Visual attentional processing was examined in adult meditators and non-meditators on behavioral measures of change blindness, concentration, perspective-shifting, selective attention, and sustained inattentional blindness. Results showed that meditators (1) noticed more changes in flickering scenes and noticed them more quickly, (2) counted more accurately in a challenging concentration task, (3) identified a greater number of alternative perspectives in multiple perspectives images, and (4) showed less interference from invalid cues in a visual selective attention task, but (5) did not differ on a measure of sustained inattentional blindness. Together, results show that regular meditation is associated with more accurate, efficient, and flexible visual attentional processing across diverse tasks that have high face validity outside of the laboratory. Furthermore, effects were assessed in a context separate from actual meditation practice, suggesting that meditators’ better visual attention is not just immediate, but extends to contexts separate from meditation practice.

© 2010 Elsevier Inc. All rights reserved.

1. Introduction

In everyday life, humans function as though visually perceived stimuli represent veridical external reality. However, among psychologists it is widely accepted that perception is constructed both from bottom-up (or sensory) and top-down (or cognitive) processes (e.g., Brewer & Loschky, 2005; Long & Toppino, 2004). Furthermore, much research shows that top-down or cognitive factors influence what we actually see in visual perception (e.g., Balcetis & Dale, 2003; Bhalla & Proffitt, 1999; Proffitt, Creem, & Zosh, 2001; Ruz & Nobre, 2008). One top-down process that influences basic visual perception is self-related beliefs. Specifically, Balcetis and Dunning (2006) investigated in five studies how the motivation to think favorably of one’s future outcomes influences visual perception. They demonstrated that experimentally manipulated self-related motivational states caused individuals to perceive ambiguous visual stimuli in directions that would accrue favorable outcomes for themselves. Moreover, Study 5 ruled out conscious deception as an explanation, allowing the authors to conclude that self-related motivation biases visual perception at the preconscious level.

Given that self-related constructs can bias visual perception, individual differences in self-functioning also might systematically influence perception, but this has not been widely examined. The current study investigated perception as a function of meditation practice. Gradual de-construction of self-related beliefs is at the core of Buddhist practice (Loori, 1992; Trungpa, 1995); hence, over time, effective meditation should lessen the tenacity of self-related motivational states. To the extent that meditation lessens self-absorption, perceptual bias associated with self-related motivation (e.g., Balcetis & Dunning, 2006) also might be reduced.
An alternative second pathway by which meditation could decrease visual perceptual bias is even more direct and concrete. Although meditation techniques differ (Lutz, Slagter, Dunne, & Davidson, 2008), they have in common the monitoring and regulation of attention, which is central to visual perception. Thus, meditation could improve perception quite directly, by heightening attentional processes, and also indirectly, by altering the self-functioning that contributes to perceptual bias. The current study examined the hypothesis that meditation is associated with superior visual perception, without distinguishing between the two possible mechanisms.

Some past evidence supports that meditation benefits visual perception. For example, intensive short-term meditation training improves stimulus detection (Brown, Forte, & Dysart, 1984), long-term Zen meditators show less Poggendorff visual illusion than novice and non-meditators (Tloczynski, Santucci, & Astor-Stetson, 2000), experienced meditators show greater improvement in stimulus detection during intensive retreat relative to new and non-meditators (Jha, Krompinger, & Baime, 2007), and those who focus on visual images during deity meditation have better mental imagery immediately afterward relative to non-meditators and meditators who use non-deity meditation techniques (Kozhevnikov, Louchakova, Josipovic, & Motes, 2009). Meditation also enhances specific attentional measures; for example, it improves short-term attention switching (Chambers, Lo, Allen, & Allen, 2008), decreases Stroop interference and improves concentration (Moore & Malinowski, 2009), changes brain-resource allocation, reducing the “attentional-blind” refractory period (Slagter et al., 2007), and is associated with the absence of expected age-related increases in attentional blink (van Leeuwen, Muller, & Melloni, 2009).

