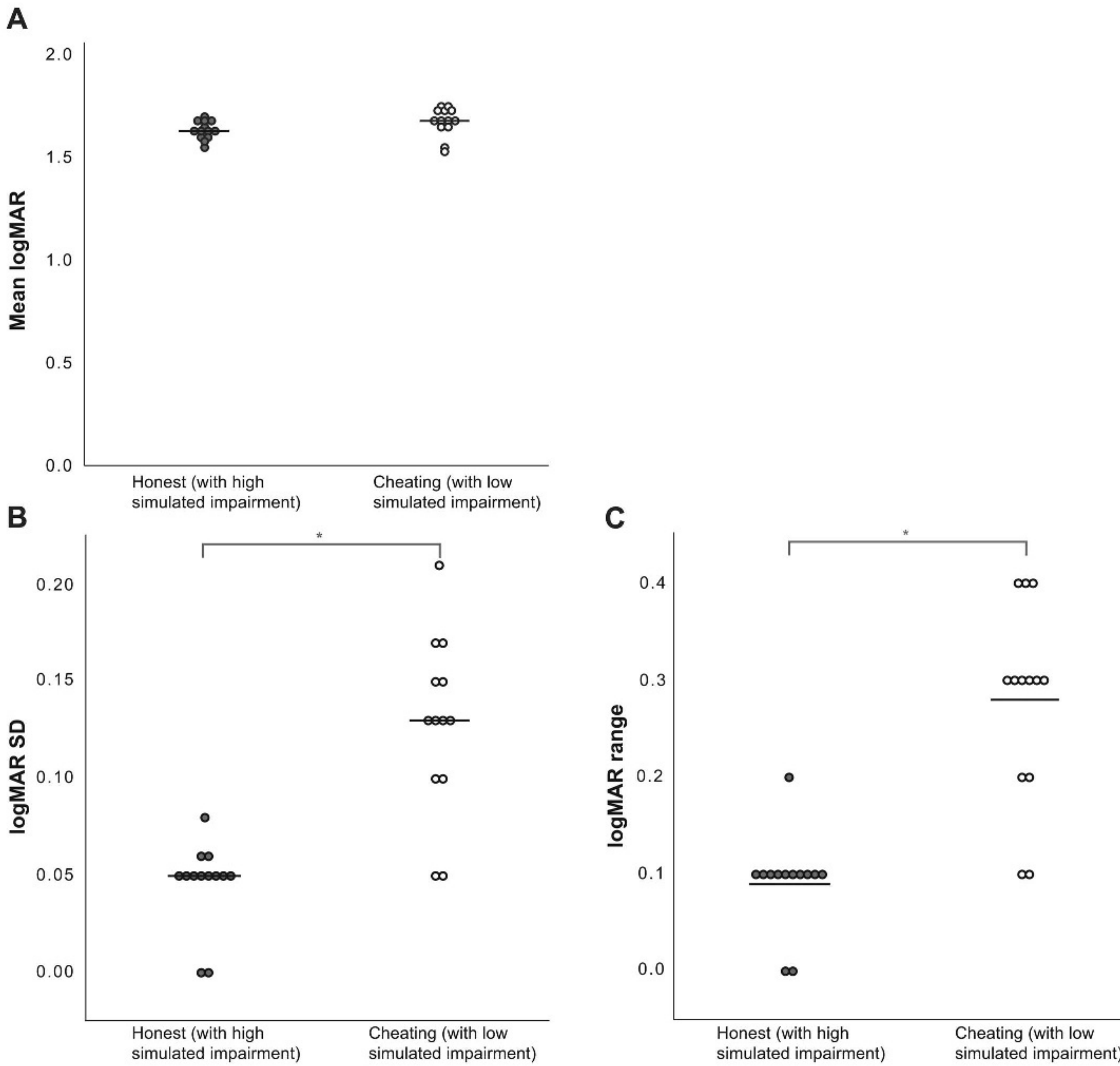

FIGURE 4. Comparison of the Berkeley Rudimentary Vision Test outcomes when cheating (with low simulated impairment) and when honest (with high simulated impairment). (A) Mean logMAR values. (B) SD in logMAR values. (C) Range in logMAR values. The visual acuity in the cheating (with low simulated impairment) condition was not different from that in the honest (with high simulated impairment) condition. Increased variability was found in the logMAR values in the cheating (with low simulated impairment) condition when compared with responding honestly with high simulated impairment. *Significant difference ($P < .05$).

