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An effect of mood on the perception of geographical slant

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Abstract

Previous research has shown that hills appear steeper to those who are fatigued, encumbered, of low physical fitness, elderly or in declining health (Bhalla & Proffitt, 1999; Proffitt, Bhalla, Gossweiler &Midgett, 1995). The prevailing interpretation of this research is that observers' perceptions of the environment are influenced by their capacity to navigate that environment. The current studies extend this program by investigating more subtle embodied effects on perception of slant; namely those of mood. In two studies, with two different mood manipulations, and two estimates of slant in each, observers in a sad mood reported hills to be steeper. These results support the role of mood and motivational factors in influencing spatial perception, adding to the previous work showing that physiological factors influence perception.

KEYWORDS: mood, slant perception, emotion and perception, space perception, embodied perception

An Effect of Mood on the Perception of Geographical Slant

"The world of those who are happy is different from the world of those who are not."

- *Ludwig Wittgenstein* Wittgenstein (1922), 6.43

Wittgenstein gives voice to a common belief; not only does our mood affect our thoughts and feelings, but mood can affect the experienced world. Recent research supports this belief, showing that one's affective state can influence attention, decision-making, and memory, thereby changing our experience of the world. But do happy people *see* the world differently? Many contemporary researchers in perception contend that perception of basic properties of surfaces in the world (such as the slant of a hill) is unaffected by mood. This paper offers evidence to the contrary. Happy people may see the basic geometry of the world differently.

Previous research has shown that an observer's capacity to walk up a hill affects their perception of that hill's slant (Proffitt, 2006). We hypothesize that affective state can also influence the perception of hill slant. Changes in affective state, however, can coincide with changes in energetic state. Could a change in mood be a subtle change in energetic state, merely replicating Proffitt's findings? In the following two experiments we attempted first to demonstrate an effect of mood on slant perception, then to parse the mood effect from the influence of the energetic state of the observer.

A bit of background is necessary before describing our current study. First, we systematically overestimate hill slant (Proffitt, Bhalla, Gossweiler, & Midgett, 1995). A 7 degree hill is reported to be between 25 and 30 degrees on average. Proffitt (2006) argued that overestimation is useful because it facilitates increased sensitivity to hills we can traverse. We are able to distinguish a 4 degree hill from a 5 degree hill (two navigable hills that require different amounts of energy) by emphasizing the difference between them.[1] While this normative overestimation of hill slant hints at a relationship between our ability to scale a hill and our perception of its slant, several studies conducted by Proffitt and colleagues offer more direct evidence of this relationship (Bhalla & Proffitt, 1999; Proffitt, Bhalla, Gossweiler & Midgett, 1995; Stefanucci, Proffitt, Banton & Epstein, 2005). These studies show that perception of a given hill varies with the perceiver's capacity to scale that hill. In other words, not only are hills systematically overestimated, but that overestimation is modulated by changes in physiological potential (for a review, see Proffitt, 2006).

According to this account, explicit perception of geographical slant is recruited for planning purposes, and the biases observed are due to increases in anticipated effort. The current studies seek to extend or constrain such an explanation. One recent study with similar goals has extended the previous energetic account into the domain of social resources. Schnall, Harber, Stefanucci, and Proffitt (2008) showed that being with a friend at a hill or simply imagining a friend before judging the slant of a hill made hills

[1] Although it is useful to consciously overestimate the slant of the hill, when one ascends the hill, actions must be appropriate to the physical slant of the hill. In the present studies (as in past ones), we distinguish between explicit awareness of the hill slant, assessed by a verbal measure ("how many degrees is that hill"), a visual matching device, and an understanding of slant that supports action, reflected in a haptic measure. In previous experiments (Proffitt, 2006), the explicit awareness measures (verbal and visual) exhibit large overestimations, but the haptic measure evokes relatively accurate responses. Despite overestimation of slant, we still are able to act on the hills appropriately (i.e. we do not place our foot as if a hill were overestimated), and the palmboard measurement seems to reflect this fact.

seem less steep to the observer. All participants wore heavy backpacks while viewing the hill, but those participants who were with a friend, or imagining a friend estimated the hill to be less steep than those who were not thinking of or were not with a friend. The authors argued that psychosocial resources can influence the perception of hill slant, just as the physiological resources studied previously. The current studies suggest that mood may have a similar effect. Given that changes in mood can influence rated effort of certain tasks (Gendolla, 2000), can they likewise change the perception of slant?

