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When Perception Says “No” to Action:

Approach Cues Make Steep Hills Appear Even Steeper

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Abstract

Previous research has established that people's resources and action capabilities influence visual perception, and for example, make hills appear more or less steep. What has remained unexamined, however, is whether perception also changes when an action is impending. We propose that when action is expected in an environment that is challenging because it poses high energetic costs, perceptual estimates are increased. Experiment 1 showed that motor movements of approach led to steeper slant estimates than motor movements of avoidance, but only if participants were in good physical condition and thus capable of undertaking costly actions. Experiment 2 used a mindset priming task and found that approach resulted in higher slant estimates than either avoidance, or a neutral control condition, again for participants who were in good, but not for those in poor physical condition. Experiment 3 further showed that the approach cue on its own had the same effect as when combined with instructions that climbing was involved, thus suggesting that approach manipulations indeed implied the action of climbing. However, the effect of approach disappeared when climbing was explicitly ruled out. We suggest that inflated perceptual visual estimates in the face of challenging environments are adaptive because they discourage future actions that may be costly to perform.

Keywords: slant perception; economy of action; approach; avoidance; affordance

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Traditional theories of perception assume that viewing objects in the environment involves visual processes independent of a person’s bodily states and abilities (Pylyshyn, 2003). For example, how people see a chair is considered no different from how they see the table next to it, or the ceiling above it. This view was challenged by Gibson (1979), who proposed that people perceive their environment in terms of affordances, or the opportunities it provides for undertaking an action. For example, a chair affords the immediate action of sitting on it, a table instead affords placing objects on it, but a ceiling does not afford much in terms of specific actions. In recent years, this notion has been investigated by researchers interested in how affordances in the environment influence people’s visual perception relative to their bodily states and abilities (Proffitt, 2006).

Affordances and the Perception of Spatial Layout

The *economy of action* account proposes that the perception of the environment is influenced by a person’s bodily potential to pursue the actions this environment affords (Proffitt, 2006; Witt, 2011). For example, a hill appears steeper when a heavy backpack makes it harder for a person to climb up (Bhalla & Proffitt, 1999). Although the fundamental premise of the account has been investigated in relation to height (Stefanucci & Proffitt, 2009; Harber, Yeung, & Iacovelli, 2011) and distance perception (Proffitt, Stefanucci, Banton, & Epstein, 2003; Witt, Proffitt, & Epstein, 2004, 2010), its initial support comes from studies investigating how the perception of hills is influenced by a person’s potential to climb them. These studies have yielded the consistent finding that resources that increase a person’s potential to act decrease perceived hill slant relative to a lack of such resources. This includes physiological resources, such as glucose (Schnall, Zadra, & Proffitt, 2010), or psychosocial resources, such as social support (Schnall, Harber, Stefanucci, & Proffitt, 2008), positive mood (Riener, Stefanucci, Proffitt, & Clore, 2011), or the motivation to reduce cognitive dissonance (Balcetis & Dunning, 2007).

In this sense, research on the economy of action has predominantly focused on the factors that make action in a given environment either easy or difficult, and how they shape perception accordingly. Indeed, when explaining attributes that underlie the economy of action, Proffitt and Linkenauger (2013) summarize the research on the influence of bodily phenotype and its three components: morphology, physiology, and behavioral repertoire. These components determine the bodily potential relative to affordances of the surrounding environment and hence influence perception when a person anticipates performing an action. For example, when an object is placed on a table, the person's arm length (morphology), movements that can possibly be performed with the arm (behavioral repertoire), and energy available for moving the arm (physiology) will determine the actions that can be performed with the object and in turn, all these factors influence perception. What has not been investigated, however, is whether perception changes even when the attributes that underlie the potential of a person to undertake an action are held constant, and the action itself is about to happen. In other words, when an actor approaches a specific action in a physical environment, does the visual perception of this environment change?

People constantly evaluate the environment in terms of affordances, even when no action is planned (e.g. Jeannerod, 2001, 2006). This is adaptive because it enables a person to build a behavioral repertoire that will allow appropriate responses when an action becomes likely. For example, merely observing an object that is graspable with the right hand prepares a person to respond more readily with this hand compared to the left hand when pressing a button to make categorization judgments about the object (Tucker & Ellis, 1998). Further, hills generally appear steeper than they actually are because climbing them is costly in terms of bodily resources, and overestimating the actual slant may discourage the behavior of climbing (Proffitt, Bhalla, Gossweiler, & Midgett, 1995; Proffitt, Creem, & Zosh, 2001). Thus, when approaching an action in a physically demanding environment, it would be adaptive to view this environment as even more challenging, to discourage the action unless performing it is absolutely necessary. Therefore, when the action of climbing is impending, steep hills should appear even steeper.

Approach and Avoidance Cues

How can one imply that an action is about to happen without making it explicit and creating demand characteristics (Orne, 1962)? Research has found that certain motor behaviors signal an impending action regarding a stimulus even when the person is not consciously aware of it. For example, just flexing an arm in a pulling motion (Cacioppo, Priester, & Berntson, 1993; Centerbar & Clore, 2006) is a signal of approaching a stimulus, whereas extending an arm in a pushing motion is a signal of avoiding it. Accordingly, researchers have proposed that such motor movements constitute cues for approach and avoidance actions because they, through previous behavioral associations, became linked to engaging with a stimulus, or disengaging from it. Further, approach and avoidance cues such as arm movements induce identical psychological and behavioral effects as actual physical movements towards or away from a stimulus. For example, people respond more rapidly to positive words associated with approach compared to negative words associated with avoidance when flexing their arm, whereas this response pattern reverses for arm extension (Chen & Bargh, 1999). These effects also occur when literally pushing or pulling valenced words (Van Dantzig, Pecher, & Zwaan, 2008). Furthermore, when people are presented with words on a computer screen that appear as moving towards them, they categorize positive words faster than negative words, whereas the opposite is the case when words appear as moving away. An analogous effect occurs when people flex versus extend their arm while observing static words (Neumann & Strack, 2000). These and similar findings suggest that arm flexion versus extension serve as powerful approach versus avoidance cues.

Although motor movements such as arm flexion serve as cues for approaching a stimulus and undertaking the behavior it affords, they do not necessarily lead to this behavior. Indeed, a person may interpret these cues as appropriate and undertake the behavior only when it has energetic benefits. For example, participants who flexed their arm consumed more foods and drinks high in caloric energy, such as cookies or orange juice, than participants who extended their arm or were in a control condition (Förster, 2003). In contrast, arm flexion did not increase consumption of energetically neutral lukewarm water. Thus, if energetically non-beneficial actions are generally avoided, it may be that approach cues associated with such actions are invalidated by the regulatory mechanism of visual perception, to prevent the action from occurring. In line with this assumption, performing an approach cue while observing a steep hill should lead to steeper slant estimates relative to avoidance, and this perceptual change may in turn serve to prevent the energetically costly action of climbing.

