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Abstract

Contrary to the assumption that vision worsens over time, the current experiments show that visi\ be improved by manipulating mindsets. Experiment 1 primed the mindset that pilots have excellent vision. Vision improved for participants who experientially became pilots through instructions and by flying a realistic flight simulator compared to control participants who pretended they were pilots and performed the same task in a "broken" flight simulator. Participants in two further conditions, an "eye exercise" condition (mindset: improvement occurs with practice), and a "motivation" condition (mindset: try and you will succeed) demonstrated visual improvement relative to the "pretend pilot" group. Experiment 2 primed the mindsets that athletes have superior vision. Controlling for arousal, more athletic jumping jacks resulted in greater visual acuity than skipping. Experiment 3 took advantage of the mindset primed by the traditional eye chart: since letters get progressively smaller, soon we will not be able to see and we expect to be able to read the first few lines of the chart. By using a "reversed chart" and a "shifted chart" participants could now see what they couldn't see before. Thus, mindset manipulation can counteract physical limits imposed on vision.

Believing is Seeing: Using Mindlessness (Mindfully) to Improve Visual Acuity

Contrary to the assumption that vision worsens due to increasing physiological limitations, the current experiments test whether vision can be improved through psychological means. The constructive nature of visual perception is evidenced through a complementary interaction between top-down inputs, including expectations, contextual information, pre-existing networks of knowledge, and bottom-up stimuli (Cavanagh, 1991; Engel, Fries, & Singer, 2001; Miller & Cohen, 2001). The contributions of the top-down system point toward the possibility that mindlessness may unwittingly limit our visual acuity. Indeed, when we showed people index cards with slightly altered familiar sayings (e.g. “Mary had a a little lamb), people were blind to the letter repetition (Chanowitz & Langer, 1981; Chun & Marois, 2002). The most dramatic example of mindless blindness was an experiment by Simons and Chabris (1999), in which over 50% of the participants, instructed to count the number of passes of two basketballs among team members, failed to see a man in a gorilla suit walk on the court in the middle of a basketball game.

It seems reasonable that stimuli not attended to (nor relevant for one’s task) would be swallowed by perceptual darkness, even if the stimuli are dynamic. Even goal related stimuli, however, if seen as static, would succumb to invisibility due to neural eye adaptation, if they were not counterbalanced by fixational eye movements (Martinez-Conde, Macknik, & Hubel, 2004). In a psychological extension of this neural law, we hypothesize that goal-relevant objects whose meanings are seen as static would succumb to habituation and therefore become invisible sooner than others. States of mind, particularly those concerning mindless stability versusmindful flexibility of meaning, could be seen as directly affecting visual perception.

ther cognitive states also have been shown to affect visual processing. In the study of over-learned phrases discussed above (Chanowitz & Langer, 1981), we found that while most people did not see the repeated letters on the cards, advanced meditators did. Brown and colleagues (1984) also found that advanced practitioners of Buddhist meditation have better visual sensitivity than non-meditators. They are better able to detect short single-light flashes, and require a shorter interval to differentiate between successive flashes correctly, in comparison to the control group (Brown, Forte, & Dysart, 1984).

Thus research suggests that vision may be improved by changes in our consciousness. We believe that it is our mindsets regarding vision that limit our visual performance Mindsets are often referred to as cognitive processes that support solving various tasks (see Gollwitzer, Heckhausen & Steller, 1990), such as 'seeing'. They incorporate implicit expectations people hold about actions, behaviors, activities, and people related to certain tasks and are often the result of mindless processing of potentially relevant information. Mindlessness (e.g. Langer 1978, 1985, 1989, 2002, 2009) is characterized by an absence of active, conscious, information processing, where individuals rely on cues that have been built over time or have been appropriated from another source with no new interpretations. Research has shown that participants who form such mindsets perform in accordance with their mindless beliefs, often for the worse (Chanowitz & Langer, 1981). Mindsets, however, can also affect performance positively as in the case of placebos.