In the following studies, we sought to manipulate mood, rather than induce emotional reactions. As opposed to moods, emotions, such as fear, anger and disgust, are discrete reactions to a particular event or source (such as fear of a snake). A mood, on the other hand, generally has a valence (positive or negative) and a magnitude (strong or weak), but does not necessarily have a specific source, nor a discrete interval. While emotional reactions such as fear (Stefanucci, Proffitt, Clore & Parekh, 2008; Stefanucci & Proffitt, 2009) have been shown to influence perception of both slant and distance, mood, the subject of the current studies, has not yet been investigated in relation to the perception of spatial layout.

There are two major underlying dimensions to mood, valence (the pleasantness or unpleasantness of a mood) (Diener, Smith, & Fujita, 1995; Watson & Clark, 1992) and arousal (Feldman, 1995; Larsen & Diener, 1992; Russell, 1980). There is some disagreement about whether each dimension represents a distinct component of affect, or whether valence alone is sufficient to describe mood, and arousal should be considered separately (Barrett, 2006; Watson & Clark, 1997). Whether or not arousal belongs as a component of affect, it could present an alternative explanation for an effect of mood on perception (see Stefanucci & Storbeck, 2009). For this reason, we administered a questionnaire (Larsen & Diener, 1992) based on the circumplex model proposed by Russell (1980), that assessed both positive and negative affect, as well as arousal.

While research to date has not isolated the mechanism that links perception of hill slant to affect and physiology, it has shown that changes in affect can elicit differences in perception, either with or without apparent changes in physiological state. One purpose of the current studies is to determine whether changes in mood can influence perception of slant, independent of physiological state. Given that Proffitt and Bhalla have shown the robust effect of changes in physiology, it would be a novel contribution to show that affect can influence perception, without a similarly robust change in physiology. This finding would extend the evidence from Stefanucci et al. (2008), that affect can indeed affect slant perception, without a large amount of corresponding physiological arousal.

Experiment 1: Mood influences the perception of slant

The first study demonstrated the existence of the effect of mood on perception of slant using a simple paradigm. A common mood manipulation was chosen that used music as a mood induction, with pieces that had previously been shown to influence mood (Niedenthal & Setterlund, 1994). The slant measures used were those described in studies by Proffitt and colleagues (e.g., Bhalla and Proffitt, 1999).

Method

Participants. Fifty-seven (33 female, 24 male) undergraduates participated in the study for course credit or payment. There were 28 in the sad group (17 females, 11 males), and 29 (16 females, 13 males) in the happy group.

Design. Participants assessed the slant of a five degree hill near the psychology building. They did so by verbally reporting the slant of the hill in degrees (where 0 is flat and 90 is a vertical cliff), by adjusting the visual matching disk and by adjusting the haptic palmboard (both devices were used in previous slant studies, e.g., Bhalla and Proffitt, 1999).

Participants listened to music through headphones. They were randomly assigned to either the happy music (Mozart's *Eine Kleine Nachtmmusik*) or sad music (Mahler's *Adagietto*) condition. The music was looped to be continuously presented throughout the experiment. Participants also completed a mood questionnaire by rating how well mood-related adjectives, adapted from the Current Mood Report (Larsen & Diener, 1992), described their feelings at that moment.

Procedure. Participants were told that they would be listening to music for the entirety of the experiment. They believed the experiment to be concerned with the role of music in a variety of perceptual tasks. To begin, they sat in a room with dimmed light and listened to the music for five minutes. They were urged to listen to the music, and to "really get into it", but not to fall asleep. After five minutes, still listening to the music, they were led outside to a hill and asked to judge its slant, verbally (how many degrees, when 0 is flat and 90 is a vertical cliff), visually and by adjusting the haptic device. The order of the verbal and visual measures was counterbalanced. Then, participants came back into the lab, stopped the music, and completed the mood questionnaire. Finally, participants were fully debriefed.