A person considering an energetically demanding behavior such as climbing has to possess the resources required for it. People whose energetic potential is relatively high because they are in good physical condition, young, or without heavy load see inclines as less steep than those in poor physical condition, and thus they may be more encouraged to climb them (Bhalla & Proffitt, 1999). Indeed, people with these characteristics are also more likely to undertake demanding action such as climbing stairs in shopping malls (Eves, 2013). Based on this research we predict that approach should inflate perceptual estimates only for people in good physical condition because they possess the necessary resources and therefore undertaking the action of climbing is a real possibility, whereas it is less feasible for people in poor physical condition. Thus, for people who are in good shape approach implies that engaging in this behavior is highly likely, so it would be adaptive if visual perception were to discourage it given the high energetic cost. In contrast, for people who are not in good shape approach cues should not influence visual perception because the behavior of climbing is unlikely to occur in the first place. Thus, people in a state of approach while looking at a steep hill may see it as even steeper only when they are physically capable of responding to its affordance.

In order to investigate the relationship between action cues and visual perception of a geographical environment, the present research assessed how people viewed a steep hill while engaging in approach or avoidance induced by simple motor movements (Experiment 1) or by mindset priming (Experiment 2). Further, we tested whether the influence of approach on visual perception of hill slant is indeed due to its implied meaning of an impending action of climbing (Experiment 3), and whether the effect was abolished if this implication is called into question.

Experiment 1

Experiment 1 tested whether people performing arm flexion as a cue for approach see a steep hill differently than people performing arm extension as a cue for avoidance. Assuming an adaptive role of visual perception to discourage actions that carry high metabolic costs, we hypothesized that arm flexion, a motor movement that signals an impending behavior afforded by the hill, should increase perceived hill slant relative to arm extension, a motor movement that signals absence of this behavior. Because people in poor physical condition perceive inclines as steeper than those in good physical condition (Bhalla & Proffitt, 1999) and are relatively less likely to perform costly behaviors (Eves, 2013), we further hypothesized that this influence should occur only for people in good physical condition. We decided to assess physical condition using a questionnaire item rather than a more objective measure (e.g. body mass index). Although such assessment of physical condition may not clearly distinguish between participants' subjective mental states and their actual fitness levels, we assumed that participants' self-reports would more accurately capture their ability to perform costly actions in the given situation and thus determine the influence of approach versus avoidance on slant perception. Furthermore, because previous hill studies (e.g. Proffitt et al., 1995; Bhalla & Proffitt, 1999) assessed two functionally distinct components of perception, one related to explicit awareness of the environment and another related to visual guidance of bodily movements, we first need to explain how the present hypothesis pertains to each of the two.

Explicit Awareness versus Visual Guidance of Behavior

Visual perception reflecting explicit awareness of the environment is controlled by the *ventral stream* (Milner & Goodale, 1995; Creem & Proffitt, 2001) and is involved in the process of action planning (Glover, 2004). Because this component of perception guides a person when making a decision about which type of action to initiate, and under what circumstances, it is influenced both by visual information, and information regarding the person's bodily capabilities (Witt & Proffitt, 2007). Explicit awareness of a hill is captured via measures that require a person to verbally indicate the number of degrees, or to adjust a metal plate to match the hill's incline. Verbal and visual measures are related to the planning of undertaking the action of climbing, for which lack or availability of resources are taken into account. Accordingly, these measures yield overestimations of hill slant and are influenced by a person's bodily resources (e.g. Proffitt et al., 1995, Bhalla & Proffitt, 1999). In contrast, visual perception that guides behavior is not influenced by bodily resources but only by the spatial characteristics of the environment (Glover, 2004) because it is involved in action execution controlled by the *dorsal stream* (Milner & Goodale, 1995; Creem & Proffitt, 2001). Indeed, measuring hill slant haptically, which involves adjusting a movable palm-board to be parallel to the hill's surface without looking at one's hand, yields fairly accurate estimates because it captures the role of perception to correctly coordinate a person's bodily movements to climb the hill (Witt & Proffitt, 2007).[1] Visual perception that guides behavior is therefore functionally different from visual perception involved in explicit awareness because it controls action execution, and not action planning.

Given that we reasoned that approach and avoidance are cues related to undertaking a behavior afforded by the hill and therefore influence action planning, we expected the hypothesized effects of arm position for people in good physical condition only on the verbal and visual measures. In contrast, no effect was predicted for the haptic measure of slant because it captures perceptual processes that guide action execution.

Method

Participants. Fifty-four participants were recruited from passersby at Castle Mound, Cambridge, using convenience sampling. They were randomly assigned to either the approach or avoidance condition (54% male; M_{age} = 28.15 years; *SD* = 8.35). Data from two participants were excluded because of failure to follow instructions.

Stimulus. A steep section (39°) of the hill was used because inclines steeper than 30° are considered challenging to climb (Proffitt et al., 1995).

Procedure. Participants were instructed to stand at a level surface facing the hill and assume either arm flexion (i.e., approach) or arm extension (i.e., avoidance). Arm flexion (Figure 1) involved pressing the metal bar of a step ladder positioned on participants' left side from below with their left arm slightly extended, whereas extension (Figure 2) involved using the arm to press the bar from above (Cacioppo et al., 1993). While assuming the arm position, participants estimated hill slant explicitly, via the verbal and visual measures, and implicitly, via the haptic measure. The verbal estimate involved orally reporting hill slant in degrees; the visual estimate involved regulating a metal disc that consisted of an adjustable plate representing hill surface and a fixed plate representing the ground; the haptic estimate involved using the right hand to adjust a movable wooden board to be parallel to the hill's surface (visual and haptic measures are depicted in Schnall et al., 2008; Schnall et al., 2010). The order of measurement was counterbalanced across participants and they were allowed to rest their left arm between each measurement if necessary. However, they always assumed the arm position during slant estimates. In contrast to previous hill studies, the visual estimation task was not performed by participants themselves because the manipulated arm position prevented them from using both hands. Instead, the experimenter stood in front of participants such that both the disc and the hill section were visible. He gradually moved the adjustable plate from the 90° position towards the 0° position, and participants instructed him when to stop, or further directed him to move the plate upwards or downwards until satisfied.

Then participants completed a follow-up questionnaire assessing mood (*happy, anxious, stressed, depressed, angry, and sad*) on a scale from "1=not at all" to "5=a great degree". Mood influenced hill slant perception in a previous study (Riener et al., 2011) and was thus measured as potential confound. Furthermore, the questionnaire assessed participants' *physical condition* on the experimental day on a scale from "1=very unwell" to "5=excellent". Finally, participants were debriefed and probed for suspicion regarding the study objective. No participant reported any insight into the purpose of the hand movement, or the hypothesis.

Results

Overall effects of arm position on slant perception. One-way ANOVAs with arm position as a between-subjects factor were conducted. For the verbal measure, flexion (M = 63.77, SD = 9.57) led to steeper slant estimates than extension (M = 57.65, SD = 11.20), $F(1, 50) = 4.48$, $p = .039$, $\eta_p^2 = .08$. Similarly, for the visual measure, flexion (M = 63.46, SD = 7.21) yielded steeper slant estimates than extension (M = 58.31, SD = 8.71), $F(1, 50) = 5.41$, $p = .024$, $\eta_p^2 = .10$. As predicted, no significant effect was obtained for the haptic measure, $F(1, 50) = 0.50$, $p = .482$, $\eta_p^2 = .01$.