In contrast, Mindfulness (e.g. Langer 1978, 1989, 2002, 2005, 2009) can be defined as active distinction making, where new stimuli are perceived as having continually emerging meanings, rather than fossilized versions of previously held ones. It has been demonstrated that mindful processing of information results in various health related outcomes including increased longevity (Langer, E. & Rodin, J., 1976; Rodin, J. & Langer, E., 1977; Langer, E., Beck, P., Janoff-Bulman, R. & Timko, C., 1984; Alexander, C., Langer, E., Newman, R., Chandler, H. & Davies, J., 1989; Langer, 2009). . In the following research, we test the hypothesis that visual acuity is limited by mindsets. In four experiments, we varied mindsets within the context of visual performance, arguing that an individual's mindfulness might be as powerful if not more to bring about the physical changes we describe below.

It is important to note that mindsets are not necessarily inaccurate, only inflexible. We use the following mindsets to test the malleability of visual acuity: 1) pilots have excellent vision, 2) exercise and 3) motivation improve performance, 4) physical fitness improves performance, 5) one is bound to see less as one reads down the eye chart, and that 6) one should be able to read the first few lines of an eye chart. Doing so, we extend the priming literature to vision and are able to explore visual acuity in mundane circumstances, allowing for greater generalization. As will be seen in Study 2 we test the added effects of mindsets over momentary arousal as the explanation for improvement.

Study 1

Experimental Overview

To exploit the belief that Air Force pilots have excellent vision, experimental subjects were asked to allow themselves to become pilots and fly a flight simulator. It was explained that to be a pilot is to become the part being played and not, as in role-playing, to have a sense of oneself as separate from that part. Comparison participants were asked to pretend to fly a flight simulator and role-play being pilots. It was hypothesized that the experimental group, with minds more fully in a pilot context, would take on some of the attributes associated with pilots. The attribute we tested was that of having excellent vision. No mention of vision was made to either group. In addition, we controlled for effects of exercise and motivation on vision to see if mindset effects did indeed account for additional improvement. Accordingly, two new groups were added to the above design. For the first group we primed the mindset that exercise improves performance. These participants were given eye exercises. For the second group, we primed the mindset that improvement follows motivation. These participants were asked to read motivational instructions (try hard to improve vision).

Method

Participants

In a first run (study 1a), nineteen members of Reserve Officers Training Corps (ROTC) program at Massachusetts Institute of Technology (MIT) (none of whom were pilots) served as participants. Many ROTC members aspire to become fighter pilots and a prerequisite for pilot training is 20/20 vision or better. Thus, an ROTC student should strongly associate good vision with pilots. An independent sample of twenty cadets from this population was questioned about the ten most important characteristics of a pilot: 100% listed vision, and for 95% it was among the top three characteristics named.

All of the cadets in the experiment had at least 20/20 vision and were randomly assigned to either the experimental group (N=10) or the control group (N=9), which were equivalent with respect to their vision at the start of the investigation.

In a second run, we attempted to replicate and extend the previous findings with 44 further MIT ROTC members. In addition to the previous conditions we tested the effect of exercise and motivation on vision.

Procedure

Participants were tested individually. They were given a standard eye test. To avoid practice effects, two separate Snellen eye charts were counter-balanced. The conditions in which all of the eye tests were administered, such as the lighting, were kept constant for both groups. Participants then completed the procedure in accordance with the group to which they were randomly assigned.

Experimental Group (N=10). The participant was brought into a flight simulator. An actual cockpit including flight instruments was mounted on hydraulic lifts mimicking aircraft movement and performance. Participants were asked to *be* Air Force Pilots, whatever that meant to them. Towards this end, participants were given green army fatigues to wear. The participant was brought into a *working* simulator and positioned in the pilot's seat. Thus, "flying" the simulator closely approached flying an actual fighter jet.

Looking at the screen, participants were performing simple flight maneuvers. Afterwards, while remaining flying on a straight and level course (with the aid of the experimenter when needed), the participant was asked to identify the markings on the plane wings. Outside the front window at eye level, twenty feet away, were four schematic wings. On each, in place of traditional markings, was a line from an eye chart. The eye chart was divided so that each of the bottom four lines (20/20 to 20/10) of the chart appeared on one wing. Stars were added to the beginning of each line to offer a more realistic effect. The results of this eye test were recorded and participants were debriefed.

Broken Simulator Control Group (N=9). This group was treated in exactly the same manner as the experimental group, with the following changes: Participants in this group were informed that the simulator was broken, but that the experiment would proceed anyway. The participant was seated in the pilot's seat while an experimenter sat in the co-pilot's seat. The participant was asked to take hold of the steering wheel and to play the role of a pilot.