Results

Participants who responded with a verbal estimate of 10 degrees or less were excluded from the analysis. Very few people respond with such a low estimate without prior knowledge of actual hill slants. When directly questioned after the study, many who responded in this way admitted to knowing that hills are typically overestimated. There were 11 participants excluded because of a verbal estimate of 10 degrees or less. Five were in the happy condition and 6 in the sad condition. Three additional participants (2 happy, 1 sad) were excluded from the analysis because their estimates were more than 2 standard deviations greater than the mean.

Slant. A one-way analysis of variance (ANOVA) indicated that participants in the sad condition visually estimated (M = 23.4, SE = 1.4) the hill to be steeper than those in the happy group (M = 18.78, SE = 1.44), $F(1,41) = 5.22$, $p = 0.03$, $\eta_p^2 = 0.09$ (see Figure 1). There was a notable but non-significant trend in the verbal measure (sad: M = 26.95, SE = 2.00; happy: M = 22.52, SE = 1.46), $F(1,41) = 3.31$, $p = 0.08$. The haptic estimates were no different across condition, $p = 0.33$.

Mood. The mood questionnaire was analyzed by computing a composite z-score for valence and arousal by weighting the adjectives in the list depending on their relative valence and arousal (Larsen and Diener, 1992). There were no differences across condition in either the valence score, $p > 0.5$, or the arousal score, $p > 0.4$.

When participants listened to sad music (Mahler's Adagietto), they estimated the hill to be steeper on average than those who listened to happy music (Mozart's Eine Kleine Nachtmusik). In Experiment 1, the visual measure was influenced by the music, while the verbal measure showed a non-significant trend. However, responses on the mood questionnaire showed no significant differences between the groups. Was the difference in slant estimates between the groups due to changes in mood (perhaps too subtle to be reflected in the mood questionnaire), or to another factor evoked by the different music treatments, such as arousal, or perhaps even familiarity?

Why does music affect people's judgments of slant? The music was intended to influence emotional state, as it has in other studies (Eich & Metcalfe, 1989; Niedenthal & Setterlund, 1994), but one possibility is that the music influenced something else, which thereby changed the perception of the slant. The most likely candidate seems to be autonomic arousal, most often measured by heart rate (Ellis & Brighouse, 1952). The happy music has a faster tempo, and this may have a subtle influence on heart rate. A change in heart rate, given Proffitt et al.'s previous studies on physiological state and slant perception, seems a logical possibility to change the perception of slant.

Experiment 2: A different mood manipulation also influences judgments of slant

For the following study, we manipulated mood in a manner unlikely to change heart rate. Specifically, participants wrote an emotional story (Schwarz & Clore, 1983), an effective mood induction, but one less likely to alter arousal. As a result, we hoped to dissociate mood and arousal as agents of change in perceptions of slant.

Method

Participants. Twenty-five University of Virginia undergraduates (17 female, 8 male) participated in the study for course credit. There were 13 in the happy condition (4 males and 9 females) and 12 in the sad condition (4 males and 8 females).

Design. The same hill was used as in Experiment 1. Instead of music, the mood manipulation involved writing an outline of a personal story of an emotional nature, and then later writing that story. Participants in the sad condition wrote of a negative personal experience, and participants in the happy condition wrote of a positive personal experience. The words "negative" and "positive" were used so as to not call participants' attention to mood (e.g., being happy or sad). Participants wrote their outlines and stories on a legal pad on a clipboard. The circumplex questionnaire was used to assess mood, but more adjectives were added to increase the reliability of the separation of arousal and valence.

Procedure. Participants first heard instructions for the entire experiment and then spent 5 minutes outlining and thinking about either a very positive event or a very negative event in their lives (Schwarz & Clore, 1983). The intention of the experiment was masked by telling the participants that we were interested in how the quality and character of their writing was influenced by outlining, then taking a short break, as opposed to outlining and writing without a break. The measures of slant were presented to the participants as a distractor task between the outlining and writing about the event. Participants were asked to continue to think about their outline and their story, as they went outside to do the "other" tasks. This procedure was intended to maintain the mood elicited by the writing manipulation as participants went outside.