Slant perception at different levels of physical condition. To assess whether arm position influenced slant perception primarily for participants in good physical condition, we computed the interaction between arm position and physical condition on experimental day by specifying the model in the ANOVA. Furthermore, we performed simple effects analyses investigating the effects of arm position on slant perception for participants in poor (-1 *SD*) and good (+1 *SD*) physical condition. For the verbal measure, the interaction was not significant, $F(1, 48) = 0.25$, $p = .621$, $\eta_p^2 = .01$.[2] However, in line with predictions, simple effects analyses showed that flexion led to marginally steeper slant estimates compared to extension for participants in good, $p = .068$, but not in poor physical condition, $p = .251$ (see Figure 3 for means). For the visual measure, the interaction between arm position and physical condition also did not reach the conventional significance level, $F(1, 48) = 2.62$, $p = .112$, $\eta_p^2 = .05$. However, simple effects analyses again showed that flexion resulted in higher slant estimates compared to extension for participants in good, $p = .006$, but not in poor physical condition, $p = .583$. Finally, for the haptic measure, the interaction effect was not significant, $F(1, 48) = 0.04$, $p = .837$, $\eta_p^2 < .01$, nor simple effects for participants in poor, $p = .530$, or good physical condition, $p = .739$.

Confounding effects. To investigate whether mood had an effect, we conducted the analyses investigating overall effects of arm position on slant perception as well as the effects for participants in poor and good physical condition while controlling for mood as a covariate.[3] All the effects obtained in the main analyses remained robust, thus indicating that mood did not confound the results.

Discussion

Overall, the findings of Experiment 1 support the hypothesis that approach cues increase perceived hill slant compared to avoidance cues. This was primarily the case for participants in good physical condition, for whom acting on the hill by climbing was a realistic possibility. For both the verbal and visual measure, such participants found the hill to be steeper when performing arm flexion, as if pulling, than when performing arm extension, as if pushing. Participants' mood did not account for the findings. In contrast, and as expected, for the haptic measure no effects of arm position were obtained.

Experiment 2

The second experiment extended the approach of Experiment 1 by testing whether, for participants in good physical condition, approach cues influence slant perception not only compared to avoidance cues, but also compared to a relative absence of action or inaction cues. Hence, we included a control condition in which participants did not undergo any experimental manipulation. Moreover, we wanted to investigate whether approach influences how people view hills relative to avoidance not only when elicited via motor movements but also when elicited via a cognitive manipulation, such as mindset priming (Bargh & Chartrand, 2000). Thus, we used Friedman and Förster's (2001, 2005) maze task to induce approach and avoidance. This task involves virtual enactment of approach and avoidance behaviors and influences cognitive processing. For example, approach versus avoidance induced by the maze task influence creativity, analytical reasoning, and the scope of perceptual and conceptual attention in similar ways as arm flexion and extension (Friedman & Förster, 2000, 2001, 2002, 2005, 2010; Förster, Friedman, Özelsel, & Denzler, 2006).

Method

Participants. Fifty-eight participants were recruited at the site of Experiment 1 and randomly assigned to the control, approach, or avoidance condition (60% male; M_{age} = 32.21 years; *SD* = 12.18). Data from one participant were excluded because she was familiar with the incline of the hill.

Procedure. All participants except for those in the control condition first solved the maze task. Participants in the approach condition were instructed to help a mouse at the center of the maze to find the way out to reach a cheese, whereas those in the avoidance condition helped the mouse to escape from an owl. Immediately after the task, participants estimated hill slant using the identical procedure as in Experiment 1, except that they themselves adjusted the disk for the visual measure. Then participants completed the follow-up questionnaire assessing their *mood* and *physical condition* on the experimental day as in Experiment 1. Finally, they were debriefed and probed for suspicion. No participant reported any insight into the purpose of the hand movement, or the hypothesis.

Results

Overall effects of the maze task on slant perception. One-way ANOVAs with condition as a between-subjects factor were conducted. For the verbal measure, a significant effect of condition was found, $F(2, 54) = 5.24$, $p = .008$, $\eta_p^2 = .16$. Planned contrasts showed that approach ($M = 64.42$, $SD = 12.59$) led to steeper slant estimates than avoidance ($M = 51.79$, $SD = 11.03$), $t(54) = 3.20$, $p = .002$, $d = 0.87$, or control condition ($M = 56.42$, $SD = 12.82$), $t(54) = 2.03$, $p = .048$, $d = 0.55$. The latter two conditions did not differ, $t(54) = 1.17$, $p = .246$, $d = 0.32$. Similarly, the effect of condition was significant for the visual measure, $F(2, 54) = 4.51$, $p = .015$, $\eta_p^2 = .14$. Approach ($M = 60.32$, $SD = 9.32$) again produced higher slant estimates than avoidance ($M = 51.58$, $SD = 9.86$), $t(54) = 2.96$, $p = .005$, $d = 0.81$, or control condition ($M = 54.68$, $SD = 7.98$), $t(54) = 1.91$, $p = .061$, $d = 0.52$. However, the latter two conditions did not differ, $t(54) = 1.05$, $p = .297$, $d = 0.29$. As predicted, no effect of condition was found for the haptic measure, $F(2, 54) = 1.14$, $p = .328$, $\eta_p^2 = .04$.

Slant perception at different levels of physical condition. To assess whether the maze task influenced slant perception only for participants in good physical condition, we computed the interaction between condition and physical condition on experimental day and performed simple effects analyses as in Experiment 1. For the verbal measure, the interaction effect was significant, $F(2, 51) = 3.89$, $p = .027$, $\eta_p^2 = .13$. For participants in good physical condition (+1 *SD*), approach led to steeper slant estimates than avoidance, $p < .001$, or control condition, $p = .004$ (see Figure 4 for means), whereas the latter two conditions did not differ, $p = .195$. However, for participants in poor physical condition (-1 *SD*), slant estimates did not differ between conditions, all *p*s > .481. For the visual measure, the interaction was also significant, $F(2, 51) = 3.51$, $p = .037$, $\eta_p^2 = .12$. For participants in good physical condition, approach again yielded higher slant estimates compared to the avoidance, $p < .001$, or control condition, $p = .026$. Furthermore, the control condition led to marginally higher slant estimates compared to the avoidance condition, $p = .053$. However, for participants in poor physical condition, slant estimates did not differ between conditions, all *p*s > .622. Finally, the interaction was not significant for the haptic measure, $F(2, 51) = 0.31$, $p = .733$, $\eta_p^2 = .01$, and there were no significant differences between any of the conditions for participants in either good or poor physical condition, all *p*s > .179.

Confounding effects. Potential effects of mood were investigated as in Experiment 1. All the effects obtained in the main analyses remained robust after controlling for mood.[4]

Discussion

Overall, the findings of Experiment 2 replicated the findings of Experiment 1 by showing that, for participants in good physical condition, approach induced via a mindset priming procedure influenced slant perception analogously to approach induced via motor movements. Moreover, the approach condition yielded higher slant estimates compared to the control condition, indicating that participants who approach steep hills see them as even steeper compared to those not primed by any approach or avoidance cues. Important for our hypothesis, these effects were not obtained for participants in poor physical condition. Controlling for participants' mood again showed the findings to hold regardless of affective feelings.

Experiment 3

Next we investigated the mechanism behind the previous findings. If approach manipulations influenced slant perception because they indeed implicitly evoked climbing, then such manipulations should yield identical slant estimates when administered either alone or with explicit instructions specifying climbing. Furthermore, if participants are told that the experiment would involve no climbing, approach should yield lower slant estimates because the implied meaning of approach is invalidated. These predictions should occur only for participants in good physical condition because they possess the necessary resources to climb the hill. To test these predictions, we included three conditions in which all participants solved the maze task inducing approach as in Experiment 2. Additionally, in one condition, participants were given no instructions regarding climbing, as in the previous experiments; in another condition, participants were told that the experiment would involve climbing, and they could choose how much of the hill they wished to climb; in the third condition, participants were told that the experiment would involve no climbing.