impairment participants, three estimates of visual acuity (i.e., assessed using the three largest optotype sizes) were used to calculate the logMAR SD and range. To allow for a valid comparison against those with simulated impairment, their logMAR SDs and ranges were recalculated using only the estimates from the three largest optotype sizes.

All vision impairment participants had low vision according to the World health Organization definition[17] (i.e., a visual acuity of 1.0 logMAR or worse), where the average visual acuity was 1.6 logMAR and ranged from 1.07 to 1.87 logMAR. The variability in visual acuity estimates was significantly greater in the vision impairment group compared with the simulated impairment group in the honest condition. Significant effects between these groups were found in both the logMAR SD (vision impairment vs. simulated impairment honest = 0.08 [95% CI, 0.06 to 0.10] vs. 0.04 [95% CI, 0.03 to 0.06]; $P = .005$, $d = 1.1$; Fig. 5A) and logMAR range (vision impairment vs. simulated impairment honest = 0.15 [95% CI, 0.11 to 0.18] vs. 0.09 [95% CI, 0.06 to 0.12]; $P = .02$, $d = 0.9$; Fig. 5B), indicating that vision impairment participants were less consistent in their responses compared with those with simulated impairments when providing honest answers. However, those with actual impairments remained significantly more consistent when compared with those with simulated impairment while they attempted to cheat on the test. These effects were found in both the logMAR SD (vision impairment vs. simulated impairment cheating = 0.08 [95% CI, 0.06 to 0.10] vs. 0.13 [95% CI, 0.10 to 0.16]; $P = .005$, $d = 1.1$; Fig. 5A) and logMAR range (vision impairment vs. simulated impairment cheating = 0.15 [95% CI, 0.11 to 0.18] vs. 0.28 [95% CI, 0.22 to 0.34]; $P = .001$, $d = 1.5$; Fig. 5B).

Crucially, even though there was some overlap of the SDs and the ranges found in the performances of the vision impairment participants and the simulated impairment participants while attempting to cheat, these measures could be used with reasonable accuracy to discriminate those with actual impairment from the cheaters. For the logMAR SD, the results showed overlap between the two groups for scores up to 0.12 logMAR (Fig. 6A). As a result, a cutoff for the logMAR SD of 0.13 or greater would correctly identify 100% of the vision impairment participants who were not cheating and 69% of the cheaters. Similarly, for the logMAR range, there was overlap at 0.1 and 0.2 logMAR with a cutoff of 0.25 or greater, also correctly classifying 100% of the honest performances of the vision impairment group and 69% of the cheaters (Fig. 6B). A combination of the two measures did not improve discriminability between those with actual vision impairment and those attempting to cheat, because there were no cases where the cutoff for logMAR range might have correctly identified someone who was cheating who was missed using the cutoff for SD. As a result, either a threshold SD of 0.13 logMAR or greater or a range of 0.25 logMAR units or greater both provided the most accurate detection of whether someone was cheating.