After outlining for 5 minutes, participants were led outside to the hill to make three estimates of slant. Verbal and visual measures were presented in counterbalanced order, while the haptic measure was presented last.[2]

Again, by informing participants at the beginning of the study that they would return and continue to write after the task outside, the intention was to maintain the emotional experience. After making the slant judgments, they returned to the lab and wrote about the emotional event for another 5 minutes. After the 5 minutes of writing, participants were interrupted, and told that it was okay if they were not finished with their story. They were then given the Current Mood Report to assess their emotional state.

Results

Slant. Six participants were excluded (3 in each condition), based on the criteria of verbal estimates of 10 degrees or less. A one-way ANOVA indicated that those in the sad group reported the hill to be steeper than those in the happy group in both verbal (sad: $M = 23.4$, $SE = 2.5$; happy: $M = 16.56$, $SE = 1.2$), $F(1, 17) = 5.66$, $p = 0.03$, $\eta_p^2 = 0.21$ and visual estimates of slant (sad: $M = 21.80$, $SE = 2.05$; happy: $M = 14.56$, $SE = 1.06$), $F(1,17) = 9.23$, $p < 0.01$, $\eta_p^2 = 0.31$ (see Figure 2). Haptic estimates were no different across conditions, $p > 0.5$.

Mood. Furthermore, the mood questionnaire also indicated significant differences between the groups. Participant ratings on the adjectives were again split into weighted *z*-scores for valence and arousal. Those in the happy condition reported themselves to be

[2] The conscious estimates were of more interest for the current studies, and were therefore first, to minimize influence of the haptic estimate, which in previous studies (Proffitt, 2006) has been found to be unaffected by manipulation of physiological state. The verbal and visual estimates were counterbalanced to account for any influence they might have on each other.

significantly happier (higher valence) than those in the sad condition, $F(1,17) = 18.80$, $p < 0.001$, $\eta_p^2 = 0.53$).

To assess the independent contribution of valence and arousal we conducted a separate multiple regression for each slant measure, with simultaneous entry of valence and arousal. Valence but not arousal was a significant predictor of the verbal measure, and had a unique contribution (valence: $t(2, 16) = -2.26$, $p = 0.04$; arousal: $t(2, 16) = -1.03$, $p = 0.32$). The visual measure had significant and unique contributions from both valence and arousal (valence: $t(2, 16) = -2.28$, $p = 0.04$; arousal: $t(2, 16) = -2.37$, $p = 0.03$).

General Discussion

The experiments, as a pair, lend support to the hypothesis that mood can influence slant perception. Experiment 1 began with a basic and common manipulation of mood; music. Those who listened to sad music (Mahler's Adagietto) reported the hill to be steeper than those who listened to the happy music (Mozart's *Eine Kleine Nachtmusik).* Did the music influence mood, as was intended, or did it change something else? Arousal is a possible alternative characteristic, which could have been changed by the music in question. Experiment 2 replicated the difference between groups on slant judgments, but used a different manipulation of mood intended to leave arousal unchanged. In this experiment, participants wrote about a positive or negative personal experience, and then judged the slant of a hill. Those in the sad group estimated the hill to be steeper than those in the happy group, while their self-reported arousal levels were no different.

While it is nearly impossible to completely separate the effects of mood and arousal, there are several follow-up studies which may further elucidate their relationship in the case of slant perception. For example, an arousing but negative mood, such as anger, could be compared to a non-arousing but positive mood. Another option would to use a tool such as the International Affective Picture System (IAPS, Lang, Bradley, & Cuthbert, 1999) to manipulate mood and arousal independently with more precision, and observe the effects on judgment of slant.

If it is indeed perception that is being affected, and it is mood that is instrumental in this change in perception, how does this effect occur? The question of the mechanism of perceptual effects is always a difficult one. Paradigms such as these are particularly thorny, given that there are few animal analogs and functional brain scanning technology does not currently allow for real-world viewing. However, despite these constraints, there are three avenues of possibility that are readily apparent.