Because we argue that steep hills are seen as steeper when approached due to the adaptive role of perception in discouraging costly behaviors, we also assessed participants' climbing propensity at the end of the study. This variable comprised various aspects of participants' aptitude to climb the hill, such as the perceived difficulty of climbing and their motivation to climb. If participants in good physical condition are indeed discouraged from climbing after solving the maze without instructions or additionally receiving explicit instructions evoking climbing, then they should report lower climbing propensity than participants told that climbing will not occur.

Because all conditions in Experiment 3 involved approach, we expected that the effects may be more difficult to detect than in the previous two experiments. Thus, we recruited a relatively larger sample to ensure sufficient power to test our predictions.

Method

Participants. One hundred fifty participants were recruited at the site of Experiments 1 and 2 and randomly assigned to the approach and climb, approach and no climb, and approach without instructions conditions (65% male; M_{age}=27.60 years; SD=6.92). Data from nine participants were excluded: Five did not complete the maze task, three failed to comply with instructions, and one was familiar with the incline of the hill.

Procedure. All participants first completed the consent form with background information containing a question assessing their *physical condition* on experimental day on a scale from “1=very poor” to “6=excellent”. Thereafter, they were given a brief overview of the experiment. All participants were told that the main task would involve estimating the slant of the hill. Participants in the *approach and climb* condition were further told that they would be asked to climb the hill at the end of the experiment, and could climb any proportion of the hill ranging from not climbing at all to climbing all the way up. Participants in the *approach and no climb* condition were explicitly told that the experiment would involve no climbing. Furthermore, those in the *approach without instructions* condition were not given any further details regarding climbing.

Then all participants completed the approach maze and estimated the slant of the hill as in Experiment 2. They further completed a questionnaire assessing their climbing propensity (*energy* and *effort* required to climb up, how *difficult*, *risky*, and *pleasant* it would be to climb up, and *motivation* to climb the hill) on a scale from “1=disagree strongly” to “7=agree very strongly”.[5] The questionnaire also assessed three basic dimensions of affect, *pleasure-displeasure*, *awake-tiredness*, and *tension-relaxation* on a scale from “1=very slightly or not at all” to “5=extremely” (Schimmack & Grob, 2000). Finally, all participants were debriefed, and those in the approach and climb condition were told that they would not have to climb the hill. No participant reported any insight into the hypothesis.

Results

Overall effects of experimental manipulations on slant perception. One-way ANOVAs with condition as a between-subjects factor were performed. For the verbal measure, a marginally significant effect of the experimental manipulation was found, $F(2, 138) = 2.40$, $p = .094$, $\eta_p^2 = .03$. Planned contrasts showed that the approach and no climb condition ($M = 48.46$, $SD = 12.06$) produced lower slant estimates than the approach without instructions ($M = 53.61$, $SD = 11.57$), $t(138) = 2.11$, $p = .036$, $d = 0.36$, or the approach and climb condition ($M = 52.21$, $SD = 11.80$), although the latter difference did not reach statistical significance, $t(138) = 1.55$, $p = .124$, $d = 0.26$. As expected, slant estimates for the latter two conditions were relatively similar, $t(138) = 0.57$, $p = .570$, $d = 0.10$, thus suggesting that approach without instructions implicitly evoked climbing. For the visual measure, there was a significant effect of experimental manipulation, $F(2, 138) = 5.87$, $p = .004$, $\eta_p^2 = .08$. Further, the approach and no climb condition ($M = 45.27$, $SD = 8.88$) yielded less steep slant estimates than the approach without instructions ($M = 50.57$, $SD = 9.47$), $t(138) = 2.86$, $p = .005$, $d = 0.49$, or the approach and climb condition ($M = 50.87$, $SD = 8.51$), $t(138) = 3.05$, $p = .003$, $d = 0.52$. Furthermore, the latter two conditions did not differ, $t(138) = 0.17$, $p = .869$, $d = 0.03$, again suggesting that approach without instructions implicitly evoked climbing. Finally, there was no effect of condition on the haptic measure, $F(2, 138) = 0.26$, $p = .769$, $\eta_p^2 < .01$.

Slant perception at different levels of physical condition. To assess whether the approach and no climb condition differed from the other two conditions primarily for participants in good physical condition, we used the same procedure as in the previous two experiments.[6] For the verbal measure, the interaction between experimental manipulation and physical condition was marginally significant, $F(2, 128) = 2.99$, $p = .054$, $\eta_p^2 = .05$. As predicted, for participants in good physical condition (+1 *SD*), the approach and no climb condition led to lower slant estimates than the approach without instructions, $p = .007$, or the approach and climb condition, $p = .004$ (see Figure 5 for means). However, the latter two conditions did not differ, $p = .886$, supporting the prediction that approach yields identical slant estimates when climbing is implicitly or explicitly evoked but not when it will not happen. For participants in poor physical condition (-1 *SD*), no differences between conditions occurred, all *p*s > .408. For the visual measure, the interaction between experimental manipulation and physical condition was marginally significant, $F(2, 128) = 2.64$, $p = .075$, $\eta_p^2 = .04$. For participants in good physical condition, the approach and no climb condition again yielded lower slant estimates than the approach and climb, $p < .001$, or the approach without instructions condition, $p = .002$, whereas the latter two conditions did not differ, $p = .797$ (see Figure 5 for means). Thus, approach again yielded identical slant estimates when climbing was implicitly or explicitly evoked but not when it was ruled out. For participants in poor physical condition, we found no differences between conditions, all *p*s > .314. Finally, for the haptic measure, the interaction effect was not significant, $F(2, 128) = 0.52$, $p = .596$, $\eta_p^2 = .01$, and experimental conditions did not differ for participants in either poor or good physical condition, all *p*s > .198.

Propensity to climb the hill. In this set of analyses, we investigated whether participants in good physical condition indeed experienced higher propensity to climb the hill when in the approach and no climb condition compared to the other two conditions. Therefore, we computed the interaction between experimental conditions and physical condition on experimental day and investigated the effects for participants in poor (-1 *SD*) and good physical condition (+1 *SD*) as in the previous analyses. The interaction term was marginally significant, $F(2, 128) = 2.70$, $p = .072$, $\eta_p^2 = .04$. For participants in good physical condition, the approach and no climb condition yielded higher climbing propensity compared to the approach and climb, $p = .001$, or the approach without instructions condition, $p = .036$ (see Figure 6 for means). As predicted, the latter two conditions did not differ, $p = .348$. For participants in poor physical condition, no differences between the conditions were found, all *p*s > .566.

Climbing propensity and slant perception.

Given that we claim that perception discourages behavior, a direct test would be to show that verbal and visual slant estimates mediate the influence of experimental conditions on climbing propensity, but only for people in good physical condition. The first step would thus be to show that, for people in good physical condition, experimental condition influences verbal and visual slant estimates as potential mediators (Hayes, 2013). This is what the reported analyses indeed showed. The second step requires showing that the influence of experimental conditions on climbing propensity for people in good physical condition disappears when either verbal or visual slant estimates are included in the analysis as a covariate, one at a time, because they themselves predict climbing propensity. Although we did perform such analyses, neither verbal, $F(1, 127) = 0.13$, $p = .722$, $\eta_p^2 < .01$, nor visual slant estimates, $F(1, 127) = 1.46$, $p = .229$, $\eta_p^2 = .01$, predicted climbing propensity, and the previously observed effects of experimental conditions on climbing propensity for people in good physical condition remained similar.