DISCUSSION

The aim of this study was to investigate whether the intentional underrepresentation of vision could be detected when performing a test of visual acuity in order to protect the interests of individuals who truly have vision impairment. Participants were tested with the Berkeley Rudimentary Vision Test both when they performed the test honestly and when they had the intention to cheat so that their visual acuity would appear worse than it really was. The results revealed that participants were successfully able to cheat on the Berkeley Rudimentary Vision Test in order to underrepresent their level of visual acuity. However, their responses on the Berkeley Rudimentary Vision Test were significantly more variable when they were cheating. This increased level of variability when cheating could not be explained by the worse level of vision being simulated and/or differences in the tests (Tumbling E's or letter chart) used. Even though variability in honest testing conditions was increased in individuals with actual rather than simulated vision impairment as expected,[16] the level of variability of those attempting to cheat remained significantly more variable. These results are promising in that they indicate that the variability in performance on a set of similarly difficult tasks of visual function might provide a useful means of detecting the intentional underrepresentation of vision. Against our expectations, though, the variability in responses did not change when using a modified test procedure that was designed to be less predictable than the standard procedure, supporting the suitability of the current procedure.

The results of this study show that it is, not surprisingly, markedly easy to "cheat" on a test of visual acuity. The participants were clearly capable of pretending that their vision was much worse than it was. The subjective nature of most vision tests presents a

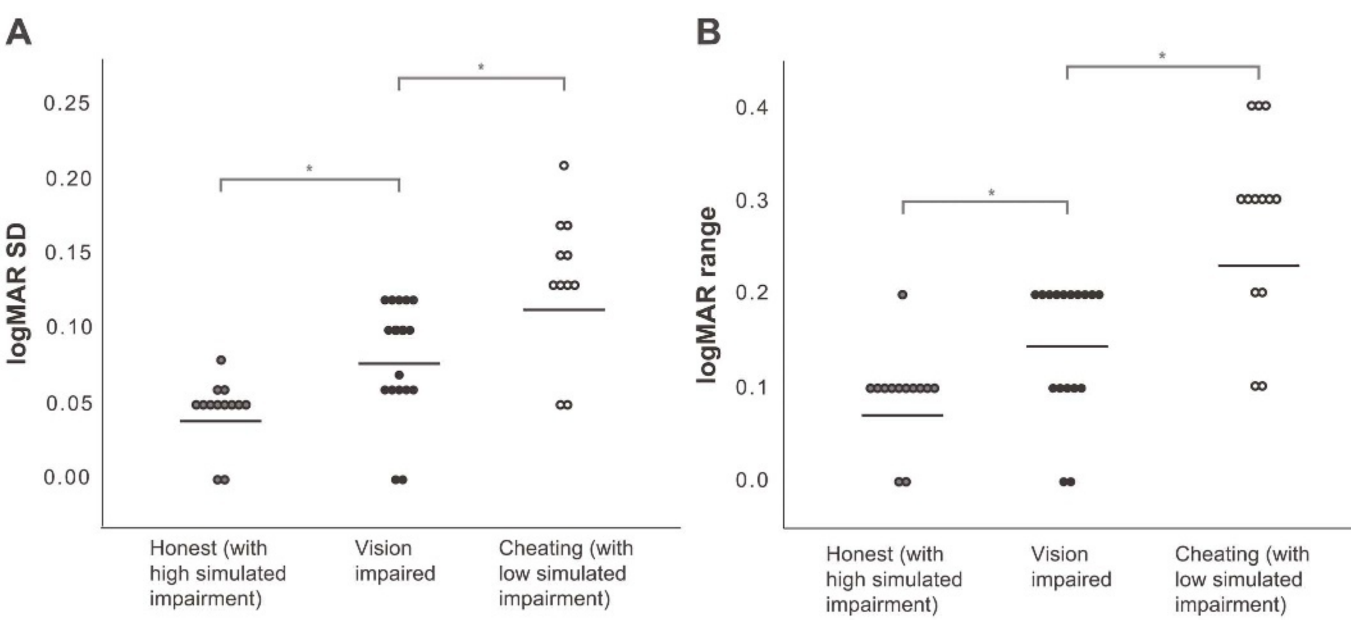

FIGURE 5. Comparison of the Berkeley Rudimentary Vision Test outcomes of the vision impairment participants with the participants with simulated impairment when honest (with high simulated impairment) and when cheating (with low simulated impairment). (A) SD in logMAR values. (B) Range in logMAR values. Increased variability was found in the logMAR values of the vision impairment participants when compared with the normally sighted participants when responding honestly with high simulated impairment. Lower variability was found in the logMAR values of the vision impairment participants when compared with the normally sighted participants when cheating with low simulated impairment. *Significant difference ($P < .05$).