The conclusions allowed by the previous research are limited, however. Many of the above studies examined perception during or immediately after meditation (e.g., Chambers et al., 2008; Jha et al., 2007; Kozhevnikov et al., 2009; Slagter et al., 2007). Hence, whether improvement is sustained beyond the immediate context of meditation practice remains unclear. Most studies examine only one or two measures, sometimes even using paper and pencil tests of perception (e.g., Moore & Malinowski, 2009), which are less precise and valid than reaction-time measures. Moreover, many studies use simple visual stimuli such as dots of light (e.g., Jha et al., 2007; Slagter et al., 2007), and the relation of such simple stimuli to naturalistic perception has not been established. Thus, the relation of meditation practice to complex visual perception such as that in natural settings is not well-established empirically. Other previous studies are methodologically limited due to small sample sizes (e.g., Kozhevnikov et al., 2009) or the failure to report sample size clearly (Jha et al., 2007). Hence, questions remain about the relation of meditation practice to visual attention and perception.

The current study assessed visual perception more comprehensively than many previous studies by including four previously validated reaction-time measures of visual perception. Three tasks have excellent face validity as measures of naturalistic attentional processing, which increases our confidence that results generalize to real-life perceptual processing. We examined the effect of an individual difference on visual processing by including meditators and age-matched non-meditators, and used a larger sample than many past studies ($N = 96$). We also tested participants in a context removed from the immediate practice of meditation. That is, participants did not meditate before completing tasks, which allowed us to examine whether regular practice is associated with better visual perception “off the cushion”, i.e., in everyday functioning, rather than during meditation. We hypothesized that it would be, and that regular meditators would show more efficient and flexible processing of visual stimuli as assessed by all measures.

One visual task assessed change blindness, which is the failure to detect large changes to objects or scenes (Simons & Levin, 1998). Change blindness is common and typically assessed with two versions of a static display that contain peripheral or non-distinctive changes presented with an interruption (Koivisto & Revonsuo, 2008; Simons & Ambinder, 2005). Little is known about individual differences, although situational effects in change blindness have been noted. For example, change blindness is reduced among domain-specific experts; for example, changes in football scenes are better detected by football experts (Werner & Thies, 2000). Consistent with this, participants show less change blindness when stimuli are personally socially relevant (Bracco & Chiari, 2009).

We measured change blindness with the previously validated ‘flickering task’ which alternates between two versions of static stimuli representing real-life situations (Rensink, O'Regan, & Clark, 1997). The scenes are unrelated to meditation, thus, differences in performance between meditators and non-meditators cannot be a function of expertise or social relevance demonstrated in previous research. Rather, any relation of meditation and flickering task performance would reveal general change blindness. To our knowledge this is the first study to examine the relation of an individual difference to change blindness.

Inattention that is even more pronounced is demonstrated in studies of sustained inattentive blindness, which refers to the failure to notice unexpected changes when attention is directed elsewhere (Most, Scholl, Cliford, & Simons, 2005). Sustained inattentional blindness differs from change blindness in its use of dynamic displays rather than static stimuli, and in its use of attentional sets. The most well-known measure is the gorilla video (Simons & Chabris, 1999) in which three white-shirted persons bounce basketballs as they circle among three black-shirted persons, who are bouncing balls and circling in the opposite direction. A woman dressed in a black gorilla costume enters the circle from the right, pounds her chest, and exits left. A high percentage of viewers fail to notice the gorilla, especially with an attentional set directing them away from the black gorilla, such as monitoring white-shirted players.
We utilized the gorilla video in two ways. First, we assigned a more difficult task than in previous use in order to measure visual concentration. Specifically, participants counted *dribbles and passes* by white-shirted players, rather than only passes as in much previous research (Simons & Chabris, 1999), in order to create a challenging task that assess visual attention to a fast-moving interaction that is similar to everyday life. We expected meditators to show better visual concentration, as demonstrated by greater accuracy in counting dribbles and passes. Second, we assessed sustained inattentional blindness as a function of meditation status. The difficult task was expected to increase overall sustained inattentional blindness compared to past research (i.e., 40%), however, the predicted better attentional skill of meditators should result in their lower sustained inattentional blindness relative to non-meditators, even under demanding instructions.

