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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.

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 (Harber, Yeung, & Iacovelli, 2011; Stefanucci & Proffitt, 2009) 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

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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, 2014). 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, 2014), 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) to capture participants' subjective sense of being able to engage with the physical environment in that given moment. However, because previous hill studies (e.g. Bhalla & Proffitt, 1999; Proffitt et al., 1995) 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* (Creem & Proffitt, 2001; Milner & Goodale, 1995) 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 by both visual information, and information regarding the person's bodily capabilities (Witt &