A description of some of the basic controls of the airplane (such as throttle, compass, and the artificial horizon) was given. The participant was then asked to simulate the basic maneuvers as in the experimental group, except that during this entire sequence the simulator was off. Nevertheless, the participant manipulated the steering wheel as if he were really flying. Finally, as in the experimental group, they were asked to read markings on the schematic plane wings. The results of this eye test were recorded and participants were debriefed.

In a second run of the outlined study (study 1b), we enlisted forty-four members of the R.O.T.C. program at M.I.T. as participants. As determined by an initial eye test, participants had vision between 20/15 and 20/30. Thus, the second run included participants with worse-than-average, as well as better-than-average eyesight. The cadets were randomly distributed among the prior two conditions (pilot =12, non-pilot=11) and the added conditions (exercise=11, motivation=10), and there were no significant initial group differences in vision.

The procedures followed were the same as in the first run for the working/broken simulator conditions, and additionally included eye exercise and motivation groups.

Eye exercise group. It is a common belief that improvement occurs with practice for most skills. To see if we could exploit this belief with respect to vision, participants in this group were asked to read a memo after their initial eye test. The memo was entitled "Visual Acuity Enhancement." It described imaginary "concrete steps" that could be administered to improve eyesight. The memo was purportedly signed by a Major in the U.S. Air Force. It listed the following ten steps: a) be seated comfortably; b) close eyes for 15 sec.; c) focus on a point 1-1.5 ft. away for 10 sec.; d) close eyes for 5 sec.; e) focus on a point 20 ft. away for 10 sec.; f) close eyes for 5 sec; g) focus on a point 1-1.5 ft. away for 10 sec.; h) blink for 5 sec.; i) close eyes for 5 sec.; j) read eye chart.

The participant was then brought to the simulator but did not fly it. Each participant was informed that the simulator was currently not working, but that they could proceed without difficulty anyway (they never manipulated the controls). They were then asked to follow the steps outlined in the memo. Colored cards were positioned 1.5 and 20 feet away for the participant to focus on when it came time to do so in the exercises. After completion of the exercises, participants were given the final "approaching aircraft" eye test.

Motivation control group. An attempt was made to motivate participants to try to see as well as they possibly could to control for how much of the improvement in the pilot group might be due to simple motivation. After the initial eye test, each participant was told the simulator was broken (the participant never manipulated the controls), but that the experiment would continue just the same. Once brought into the simulator the participant was asked to read a brief essay on motivation (taken from Winters, 1973). After completion the participant was strongly urged to be as motivated as possible and try hard to see the "letters or numbers on the wings of the approaching aircraft." As such a mindset was primed that being motivated meant one could see better if one chose to. Upon completion the participant was escorted from the simulator and debriefed.

Results and Discussion

In the first run (study 1 a), we observed no significant differences between the groups with respect to their initial visual performance. The mean vision pretest score was 20/14.2 for the control group and 20/14.2 for the experimental group (F < 1). Results show that in the experimental group vision improved for 40% of experimental group (4 out of 10) while no one in the control group (0 out of 9) improved ($X^2 = 4.57$, $p < .05$). In fact, one participant in the comparison group performed less well while no one in the experimental group declined in performance. This finding lends support to our hypothesis that vision may be improved by psychological means. Since all of the participants in the study already had better than average vision (mean 20/14.2) the results could imply that interventions of this sort might be used not only to improve below average performance (useful in itself), but also to extend positive performance.

In the second run (study 1b), we included two additional groups and again there were no significant differences in participants' initial visual acuity. The pretest vision scores were 20/23.2 for the broken-simulator control group, 20/18 for the motivation control group, 20/21.8 for the eye exercise group, and 20/26.7 for the pilot/working simulator group (p > .10). We found that the following proportions of participants improved their visual performance: 42% (5 out of 12) of the pilot/working-simulator group; 18% (2 out of 11) of the "eye exercise" group; 10% (1 out of 10) of the "motivated group; and 0% (0 out of 11) of the baseline broken-simulator group. A proportional contrast analysis (see Rosenthal and Rosnow, 1985) matching our hypotheses (that the "pilot" mindset group was superior to the "exercise" group, which was in turn superior to the "motivated" control group, which was better than the baseline control group) was significant ($Z = 2.86$; $p < .05$ (one-tailed)). The comparison of these transformations supports the findings of the first run. Forty-two percent of the experimental "pilot" group (asked to *be* pilots) actually improved, while no one in the broken-simulator control group showed any improvement ($X^2 = 5.90$; $p < .05$). The "pilot" group was also significantly better than the motivated control group. Even though this group was encouraged to try as hard as they could to improve their vision, only one out of 10 people of this group improved ($X^2 = 3.8$, $p < .06$). As such, we find support for the superior effect of the pilot condition over other psychological manipulations of exercise and motivation.