The third attentional task involved ambiguous images, a widely-studied visual processing task cited as exemplifying the strength of top-down processes (Long & Toppino, 2004). For example, exposure to images of young or old women bias inter-inattentional blindness relative to non-meditators, even under demanding instructions. To past research (i.e., 40%), however, the predicted better attentional skill of meditators should result in their lower sustained function of meditation status. The difficult task was expected to increase overall sustained inattentional blindness compared on demonstrated by greater accuracy in counting dribbles and passes. Second, we assessed sustained inattentional blindness as a function of meditation status. The difficult task was expected to increase overall sustained inattentional blindness compared to past research (i.e., 40%), however, the predicted better attentional skill of meditators should result in their lower sustained inattentional blindness relative to non-meditators, even under demanding instructions.

The final process we examined was selective attention, which is the ability to limit incoming information in order to focus elaborate processing on specific stimuli. Selective attention is adaptive because it allows individuals to consciously control and direct their attention. The ability has been widely studied with a cued-response time (RT) paradigm in which visual stimuli are presented in the right and left visual fields. Visual stimuli are preceded by cues that give information about the spatial location of upcoming stimuli; for example, arrows point to the right or left to indicate where the stimulus will appear (Posner, 1980). Participants are instructed to use cues to respond as quickly as possible. Most arrows point accurately to the upcoming stimulus; however, other arrows point the wrong way, or are straight lines, providing no directional information. Participants are asked to categorize stimuli (e.g., letters as W or M); response times reflect the benefit of valid cues and the cost of invalid cues, relative to neutral cues, for identifying stimuli. Good selective attention allows individuals to disengage quickly from an incorrectly cued spatial location and reorient attention to a correct location (Posner & Petersen, 1990). Thus, the measure relies on a subset of attentional processing and reflects flexibility in visual processing.

The selective attention task differs from the first three measures of attentional processing in that it is a laboratory task with less face validity in terms of real-life generalizability. However, it has been widely-used to examine perceptual attention, including individual differences (Evert, McGlinchy-Berroth, Verfaellie, & Milberg, 2003); thus, its use in the current study added a precise measure of the ability to limit incoming information, focus elaborate processing, and quickly re-direct attention. We expected that regular meditators, relative to non-meditators, would show better selective attention, reflecting greater efficiency and flexibility of visual processing.

In summary, we examined five measures of perceptual attentional processing in adults who were regular meditators and age-matched non-meditators. Four measures involved complex stimuli similar to those encountered in real-life settings, increasingly the face validity of results for naturalistic visual processing. Testing was separate from the actual practice of meditation, thus results were not due to immediate benefits; rather, group differences reflect more stable and lasting effects of meditation across everyday life. We expected that meditators would show more efficient and flexible visual perceptual processing across all measures.

2. Method

2.1. Participants

One hundred adults (66 women, 34 men) were recruited from two meditation centers and one monastery in northeastern USA, from mindfulness-based stress-reduction classes and the local NY capital district community, and from summer visitors to Skidmore College. Data were lost for one man and eliminated for 2 women and 1 man who had health-related cognitive deficits, resulting in 96 final participants (64 women, 32 men). Age ranged from 21 to 79 (M = 48.5, median = 50, SD = 12.9). Eighty-four (87.5%) self-described as Caucasian, 8 as another ethnicity, and 4 declined to answer. Data were collected between March 2007 and June 2008; participants were paid $35.

2.2. Materials

*Change blindness flickering task* (Rensink, O’Regan, & Clark, 1997). Three scenes flashed between two photographs that were identical except for one change (e.g., a railing changed height behind a couple eating dinner). The scenes included images of a restaurant, farm, and boat, each presented for 1.5 min. Participants were asked to identify the change in each scene as quickly as possible, press a key, and type a description of the change. Descriptions were coded for accuracy (range = 0–3; M = 1.39, SD = .94). Mean response latencies ranged from 8.4 to 60.2 s (M = 33.3, SD = 11.6).