The effect may be mediated by differences in attention. Bridgeman and Hoover (2005) have shown that directing observers' attention to different locations (elevations) on the hill affects estimates of the slant. For example, looking up toward the top of the hill makes the hill look steeper than looking closer to where one is standing. In the current studies, if sad mood caused participants to look at the top of the hill, it should have looked steeper ("Gosh, look at that huge hill I have to walk up"). On the other hand, if happy mood caused them to look at the hill right in front of them it should have looked shallower ("take life one step at a time"). Bar Anan and colleagues (Bar-Anan, Liberman & Trope, 2006) document a similar effect, in which individuals in a happy mood are faster to notice an object in the foreground than in the background, whereas sad participants attend to the background.

The second possible mechanism involves affect as information. Schwarz and Clore (1983) first proposed that mood can have an informational influence on behavior (in addition to a directive one) and that this informational influence was not due to mood congruent memory effects (Bower, 1981). When people make an evaluative judgment, rather than engaging in a biased search of memory for affect-congruent memories, they may ask themselves "How do I feel about this?" Basic to this position is the assumption that the strength of the informational impact corresponds to the diagnosticity of mood to the judgment. Gendolla and colleagues (Gendolla, 2000) suggest that mood is especially diagnostic for evaluative judgments such as "How much effort do I have to mobilize?" In several studies (Gendolla, Abele, & Krusken, 2001; Gendolla & Kruken, 2002; Gendolla & Krusken, 2002a, 2002b), Gendolla and colleagues demonstrate that for people in positive moods, the subjective demands of various tasks are lower than for people in negative moods. In short, for happy people, tasks are generally judged as easier. In the current studies, mood may have influenced effort perceptions as participants looked at the hill. Those in a sad mood may have perceived it to be more effortful to climb and therefore more steep.

Combining this approach with Proffitt and colleagues' approach to the perception of slant, one could surmise that the perception of slant is a combination of an evaluative judgment and a non-evaluative judgment. First, the question "How steep is that hill?" seems to be a non-evaluative one, using only information from the environment. However, as Proffitt's studies showing that the state of one's body can influence slant suggest, the question of the slant of a hill is also implicitly an evaluative one "How able am I to climb this hill?" In this way, those in a positive mood might see climbing the hill as requiring less effort (as they do with most other tasks) and therefore see it as less steep.

A final possible mechanism is based on an energetic account involving blood glucose levels. The effort explanation proposed by Proffitt (2006) has shown influences of depleted energy (fatigue) or capacity (lesser physical fitness) on perception of slant, but has not until recently linked this to the biology of how the body stores and metabolizes energy. In a recent set of experiments, Schnall, Zadra, and Proffitt (2008) did just that. Participants began by depleting blood glucose during a self-control task. Then half replenished it (with a sugared drink) and the other half remained depleted (with a drink sweetened with a non-caloric artificial sweetener). All participants then viewed a hill while wearing a backpack. Those participants who remained glucose-depleted reported the hill to be steeper than those who drank the sugared drink. This finding could apply to the current findings, if being in a sad mood requires (or depletes) more blood glucose than being in a happy mood. This possibility is supported by a series of studies by Gailliot et al. (2007), showing that self-control tasks deplete glucose. Given that blood glucose is used for demanding executive tasks, perhaps a sad mood engages certain mood regulatory processes in the brain, which use relatively more glucose than being in a happy mood.

While the mechanism remains to be discovered, the current studies indicate that the world can appear differently to those in different moods. We do not claim that mood induces hallucinations, but rather that mood can change our perception of the scale of the world, instantiated in the slant of hills. As Wittgenstein said in the sentences that preceded the quote from the beginning of this article:

> If the good or bad exercise of the will does alter the world, it can alter only the limits of the world, not the facts--not what can be expressed by means of language. In short the effect must be that it becomes an altogether different world. It must, so to speak, *wax and wane as a whole* (emphasis ours).

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Figure Captions

Figure 1. Mean estimates of hill slant by mood (music) condition. Bars represent one standard error of the mean.

Figure 2. Mean estimates of hill slant by mood (writing) condition. Bars represent one standard error of the mean.