Furthermore, we found people with poorer vision improved more than those who began with excellent eyesight, given there was more room for improvement. Of those exposed to either the "pilot" or the "eye exercise" manipulations in Experiments 1 and 2, 21 people had 20/20 vision or better. Of these, 23% improved. Of the 12 people who had 20/30 vision (in the second run of the pilot study), 50% improved ($p < .05$).

Overall, the findings support the hypothesis that mindsets influence vision, and that implicit mindsets had a stronger effect than explicit manipulation of motivation. One could argue, however, that vision did not improve because of vision-enhancing mindless beliefs, but rather because the pilot group was more aroused momentarily than the remaining groups. To test that hypothesis, we conducted the following experiment.

Experiment 2

Experimental Overview

To assess whether momentary arousal or the mindset manipulation explain the data better, two groups of aroused participants were asked to read an eye chart before and after completing physical exercise. For the experimental group, the arousal was conjoined with a potentially vision-enhancing mindset, and for the comparison group it was not.

Method

Participants and Procedure

Thirty-two male college students were randomly divided into two groups and were instructed by an experimenter, who was blind to the hypothesis, that we were interested in the relationship between arousal and vision. Participants read the Snellen eye chart, exercised, and were then informed that we expected exercise to improve vision so that we would like them to do their best and read the eye chart again.

The exercise for the experimental group consisted of doing fifteen jumping jacks (20 seconds of exercise). Comparison participants, in contrast, were asked to skip around the room for a minute. In pretesting, these two activities were found to be equivalent with respect to pulse rate from a resting position (the average pulse increase for people performing jumping jacks was 17.9, while the average pulse increase for people skipping was 21.6; $p>.1$). Pretesting also showed that jumping jacks were considered more athletic than skipping (100% of 20 people asked considered jumping jacks more athletic than skipping).

Assumptions about physical fitness often influence our assumptions regarding fitness of the senses. Moreover, athletes have consistently been examined with higher visual acuity than non-athletes (e.g. Stine, Arterburn & Stern, 1982; Christenson & Winkelstein, 1988).This seems reasonable because vision enhances most forms of coordination, the basis of athletic ability. Out of 16 people surveyed, 11 (64%) responded that athletes had better vision than non-athletes. To the extent that experimental participants were being athletes, and that their mindset linked athletes and good vision, vision should improve.

Results and Discussion

The two groups did not differ in vision on pretreatment scores. The mean for the jumping group was 20/14.58 compared to a mean of 20/16.25 for the skipping group ($p > .10$).

Only two people had poor vision (worse than 20/20) and they were in the skipping group. The results show that only 6.25% (one participant) in the skipping group improved on post testing while 37.5% (six participants) of the experimental group improved ($X^2 = 4.57$, $p < .05$). The results of this experiment suggest that it was the mindset regarding athleticism rather than sheer exercise arousal that influenced vision.

Experiment 3

Experimental overview

As the prior experiments demonstrate, mindsets can influence visual acuity. This raised a more fundamental question about how we know how well we can see. Our understanding of our visual acuity comes primarily from our visit to optometrists who test the limits of our vision under circumstances that differ greatly from the life most of us experience. In Experiment 3, we tested whether implicit expectations generated by mindsets affect these limits, while holding arousal constant.

Experiment 3 employed a within participant design and included both women and men as participants. The mindset tested here was that people hold a rigid (but rational) belief that we are likely to see less well as we read down an eye chart, since letters get progressively smaller. We presented each participant with either a classical eye chart, a reversed eye chart, or a shifted eye chart.

Reversed: Here letters become progressively larger further down the chart. Thus the standard eye chart creates the expectation that soon we will not be able to see, while the opposite is true for our reversed chart. Our hypothesis was that participants would see more letters from the reversed rather than classic condition.