*Gorilla video* (Simons & Chabris, 1999). In a video constructed for psychology research, two 3-person teams, dressed in white or black shirts, circle quickly in opposite directions while dribbling and passing basketballs. A gorilla-costumed
woman enters the circle from the right, faces the camera, pouds her chest, and exits left. In previous studies, 40% of participants instructed to count white-shirted player passes failed to notice the black gorilla (Simons & Chabris, 1999). Participants in this study received the more challenging task of counting both dribbles and passes among white-shirted players. The task required intense concentration; attesting to the task difficulty, fewer than 9% counted accurately. Discrepancy from the correct count of 29 was calculated and analyzed as a concentration measure; discrepancy scores ranged from 0 to 25 (M = 5.35, SD = 5.08).

After participants recorded the number of dribbles and passes, they described the scene. Descriptions were coded for mentions of the gorilla. Only 22% noticed the gorilla, which is lower than the 40% in past studies (Simons & Chabris, 1999), again attesting to task difficulty.

Ambiguous image perspective-switching task. Three ambiguous figures that could be viewed in two alternative ways were used to measure perspective-switching. The task was explained with the widely-known old woman/young woman image. The three experimental images were drawings that could be viewed as (1) a duck versus a rabbit, (2) a cowboy versus an old man, and (3) a saxophone-playing figure versus a woman’s profile. Participants pressed a key as quickly as possible after identifying an image. They viewed an image, wrote a description, viewed it a second time to identify the alternative perspective, and wrote a second description. No participant reported previously seeing any experimental image.

Descriptions were coded according to a gist criterion, assigning one point for every accurate description. The number of perspectives identified out of 6 possible ranged from 2 to 6 (M = 4.92, SD = .96). Response times for the first viewing ranged from 1.06 to 21.23 s (M = 5.0, SD = 3.67); second viewing responses ranged from 2.73 to 481.1 s (M = 42.18, SD = 58.40).

Selective attention task (Posner, 1980). A cued-response task modeled after the low-load condition of Evert et al. (2003) was used to measure flexibility in re-directing visual attention. Uppercase letters “M” and “W” appeared in the right and left visual fields and participants were instructed to categorize letters accurately and quickly by keeping the right index finger on the down-arrow key (labeled “M") and the left index finger on the up-arrow key (labeled “W”). Just prior to each M or W stimulus, a centrally-located cue appeared on the screen. There were three kinds of cues. Valid cues were arrows pointing right or left to accurately indicate letter location; they facilitate categorization responses and decrease RT. Neutral cues were straight lines providing no location information, and so were expected to not influence RT. Invalid cues were arrows pointing to the opposite direction from which letters appeared; invalid cues interfere with responding and increase RT because participants must disengage from incorrectly cued information. Participants were instructed to utilize cues because, although some were incorrect, there were twice as many valid as invalid cues, and therefore cues should help facilitate overall responding. In this task, flexibility in selective attention is indicated by faster RTs, especially for invalid cues.

Participants viewed the display from a distance of 45 cm where the side of each square subtended 1.27° visual angle. The distance between the center fixation point and center of an empty square subtended 5.73° visual angle. Each of 72 trials (32 valid, 24 neutral, 16 invalid) lasted approximately 4 s; stimuli were added to the screen as follows:

- central fixation dot (1000 ms);
- empty 1 cm boxes on left and right sides (500 ms);
- centrally-presented cue (180 ms);
- blank screen (15 ms);
- uppercase M or W presented in the right or left box (until response).

Incorrect response RTs and outliers (more than two SD above the mean) were recoded as missing. Eleven participants (5 meditators, 6 non-meditators) were excluded from analysis of this measure for not attending to cues, as evidenced by longer neutral than invalid cue RTs.