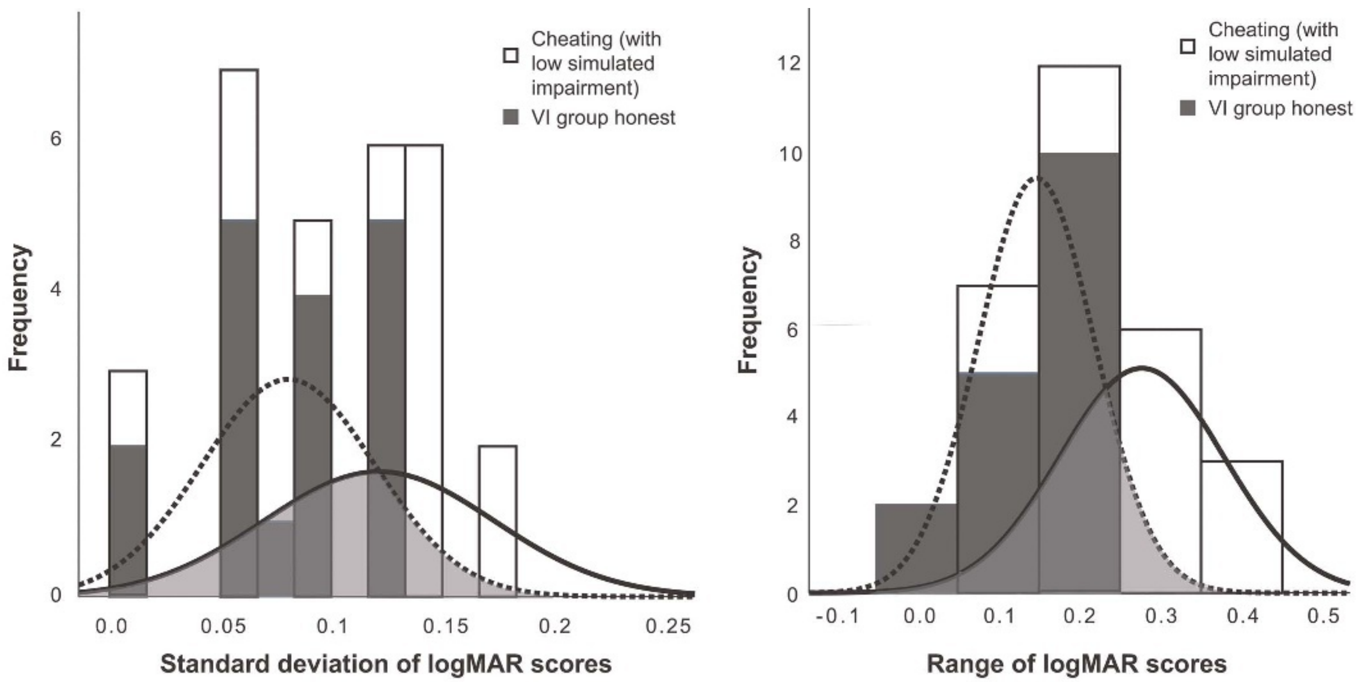

FIGURE 6. Distribution in Berkeley Rudimentary Vision Test outcomes compared between vision impairment participants and participants with simulated impairment while cheating (with low simulated impairment). (A) SD of the logMAR values. (B) The range in logMAR values. Gaussian fits are shown for the two conditions, with limited overlap (shaded areas) between the curves indicating that the outcomes are able to reliably distinguish between participants who provided honest and dishonest responses.