We believe that the negative relationship between slant estimates and climbing propensity necessary for mediated effects may not have been observed because of the dual role that climbing propensity played in the experiment: Although we assessed climbing propensity as the dependent variable, it is likely that this variable was also a moderator. It is possible that experimental conditions influenced slant perception, which in turn discouraged climbing, but only for participants who were high in climbing propensity at the beginning of the experiment. Therefore, the two conditions that implied climbing might have increased slant estimates and decreased climbing propensity compared to the no climb condition only for people who were initially high in climbing propensity. If this were indeed the case, the expected negative correlation between slant estimates and climbing propensity would have been observed only if participants initially high in climbing propensity were so discouraged from climbing after perceiving the hill as steeper that they reported lower climbing propensity than participants who were initially not inclined towards climbing. However, the fact that neither verbal nor visual estimates predicted climbing propensity in the mediation analysis suggests that this was not the case.

Therefore, a more plausible possibility is that the discouragement from climbing that people initially high in climbing propensity experienced in the two conditions that implied climbing versus the no climb condition was of a smaller magnitude, and their climbing propensity remained relatively high compared to participants initially not inclined towards climbing. To investigate this possibility, we performed analyses testing whether climbing propensity moderated the effects of experimental conditions. Indeed, climbing propensity interacted with experimental conditions in influencing verbal, $F(2, 135) = 7.17$, $p = .001$, $\eta_p^2 = .10$, and visual slant estimates, $F(2, 135) = 5.29$, $p = .006$, $\eta_p^2 = .07$, with the hypothesized differences between the experimental conditions occurring only for participants high in climbing propensity (+1 SD). This suggests that participants who may have experienced strongest discouragement from climbing because of being initially high in climbing propensity still reported relatively high climbing propensity scores later.

Therefore, the discouraging effect that visual perception had on climbing would best be captured by investigating correlations between climbing propensity and slant estimates for participants who reported relatively high climbing propensity scores. Indeed, participants with low climbing propensity scores within this category may be those who were discouraged from climbing after seeing the hill as relatively steeper, whereas participants with high climbing propensity scores within this category may be those who were not discouraged from climbing because they saw the hill as relatively less steep. Therefore, the negative correlation between climbing propensity and slant estimates should be observed within this category of participants.

To investigate this possibility, we split participants into three groups according to their climbing propensity by using the SPSS subcommand NTILES, where group one (N = 45) consisted of low climbing propensity participants (lower than 33rd percentile), group two (N = 53) of medium climbing propensity participants (between 33rd and 67th percentile), and group three (N = 43) of high climbing propensity participants (higher than 67th percentile). Furthermore, for each group we performed zero order correlations between climbing propensity and verbal, visual, and haptic estimates. In line with our predictions, strong negative correlations between climbing propensity and verbal and visual estimates occurred only in the group where climbing propensity was relatively high, whereas correlations in other groups were weak and not significant (see Table 1). These findings suggest that perception discouraged climbing only for people who were initially likely to climb up and for whom discouraging behavior was therefore adaptive.

Confounding effects. To investigate whether affect played a role, we repeated all the previous analyses while controlling for each basic dimension of affect as a covariate — *pleasure-displeasure*, *awake-tiredness*, and *tension-relaxation* — one at a time. These analyses revealed that all the effects remained robust, and were thus not confounded by affect.[7]

Discussion

Overall, the findings of Experiment 3 supported the hypothesis that implicit approach cues affect slant perception only when there is a possibility of climbing. More specifically, participants in good physical condition, who thus possessed more energetic resources for climbing, saw the hill as steeper when the approach maze either implicitly or explicitly evoking climbing, but not when it was made clear that no climbing would be performed. In other words, engaging in approach without additional instructions, or with specific instructions that the action was impending had the same effect. Thus, the approach manipulation indeed influenced slant perception because of being implicitly associated with the behavior of climbing afforded by the hill.

We argue that approach makes steep hills appear even steeper because of the functional role of visual perception in discouraging the energetically costly behavior of climbing. Indeed, the findings showed that experimental manipulations that led to increased slant perception also led to lower climbing propensity: Participants who solved the approach maze and were in good physical condition reported lower propensity to climb the hill when given explicit instructions evoking climbing or when given no instructions compared to when told that the study would involve no climbing. Thus, when climbing the hill was expected, participants in good physical condition on average reported being more discouraged from climbing compared to when no climbing was expected. Further correlation analyses showed that verbal and visual slant estimates were negatively related to climbing propensity only for participants who scored relatively high on the latter construct (above 67th percentile). This suggests that perception discouraged climbing only for participants who may have initially been more inclined towards climbing and for whom discouragement was therefore adaptive.

General Discussion

In the present article, we argue that physically demanding hills are perceived as even steeper when the act of climbing is impending. In line with the economy of action approach (Proffitt, 2006), we propose that this perceptual change may function to discourage energetically costly behaviors. To manipulate the behavior of climbing, we used approach versus avoidance cues that signal undertaking a behavior afforded by perceived stimuli versus refraining from this behavior. Experiments 1 and 2 showed that approach induced through a motor movement (Cacioppo et al., 1993) or a mindset priming procedure (Friedman &

Förster, 2001, 2005) indeed leads to steeper slant estimates compared to avoidance. This effect occurred only for people in good physical condition, who are in general more likely to undertake costly behaviors such as climbing (Eves, 2013), and for whom perception could therefore potentially discourage behavior. These findings remained robust after controlling for participants' affective state.

To ascertain that approach indeed influenced slant perception because it implies climbing, Experiment 3 investigated whether this influence disappears when climbing is not required. Indeed, participants in good physical condition who completed the approach maze but were told that the study involved no climbing saw the hill as less steep than those who solved the maze either with, or without explicit instructions that climbing would be required. Thus, the approach cue on its own had the same effect as when combined with instructions that climbing was involved. However, the effect of the approach cue disappeared when climbing was explicitly ruled out. Thus, the present research expands the current knowledge about the economy of action account (e.g. Proffitt, 2006) by showing that evoking an action can influence the perception of the environment for people with similar levels of bodily potential.

Finally, because we have argued that steep hills are perceived as steeper when approached due to the functional role of perception to discourage costly behaviors, Experiment 3 further investigated whether approach makes participants in good physical condition less discouraged from climbing when it has been explicitly ruled out. Indeed, these participants reported higher climbing propensity when in the approach and no climb condition compared to the approach and climb or the approach without instructions condition, whereas the latter two conditions did not differ. These findings suggest that people who are able to climb steep hills not only perceive their slant as more extreme, but also report lower climbing propensity than those without an option to climb up. However, we were unable to establish slant estimates as a mediator of the influence of experimental conditions on climbing propensity, arguably because of the complex role that this variable played in the experiment. Instead, we showed that verbal and visual slant estimates were negatively related to climbing propensity only for participants who scored high on the latter variable (above 67th percentile). This suggests that perception directly discouraged climbing only for participants who initially had a higher tendency to climb up and for whom discouraging the costly behavior was therefore adaptive.