Meditation questionnaire. Participants were asked about past and current meditation experience, including frequency, length, and type of meditation. Among those who reported currently meditating, meditation time ranged from very little (e.g., 10 min per month) to extensive (more than 4.5 h per day). Thus, simply dividing participants into those who meditate at all (N = 60) and not at all (N = 36) would not capture meaningful differences in meditation practice. We reasoned that benefits occur with regular meditation practice, and therefore created groups according to whether or not participants meditated fairly regularly, operationally defined as at least 3–4 days per week. Thus, the meditator group included participants who meditate at least every other day (N = 51; 29 women, 22 men) whereas the “non-meditator” group included those who meditate very little or not at all (N = 45; 35 women, 10 men). The two groups differed significantly on time per week meditating, F(1, 94) = 31.75, p < .0001, r = .50 (meditators: M = 9.95 h, SD = 1.05; non-meditators: M = 0.38 h, SD = 1.34). The groups were matched on age (meditators: range = 21–79 years, M = 48.1, SD = 14.2; non-meditators: range = 25–75 years, M = 49.0, SD = 11.4) and income (for both, range = less than $20,000 to more than $110,000; median = $50,000).

2.3. Procedure

Participants arrived at a quiet room at a meditation center, monastery, college classroom, or psychology laboratory and were run in groups of 1–4. All instructions appeared on the computer. Participants completed measures in a self-paced manner on a Dell computer with the majority completing it in an hour (range = 45–90 min). Tasks were administered in the following constant order: Gorilla video, selective attention, change blindness, perspective-shifting, and meditation.
3. Results

Data analysis. Analyses of covariance were performed with between-subjects factors of Group (meditator/non-meditator), and Sex. Age was covaried in all analyses because it correlates negatively with visual attention and RT. For the selective attention analysis, an additional within-subjects factor of Cue (invalid/neutral/valid) was included. Dependent variables included (1) number of changes noticed and response latencies in the flickering task, (2) discrepancy from accurate count in the gorilla video, (3) whether the gorilla was noticed, (4) number of correct identifications and response latencies in the perspective-switching task, and (5) selective attention task RTs. For the selective attention task, planned linear contrasts were calculated (Rosenthal & Rosnow, 1984) for cue type effects (which had three levels and therefore $2^3$ of freedom) to test the precise prediction that valid cue RTs would be shorter, and invalid cue RTs longer, relative to neutral cue RTs. For all effects, Pearson $r$ was computed as an estimate of effect size (Rosenthal & Rosnow, 1984). According to Cohen and Cohen (1983, p. 61), $r$ values of .10, .30, and .50 correspond to small, medium, and large effects, respectively.

Change blindness flickering task. Meditators identified a greater number of changes in flickering scenes than non-meditators, $F(1, 94) = 4.74, p < .03$, $r = .22$, and noticed changes more quickly, $F(1, 94) = 8.14, p < .01$, $r = .28$ (see Table 1). There was no effect of Sex, $F < 1$.

Gorilla video. Means are in the direction of less sustained inattentional blindness among meditators, but meditation status did not influence whether the gorilla was noticed, $F < 1$ (see Table 1). However, meditation did influence concentration accuracy: Meditators counted dribbles and passes more accurately than non-meditators, $F(1, 87) = 6.42, p < .01$, $r = .26$ (see Table 1). There were no effects of Sex, $F < 1$.

Ambiguous image perspective-switching task. Meditators identified more alternative perspectives of ambiguous images than non-meditators, $F(1, 95) = 5.92, p < .02$, $r = .24$, and the first perspective more quickly than did non-meditators, $F(1, 95) = 5.49, p < .02$, $r = .23$ (see Table 1). Response times for the second viewing of the image did not differ by group, $F < 1$. The amount of time spent on the second viewing was not very informative, however, because it is influenced by two factors, namely, how quickly participants could identify a second perspective, and how long they persisted if unsuccessful. There was no effect of Sex, $F < 1.4$.