Figure 1

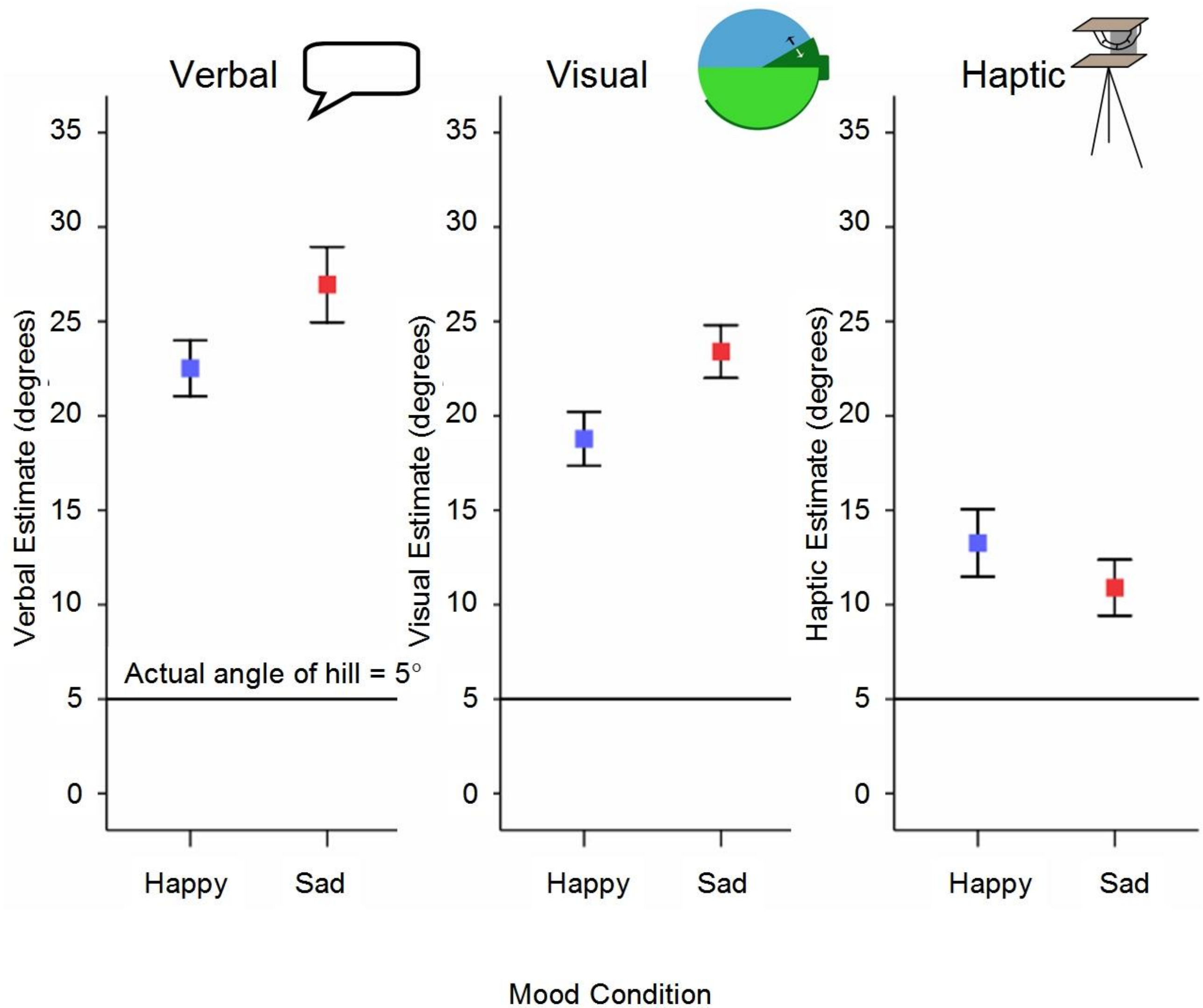
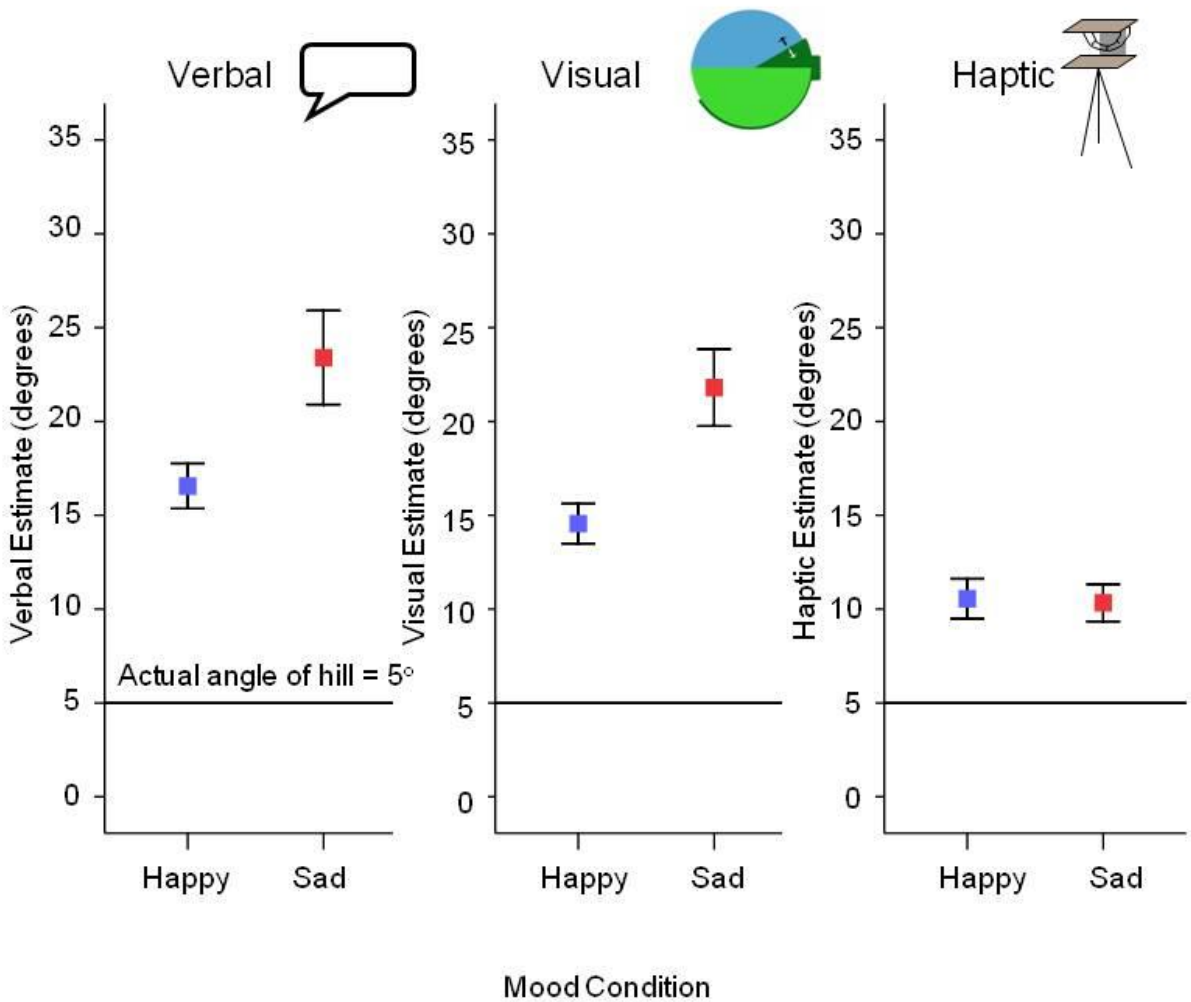

Verbal
Visual
Haptic
35
30
25
20
15
10
5
0
Verbal Estimate (degrees)
Visual Estimate (degrees)
Haptic Estimate (degrees)
Actual angle of hill = 5°
Happy
Sad
Mood Condition

Figure 2


Verbal
Visual
Haptic
Verbal Estimate (degrees)
Visual Estimate (degrees)
Haptic Estimate (degrees)
35
30
25
20
15
10
5
0
Actual angle of hill = 5°
Happy
Sad
Mood Condition