challenge for clinicians to make judgments about the vision of people who clearly have incentive to misrepresent their true ability. This means that clinicians need to search for evidence to support their clinical findings to rule out intentional misrepresentation. This would typically be done by evaluating the changes in vision that would be expected on the basis of the severity of the underlying medical condition that is causing the vision loss. Although these types of judgments are achievable when there is observable damage to the eye itself (e.g., corneal or retinal damage), they can be particularly challenging in other conditions where physical damage to the eye might not be apparent (e.g., amblyopia). Therefore, additional tools are desirable to assist clinicians in making these judgments. Electrophysiological testing may hold promise as one such means of assisting the clinician, although the ability of these techniques to provide a reliable estimation of visual acuity is doubtful.[17,18] Similarly, the optokinetic nystagmus test might also provide assistance to the clinician, although, while shown to provide a repeatable measure of visual acuity, the technique is not yet able to provide a very accurate estimation of visual acuity.[19] Fortuitously, our experiment has uncovered a simple guide for when clinicians should be doubtful about the veracity of their clinical findings when testing visual acuity using the Berkeley Rudimentary Vision Test.

A measure to detect whether someone is cheating would ideally possess both high sensitivity and high specificity. If either of these requirements is not met, then there is a risk that the measure will fail to detect those who are cheating (low sensitivity), or maybe even more importantly, it would lead to false accusations of cheating (low specificity). In the present study, both the logMAR range and SD provided perfect specificity and a reasonably good level of sensitivity. A combination of the SD and range did not add to the sensitivity reached by using only one of the two measures. Because the logMAR range is the easier measure to use in a clinical scenario because it requires only a quick subtraction of the minimum from maximum value, it would appear to be a better candidate measure for identifying those who might be cheating.

An issue worthy of further investigation is whether the degree of variability in visual acuity found when cheating can be reduced as a result of an extended period of training. In this study, participants were given brief instructions on how to pretend that their visual acuity was worse than was actually the case and were subsequently given one practice session that took approximately 15 minutes to perform. After the training, participants were given feedback about how well they cheated (i.e., how close they got to the logMAR value they aimed for). However, a person sufficiently motivated to cheat, for example, to receive disability benefits or to increase his/her chance of winning a Paralympic medal, might practice his/her cheating to a greater extent than the one practice session used in this study. Future work may investigate whether a prolonged period of training would lead to less variability in the performance on the Berkeley Rudimentary Vision Test.

A clear advantage of the Berkeley Rudimentary Vision Test is that it provides up to four estimations of a person's visual acuity, although we were also interested in uncovering whether the predictable manner in which these estimations are made might make it easier to cheat. The standard Berkeley Rudimentary Vision Test procedure recommends that a single optotype is systematically moved in toward (or away from) the observer to establish the farthest distance at which the optotype can be reliably resolved. We were concerned that this procedure might make it easier to be consistent across the four different optotypes. We designed an alternative protocol that presented each combination of optotype and test distance in a randomized fashion. If the existing test procedure did make it easier to cheat on the Berkeley Rudimentary Vision Test, then we would have found an increase in the variability of the estimates on the modified test procedure. Instead, we found no difference in the variability in the logMAR values between the different test procedures, suggesting that the standard procedure is robust to intentional misrepresentation. This should provide clinicians with confidence that the recommended procedure is suitable for detecting cheating.

Most tests of vision are subjective and, like the Berkeley Rudimentary Vision Test, rely on patients to provide their best effort to accurately determine their level of visual function. This makes these tests vulnerable to cheating. The present study provides promising results for a way to help detect intentional misrepresentation specifically on the Berkeley Rudimentary Vision Test, but this approach can certainly also be used to develop a way to detect cheating on other subjective tests of visual function. In this study, we were able to detect intentional misrepresentation by testing for variability in performance when performing different tasks that share a common level of task difficulty, similar to what has been shown to be reliable when detecting whether someone is performing submaximally on tests of physical performance.[13,15] A first step to design a method to detect cheating on other tests of vision is to ensure that test performance can be measured using different tasks that have the same level of difficulty.

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