Although physical condition on the experimental day was shown to be an important moderator across the three experiments we conducted, a critic may argue that this variable tapped into participants' subjective mental states rather than objectively measuring their physical fitness. However, we propose that capturing participants' subjective states is equally or more relevant because such states may assess their ability to perform costly actions in the given situation. On the contrary, objectively measured physical fitness may not reliably capture participants' situational potential to perform costly actions. For example, a participant may in general be physically fit but feel somewhat out of sorts on a particular day. Therefore, we propose that measuring participants' physical condition using a questionnaire item rather than a more objective measure is an advantage rather than a disadvantage when it comes to the present research. However, we acknowledge that using such a measure may make the present research less directly comparable to Bhalla & Proffitt (1999) because they either manipulated physical condition experimentally or used objective measures such as the resting heart rate or body mass index to assess it.

Another important consideration is whether approach leads to inflated slant estimates compared to avoidance primarily for steep hills or this applies more broadly to a range of hills. Our research involved only a relatively steep hill (39°), so we do not know to what extent approach and avoidance would influence the perception of less steep hills. However, in line with the logic employed in inferring the hypothesis for the present research, we consider it unlikely that similar effects would occur for less challenging hills because they do not pose an equal threat to energetic resources. However, the exact cut-off point at which this influence stops will need to be determined by future research.

Demand Characteristics

Besides testing the specific research question related to approaching steep hills, the present findings also help us address the recent criticism of research showing effects of effort on slant perception. Durgin et al. (2009) and Durgin, Klein, Spiegel, Strawser, & Williams (2012) have criticized some of the previous hill studies in which participants wore a heavy backpack intended to reduce participants' potential to act on the hill (e.g. Bhalla & Proffitt, 1999; Schnall et al., 2010) for being susceptible to demand characteristics (Orne, 1962). These authors have argued that participants may have recognized that the purpose of the backpack was to make the hill appear steeper, and thus they adjusted responses accordingly. Durgin and colleagues thus question the validity and generalizability of previous hill studies. The findings from the three experiments are informative in that respect, because they cannot be explained by experimental demand characteristics. Indeed, the manipulations involving arm position and the maze task were unlikely to be connected to approach or avoidance by participants. In post-experimental probing no participants could correctly identify what the manipulations involved, let alone infer the hypothesis that approach should lead to higher estimates compared to the avoidance or control conditions. Thus, the current results cannot be explained by experimental demand characteristics.

Alternative Explanations and Future Directions

To establish that our theoretical explanation behind the findings is indeed the most plausible one, it is necessary to examine alternative explanations frequently associated with approach and avoidance motivational orientations. The present findings can be alternatively explained if we consider the concept of affective incoherence (Clore & Schnall, 2008). This concept denotes that incongruence between motivational orientation and properties of external stimuli creates an epistemic problem that interferes with on-going cognitive processing. For example, incongruence between avoidance evoked by arm extension and positive words primed through a scrambled sentences task creates an underlying cognitive conflict that impedes memory for a subsequent story (Centerbar, Schnall, Clore, & Garvin, 2008).

Because approach cues such as arm flexion can also be interpreted as signals for safe environments rich in resources (Friedman & Förster, 2010), they may be incongruent with environments such as steep hills affording energetically consuming actions. Thus, one possibility is that in the present research this incongruence between approach cues and the hill created an underlying cognitive conflict, which, in turn, might have inflated slant estimates analogously to other psychological burdens (Slepian, Masicampo, Toosi, & Ambady, 2012). However, this explanation is unlikely to account for the present findings. If climbing is more costly for participants in poor versus good physical condition, then the former would experience a stronger cognitive conflict when performing an approach cue. Thus, the differences between the approach and avoidance or control conditions would be even stronger for participants in poor physical condition. Furthermore, in Experiment 3, these participants would report greater differences in climbing propensity between conditions than participants in good physical condition. However, in all the three experiments we found no effects of experimental manipulations for participants in poor physical condition. Thus, our explanation regarding perception as a bodily mechanism that discourages costly actions signaled by approach cues seems more plausible than the incongruence explanation.

In conclusion, our finding suggests that motor or cognitive cues for performing actions in an environment that affords costly behaviors can influence the perception of such an environment. Future research will need to explore further whether the direction of this influence changes when costly behaviors serve as means for acquiring a resource and are thus associated with energetic benefits rather than costs. Such an approach has the potential to yield new insights into the nature of human agency, to clarify how different bodily states or cognitive concepts guide actions relative to the affordances that are present in everyday physical and social environments.

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Footnotes

[1] Taylor-Covill and Eves (2013a) recently showed that the haptic measure of hill slant does not generally yield lower and more accurate slant estimates compared to the verbal or visual measures because of constraints in arm wrist movement, as critics have contended (Durgin, Hajnal, Li, Tonge, and Stigliani, 2010, 2011). They constructed an improved haptic measure in which the plate moved by participants' hand when estimating hill slant is adjusted to a pendulum that does not impose any constraints on wrist movement. Further, they showed that this measure captures the identical perceptual process as the more traditional haptic measure used in our study and previous hill studies. Furthermore, Taylor-Covill and Eves (2013b) used the improved haptic measure to assess the effects of fatigue and gender on slant perception. In line with previous hill studies using the traditional haptic measure, these variables influenced slant estimates only for the verbal and visual measure but not for the haptic measure. Thus, haptic measures do indeed yield different slant estimates compared to the verbal and visual measure because they capture a different perceptual process that cannot be explained by limitations of the experimental equipment.

[2] It is possible that, unlike in Experiments 2 and 3, the interactions between experimental conditions and physical condition did not reach conventional significance levels in Experiment 1 because a large number of participants gave identical response regarding their physical condition. Indeed, 63.5% participants answered that they felt physically good on the experimental day, whereas the next most prevalent response was "excellent" with 19.2%. Thus, it may be that this relative prevalence of one response in the moderator variable decreased the power of statistical analyses to capture the overall interaction effect.

[3] Mood items were combined into a composite score, with happiness reverse coded ($\alpha = .84$). Arm flexion remained significantly different from arm extension for the verbal, $F(1, 49) = 5.96$, $p = .018$, $\eta_p^2 = .11$, and the visual measure, $F(1, 49) = 7.28$, $p = .010$, $\eta_p^2 = .13$. For

participants in good physical condition flexion remained different from extension for the visual measure, $p = .005$, and marginally different for the verbal measure, $p = .055$. However, for those in poor physical condition the two conditions did not differ for verbal, $p = .157$, or visual estimates, $p = .395$.

[4] Items assessing mood were analyzed after being combined into a composite score ($\alpha = .86$) as in Experiment 1. Main effects on the verbal measure, $F(2, 53) = 4.99$, $p = .010$, $\eta_p^2 = 0.16$, and the visual measure, $F(2, 53) = 4.35$, $p = .018$, $\eta_p^2 = 0.14$, remained significant. For participants in good physical condition the approach condition remained significantly different from the control, $p = .004$, and the avoidance condition, $p = .001$, for the verbal measure. Again, no differences were obtained for participants in poor physical condition, all ps > .502. For the visual measure, approach yielded higher slant estimates than control, $p = .028$, or avoidance, $p < .001$, for participants in good physical condition. No differences were obtained for participants in poor physical condition, all ps > .625.