Selective attention task. As expected, there was a significant main effect of cue type, such that valid cues caused shorter RTs and invalid cues caused longer RTs, relative to neutral cues, linear contrast $F(1, 152) = 5.26, p < .03$, $r = .18$ (see Table 1, Mean across groups). This shows that valid cues facilitated and invalid cues interfered with processing visual stimuli, relative to neutral cues, and that participants completed the task according to instructions. More importantly, and in support of the hypothesis, the main effect of cue type was more pronounced for non-meditators, cue $\times$ group interaction linear contrast $F(1, 152) = 5.59, p < .03$, $r = .19$. Simple effects tests showed group differences for invalid cues, $F(1, 80) = 3.00, p < .09$, $r = .19$, and neutral cues, $F(1, 80) = 3.71, p < .06$, $r = .21$, but not for valid cues, $F < 1$ (see Table 1). The pattern indicates that all participants noticed the gorilla about equally, but in a median split design it is impossible to show a difference in the noticing of the gorilla video, one who misunderstood directions and five who had previously seen the video.

Table 1
Mean outcome measures as a function of group.

<table>
<thead>
<tr>
<th>Task</th>
<th>Meditators Mean (SD)</th>
<th>Non-meditators Mean (SD)</th>
<th>Mean Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change blindness flickering task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N changes noticed</td>
<td>1.64 (.12)</td>
<td>1.20 (.16)</td>
<td>1.42 (.10)</td>
</tr>
<tr>
<td>Response latency (sec)</td>
<td>30.1 (1.47)</td>
<td>37.1 (1.90)</td>
<td>33.7 (1.16)</td>
</tr>
<tr>
<td>Gorilla video</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gorilla noticed</td>
<td>.24 (.07)</td>
<td>.15 (.06)</td>
<td>.19 (.05)</td>
</tr>
<tr>
<td>Count discrepancy</td>
<td>3.78 (.72)</td>
<td>6.75 (.93)</td>
<td>5.27 (.59)</td>
</tr>
<tr>
<td>Ambiguous image perspective-switching task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of identifications</td>
<td>5.11 (.13)</td>
<td>4.59 (.17)</td>
<td>4.85 (.11)</td>
</tr>
<tr>
<td>Latency 1st viewing (sec)</td>
<td>4.11 (.31)</td>
<td>6.04 (.65)</td>
<td>5.09 (.41)</td>
</tr>
<tr>
<td>Latency 2nd viewing (sec)</td>
<td>48.05 (8.31)</td>
<td>35.18 (10.53)</td>
<td>41.89 (6.8)</td>
</tr>
<tr>
<td>Selective attention task</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Invalid cue RT (ms)</td>
<td>650.3 (13.9)</td>
<td>689.6 (18.0)</td>
<td>669.9 (11.4)</td>
</tr>
<tr>
<td>Neutral cue RT (ms)</td>
<td>623.6 (11.7)</td>
<td>660.2 (15.1)</td>
<td>641.9 (9.5)</td>
</tr>
<tr>
<td>Valid cue RT (ms)</td>
<td>616.0 (10.9)</td>
<td>630.6 (14.0)</td>
<td>623.3 (8.9)</td>
</tr>
</tbody>
</table>

Note: SE appear in parentheses. Noticing the gorilla was coded 0 = not noticed, 1 = noticed.
participants were similarly helped by valid cues, but that meditators were less undermined by invalid cues. That is, meditators disengaged more quickly from incorrectly cued visual information and more flexibly re-directed attention to new information. There was a main effect of Sex, such that men responded faster ($M = 621.86$) than women ($M = 618.18$) across cue type, $F(1, 76) = 5.52$, $p < .02$, $r = .26$, but it was not moderated by other variables, $F_{r} < 1$.

4. Discussion

Taken together, results show substantial support for the hypothesis that meditation is associated with more efficient and flexible visual perceptual processing. Relative to those who meditate little or not at all, regular meditators (1) detected a greater number of changes in flickering scenes, and detected changes more quickly, indicating less change blindness, (2) counted rapidly moving stimuli more accurately in the gorilla video, indicating better visual concentration, (3) identified more alternative perspectives in ambiguous still images, reflecting greater ability to shift focus and flexibly process images, and (4) had better selective attention, indicating greater flexibility in directing and re-directing visual attention, essentially letting go of incorrect information more effectively. The four tasks are diverse and previously validated as visual attention measures. The consistency of effects in demonstrating an advantage among meditators provides broad support for the hypothesis that meditation is associated with superior visual processing.