Shifted: We primed the mindset that most of us can see the first few lines of the chart and that problems seeing will occur around 2/3 of the way down the chart. As such, we shifted the eye chart to start at 2/3 of the standard Snellen eye-chart

Method

Participants and Procedure

Twenty participants (7 women and 13 men) were ushered into a room, individually, and asked to read from each of the two Snellen eye charts (in random order) from the distance of 10 feet. Afterwards the reading of the charts, participants were given a questionnaire with demographic questions; they were also asked whether they thought vision could improve.

Control condition. The control condition was a classic Snellen chart in which the letters got smaller as eye traveled down the chart. *Reversed chart* . The second chart was a reverse of the classic chart, so that from top to bottom the letters got increasingly bigger.

Shifted chart. The shifted chart was an expanded version of the bottom third of the normal Snellen chart – it began with letters equivalent to those of medium size letters on the normal eye chart at the top of the page, to letters of very small size at the bottom. The idea was that the letters at the top of the 'shifted' chart would be expected to be seen better, even though their size was relatively small, just because they are on the top of the chart. Participants were presented with the charts in random order, to control for practice effects. Results were recorded.

Results and Discussion

The results show support for our hypothesis. There were no significant differences in visual acuity between the groups in pretesting. Participants accurately saw a significantly greater proportion of letters from the smallest line of the Snellen chart (font 21 letters) when it was presented in the reversed (on the top) (M_r = .57, SD = .44) rather than the classic (on the bottom) format (M_c = .11, SD = .26). Results of the matched t-test comparing the reversed and traditional charts were significant: $t(19) = -4.45$, $p < .001$. This result was confirmed when we found that participants also saw more letters in the reversed condition on the next-to-smallest line, font 33 (line 8 in the classic, and line 2 in the reversed chart; (M_r = .77, SD = .37), than in the classic condition, (M_r = .59, SD = .43);($t(19) = -2.90$, $p<.01$)). No other lines showed any differences in visual acuity, which was expected, given that all participant could read them, and no variability in performance was generated.

The results of the questionnaire show that 11 participants believed vision could improve, 6 believed it could not, while 2 had no opinion on the issue. Post-hoc t-tests revealed that participants who thought they could improve showed significantly greater improvement ($t(15) = 2.29$, $p < .05$) than participants who did not think improvement was possible, but only for the next-to-smallest line (font 33). This effect did not hold for the smallest line.

As predicted, when we compared the shifted and traditional charts, the matched t-test showed that participants read significantly more letters accurately when they were presented at the top of the chart (shifted condition) (M_r = .87, SD = .25), than at the bottom third of the chart (control condition), (M_c = .81, SD = .31), ($t(19) = -2.34$, $p < .05$; (for font 43)).

General Discussion

These studies support an earlier investigation which found that when elderly men were primed with mindsets of their life as lived 20 years earlier, it resulted in increased hand strength, joint flexibility, mental acuity, looking younger, as well as visual performance (Langer, 1989; 2009). In the presented studies, we found additional support for the hypothesis that reversing mindsets improves visual acuity. The fact that the primed mindsets tested are unrelated to each other suggests the ubiquitous nature of the ability to overcome physical limits with psychological means. Interestingly, visual training programs where people are given eye exercises to improve visual acuity, may be effective because they prime the belief that exercise improves vision.

On a more general level, the question becomes how does mindlessness affect visual acuity? In the case of mindless blindness, stimuli that are not goal-related are not seen. In the case of habituation, even stimuli that are goal-related can become invisible. It could be the case that visual habituation processes depend not only on the physical stability of objects, but on the stability of their meaning as well. Most of the time, mindsets imply habituation to the visual stimuli – whereby we literally stop seeing things that have constant meaning to us. Mindfulness, by contrast, creates novelty and thus stimuli have different, continually emerging meaning. The mindful process of continual distinction making with regard to familiar stimuli prevents habituation, and therefore prevents mindless blindness. It is experienced as engagement; as such, it is energy begetting not consuming and may create a more sustained level of arousal if not tied to a particular mindset.

These studies suggest that vision is limited, at least in part, by mindlessness. While we made positive use of mindlessness, far greater and sustained improvement is likely to follow from mindfulness. Mindfulness does not rely on a second person's intervention, is more open process and is self-sustaining (see Langer, 1985, 1989, 1994; 2005, 2009). To take full advantage of mindfulness, however, one first has to question one's mindless beliefs about what is and is not possible.

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