[5] The items assessing climbing propensity were: I feel it would be difficult for me to climb the section of the hill in front of me; I feel it would take me a lot of energy to climb the section of the hill in front of me; I feel it would be physically effortful for me to climb the section of the hill in front of me; I feel it would be risky for me to climb the section of the hill in front of me; Overall, climbing up the section of the hill would be a pleasant experience; Overall, I feel motivated to climb the section of the hill. To create an overall index of climbing propensity, responses to these six items were combined into a composite score, with difficulty, energy, effort, and risk reverse coded ($\alpha = .75$).

[6] Because seven participants failed to answer the question regarding physical condition, their data could not be used for statistical analyses involving this variable, thus leaving forty-five participants in the approach and climb condition, forty-five participants in the approach and no climb condition, and forty-four participants in the approach without instructions condition.

[7] Important for our predictions, the approach and no climb condition remained significantly different from the approach and climb or the approach without instructions condition for people in good physical condition for both the verbal and visual measure, all *p*s $< .011$. However, the letter two conditions did not differ, all *p*s $> .816$. Furthermore, for people in poor physical condition, no significant differences between experimental conditions were obtained, all *p*s $> .312$. The differences in climbing propensity between the approach and no climb condition and the approach and climb or the approach without instructions condition remained significant for people in good physical condition, all *p*s $< .035$, whereas the latter two conditions did not differ, all *p*s $> .320$. Furthermore, the differences in climbing propensity for people in poor physical condition remained insignificant, all *p*s $> .389$. Finally, verbal and visual estimates remained negatively correlated with climbing propensity for participants high in climbing propensity (above 67th percentile) when we performed partial correlation analyses controlling for each basic dimension of affect, one at a time, all *p*s $< .026$.

Table 1: *Zero order correlations between climbing propensity and slant perception for people who scored low (below 33rd percentile), medium (between 33rd and 67th percentile), and high (above 67th percentile) on climbing propensity (Experiment 3)*

	Verbal	Visual	Haptic
Low Climbing Propensity			
Climbing Propensity	−.005	.009	−.147
Medium Climbing Propensity			
Climbing Propensity	−.046	−.099	.020
High Climbing Propensity			
Climbing Propensity	−.345*	−.415**	−.152

Note: $*p = .024$; $**p = .006$

Figure 1. Participant performing arm flexion.

Figure 2. Participant performing arm extension.

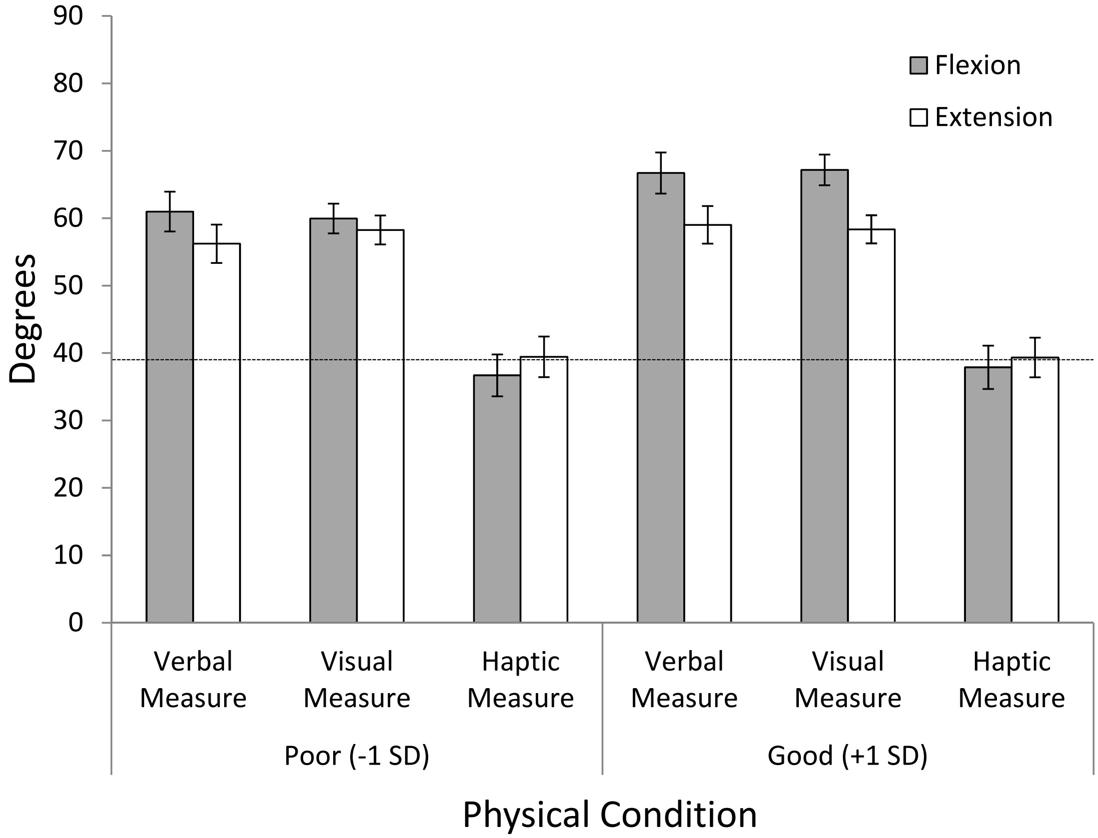

Figure 3. Effects of arm position on slant perception for participants in poor (-1 *SD*) and good physical condition (+1 *SD*) in Experiment 1. The horizontal line corresponds to the real hill slant as measured by an inclinometer (39°), whereas error bars correspond to ±1 *SE* of the mean.