Although meditators showed lower change blindness on the flickering task, there was no significant difference in the sustained inattentional blindness measure of noticing the gorilla. We suspect the group effect was not significant both because (1) participants’ attentional set was directed away from the gorilla color (i.e., black) and (2) the assigned task was so difficult. That is, the challenging task of counting all dribbles and passes of whit-shirted players led to an overall low rate of noticing. Importantly, however, the demanding task allowed us to examine visual concentration, broadening the scope of attentional processes examined.

The stimuli in three of the four tasks were similar to the complex visual stimuli that occur in natural settings rather than the simple stimuli often used in visual attention studies. Specifically, the gorilla video involved moving people and basketballs, change blindness stimuli were everyday scenes, and ambiguous figures were drawings of people and animals. This aspect of the current study differed from many past visual attention studies, and increases the external generalizability of results, which increases our confidence that the superior visual attention among meditators accrues real and noticeable advantages in everyday processing.

In much previous research, participants have been tested while meditating or immediately afterward. In contrast, our participants were tested in contexts separate from practice, and did not systematically meditate prior to testing. Thus, in contrast to much prior research, results demonstrate that meditators’ better attentional processing is stable enough to manifest beyond the immediate practice context, or in other words “off the cushion”.

It is important to note that the data are correlational and thus do not establish causal direction. Theoretically then, it is possible that regular meditation leads to better perception, or alternatively, that those with better perception choose to meditate regularly, or that a third unidentified factor causes individuals both to have superior perception and to choose meditation practice. Although our design does not address causation, results of past studies support the first explanation. For example, Tang et al. (2007) randomly assigned Chinese students to 5 days of either intensive meditation or relaxation training. After 5 days, participants who meditated had better attentional processing on alerting, orienting, and executive function measures as well as better mood, lower cortisol, and better immune function, allowing Tang et al. (2007) to conclude that randomly assigned short-term intensive meditation causes immediate benefits. In contrast, although our correlational design cannot establish a causal direction, it contributes to the literature in ways that experimental designs cannot. For example, it is impossible to randomly assign participants to long-term meditation, and therefore experimental studies cannot examine whether meditators have better visual attention in everyday life. Hence, experimental and correlational designs complement one another and the best approach is to consider both. Importantly, results from the alternative designs are consistent in showing an advantage for attention among meditators.

Many meditation practices involve techniques that direct attention to current experience, which facilitates noticing distractions and returning attention to monitoring momentary experience. Such practice aims to develop an inherently open quality of non-judgmental attention to experience. Intriguingly, our findings show that such practice is associated with literally seeing more accurately. It is likely that improved visual processing also influences various higher-order behaviors, which all rely on attentional processing. Thus, for example, accurate attentional processing might enable individuals to experience events with less distortion and defense (Hodgins, 2008; Hodgins & Knee, 2002), which enhances performance among individuals and dyads (Hodgins et al., in press; Weinstein, Hodgins, & Ryan, 2010). This speculation remains for future examination.

Nonetheless, meditation does not aim at increasing attention simply for attention’s sake. Rather, improved visual attention is a consequence of techniques aimed at reducing and eliminating erroneous conceptions. In empirical psychology, the contrast is captured by Gregory’s (2003) distinction between visual illusions and conceptual delusions. The current outcomes are more relevant to visual illusion than conceptual delusion. However, Gregory (2003) suggests that illusions can lead to delusions. Thus, the finding that contemplative practice is associated with better visual attentional processing suggests that, over time, meditation practice might also reduce, or at least avoid increasing, higher order delusions.

Acknowledgments

This work was supported by National Science Foundation Grant No. 0338749 to the first author. Many thanks to Ryushin Sensei, Ellen Rook, Dr. Selma Nemer, Caroline Russell Smith, Coleman Zeigen, and Sharon Arpey for their generous help in recruiting participants.

References