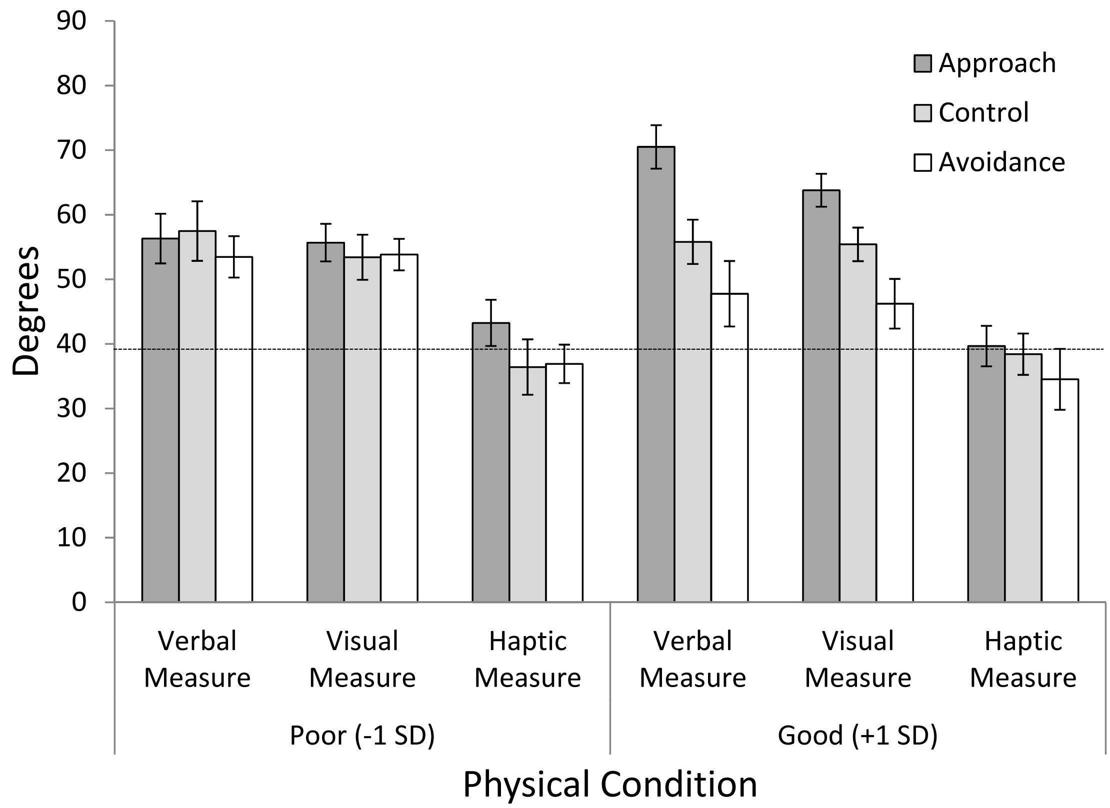

Figure 4. Effects of the maze task on slant perception for participants in poor (-1 *SD*) and good physical condition (+1 *SD*) in Experiment 2. The horizontal line corresponds to the real hill slant as measured by an inclinometer (39°), whereas error bars correspond to ±1 *SE* of the mean.

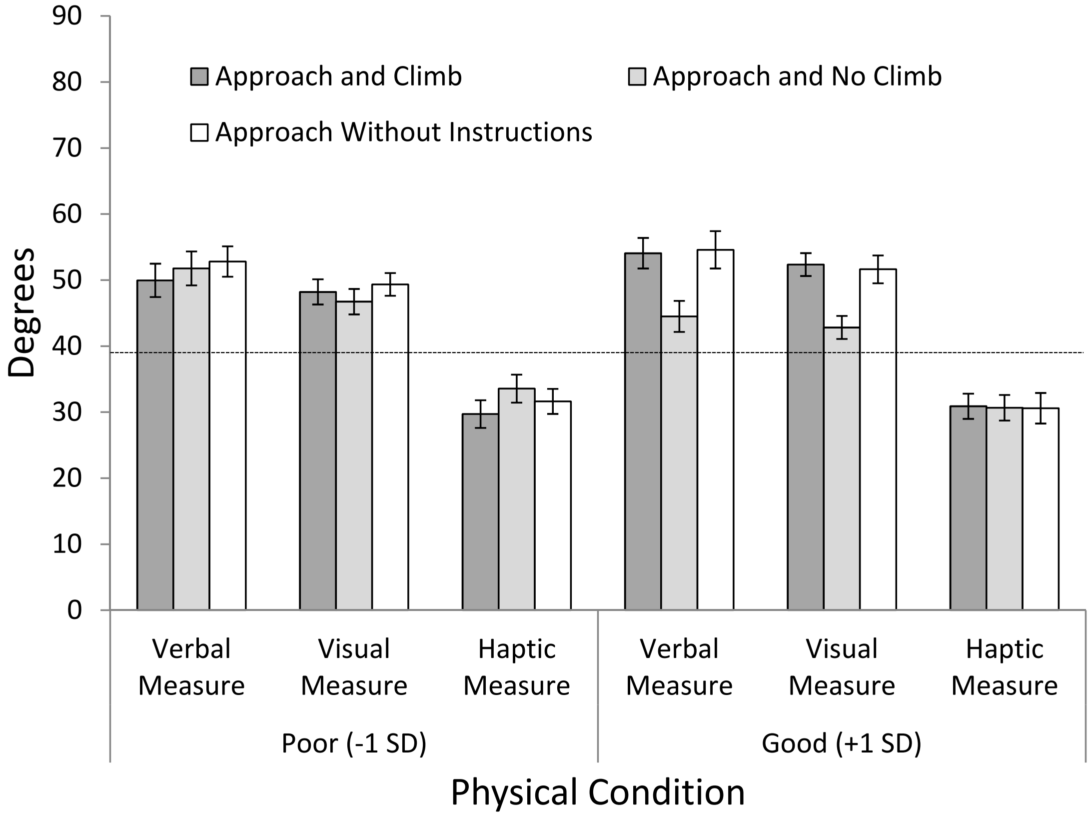

Figure 5. Effects of experimental manipulation on slant perception for participants in poor (-1 *SD*) and good physical condition (+1 *SD*) in Experiment 3. The horizontal line corresponds to the real hill slant as measured by an inclinometer (39°). Error bars correspond to ±1 *SE* of the mean.

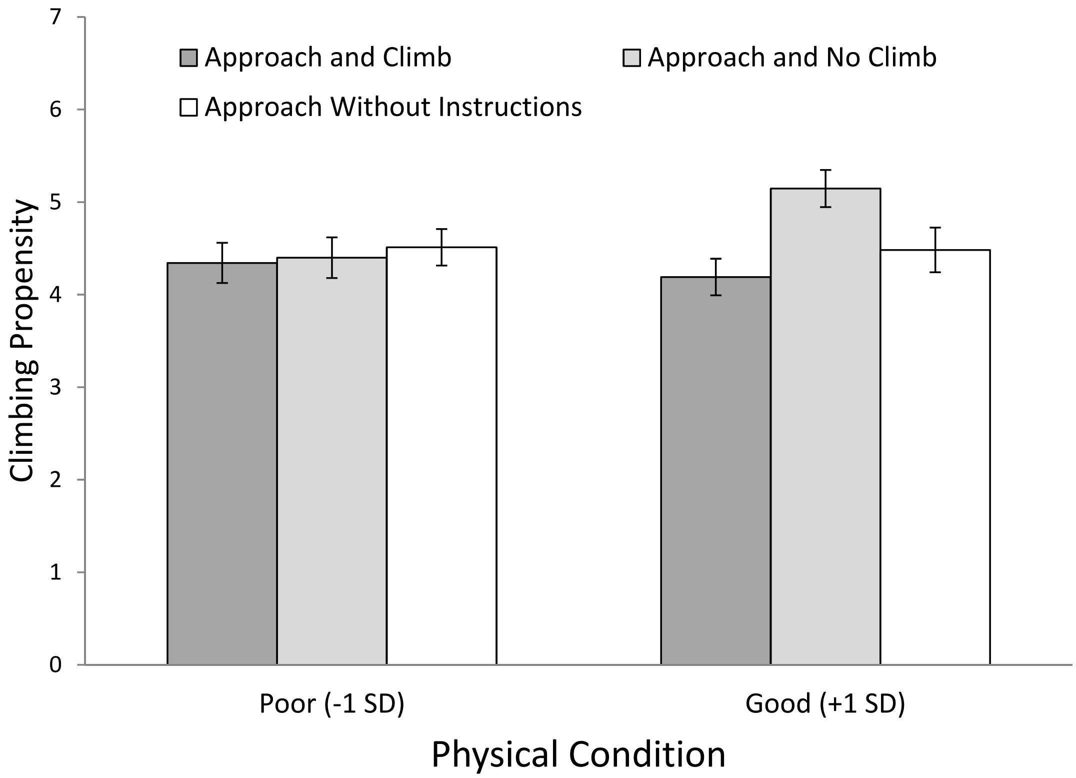

Figure 6. Effects of experimental manipulation on climbing propensity for participants in poor (-1 *SD*) and good physical condition (+1 *SD*) in Experiment 3. Error bars correspond to ±1 *SE* of the mean.