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Imagining Crawling Home: A Case Study in Cognitive Science and Aesthetics

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Abstract Philosophical accounts of narrative fiction can be loosely divided into two types. Participant accounts argue that some sort of simulation, or 1st person perspective taking plays a critical role in our engagement with narratives. Observer accounts argue to the contrary that we primarily engage narrative fictions from a 3rd person point of view, as either side participants or outside observers. Recent psychological research suggests a means to evaluate this debate. The perception of distance and slope is influenced by the energetic (e.g., task difficulty) and emotional (e.g., anxiety) costs of actions. These effects are limited to increases in the costs of actions agents intend to perform themselves, generalize to cases where participants imagine acting, and demonstrate a role for tacit motor simulation in action planning. If participant accounts are sound, one should, therefore, find similar effects across changes in the interpretation of the costs of actions depicted in static images. We asked people to copy the rough spatial layout of two paintings across different interpretations of the costs of the actions they depicted. We predicted that increasing costs would cause participants to draw distances as longer and hills as steeper. Our results confirm this prediction for the energetic, but not the emotional, costs of actions.

> Visual perception is not solely a visual process. What one sees in the world is influenced not only by optical and ocular-motor information, but also by one's purposes, physiological state, and emotions. (Proffitt 2006, p. 110).

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The general attitude towards empirical research in philosophical aesthetics has softened considerably in recent years. However, significant work is needed to clarify exactly what contribution cognitive science can make to the philosophy of art and aesthetics. It has been argued elsewhere that research in psychology and cognitive neuroscience can help us understand how particular artworks generate artistically salient effects (e.g., aesthetic effects and semantic associations constitutive of an artifact's status as an artwork) (Carroll et al. forthcoming). For instance, it is often asserted that the aesthetic quality of the Mona Lisa lies in Leonardo's use of sfumato to render the dynamics of the depicted facial expression. Margaret Livingstone (2000) has demonstrated that these perceptual effects emerge from differences in the acuity of foveal and peripheral vision. Livingstone's discussion does not establish that the target sfumato contours are aesthetic features of the painting. However, it does lend support to a standard art critical interpretation of the painting. This type of data can, in turn, be used to evaluate whether competing theories are consistent with the psychological processes underlying our engagement with artworks. In what follows we present a case study to illustrate this model for the contribution of cognitive science to philosophical aesthetics.

Why are we frightened by the fictional events in horror movies, gripped by the formulaic plots of dime store mystery novels, and moved by the plights of fictional characters depicted on the stage. We understand that none of these events or characters are real. Our responses to narrative fictions are, as a result, perplexing. Theoretical approaches to these and other questions about the nature of narrative engagement can be loosely divided into two types, participant and observer accounts, distinguished by the relative role they attribute to imagination, simulation, and perspective taking in narrative understanding and appreciation.[1] Proponents of participant accounts argue that first-person perspective taking plays a central role in narrative understanding, or, that in the course of coming to understand a novel, play, film, or narrative picture, readers and spectators adopt the perspectives of depicted characters and imagine, or simulate, a range of their thoughts, affective states, and actions from a first person point of view (Currie 1995; Giovannelli 2008). Observer accounts argue, to the contrary, that spectators and readers need not ordinarily call on any further resources than their prior knowledge of event types and the relationship between beliefs, desires, and behavior to recover the content of a narrative (Carroll 1997/2001; Kieran 2003). Critically, simulation and perspective sharing do not play significant roles in observer accounts. Rather, proponents argue that when we engage with narrative artworks we adopt the third person perspective of an observer (e.g., either an observer outside the narrative or a side-participant to the events depicted). The question at the root of this debate is, therefore, whether, and if so to what

[1] The distinction between participants and observers is borrowed from Carroll (1997/2001). This distinction roughly tracks the distinction between participant and onlooker accounts in Giovannelli (2008). In these contexts narrative understanding refers to the capacity to recognize the elements of the actions and events depicted in a narrative (e.g., the capacity to recognize a character as of a type with a particular set of goals, motives, and affective states). Narrative appreciation is less sharply defined. It is sometimes equated with a deep understanding of what it is like to be a character with a range of beliefs, goals, or affective states. Roughly narrative appreciation refers to our capacity to make sense of the events depicted in a narrative in a way that renders the behavior of characters as compelling, or necessitated by their goals, beliefs, and character traits (Kieran 2003; Neill 1996).

degree, we use ourselves to model, or simulate, the mental states and behaviors of characters when we engage with narratives.

Recent research in perceptual psychology suggests a novel way to evaluate this question. Dennis Proffitt and his colleagues have demonstrated that what one sees (e.g., the slopes of hills and distances in the local landscape) is influenced by two non-optical factors: the energetic (e.g., fatigue and expected task difficulty) and emotional (e.g., fear and anxiety) costs of actions (see Proffitt 2006). For instance, donning a backpack, walking on a treadmill, or throwing a heavy ball increases the apparent distance to target landmarks in the local environment. These effects are limited to first-person contexts in which agents directly experience an increase in the energetic or emotional costs associated with an action they intend to perform, generalize to cases where participants simply imagine performing an action, and demonstrate a role for motor simulation in action planning. Jeannine Stefanucci reports similar effects associated with the emotional costs of anticipated actions. When participants were positioned at the top of a 7º grade on a skateboard, there was a positive correlation between subjective reports of fear & anxiety associated with the pending descent and the apparent orientation (slant) of the slope and its extent (egocentric distance to the target of the anticipated action) (Stefanucci et al. 2008).

We hypothesized that if participant accounts are sound, one should find similar effects associated with changes in the energetic and emotional costs of actions depicted in static images. In order to evaluate this hypothesis one needs a method to measure how viewers perceive the space depicted in two dimensional images. We asked participants to copy the spatial layout of a painting as accurately as possible while looking at the image. In this type of task participants continuously compare what they have drawn against what they perceive. Comparisons of the two dimensional layout of their copies across different interpretations of energetic and emotional costs of depicted actions can, therefore, be interpreted as a record of change in the apparent orientation and extent in the painting. We used a set of paintings by Andrew Wyeth to test this hypothesis. In what follows we discuss the potential bearing of our study on the debate about the nature of narrative engagement. In Section 1 we motivate the distinction between participant and observer accounts of narrative engagement. In Section 2 we discuss current research on energetic and emotional costs effects in perception. In Section 3 we discuss the experiments we used to test the effects of energetic and emotional costs in picture perception. In Section 4 we evaluate the results of our study and their significance to the debate between participant and observer accounts of narrative understanding and appreciation.

We conclude this introductory section with a methodological caveat. The goal of our study was to demonstrate that motor simulation contributes to our understanding of actions depicted in static images by demonstrating that energetic and emotional costs effects generalize to picture perception. We expect that our results should, despite differences among them, generalize to other visual narrative media (e.g. film and drama). Further, research on the role played by premotor areas in, and the effects of motor interference on, the recognition and comprehension of action sentences (Buccino et al. 2005; Glenberg and Kaschak 2002) suggests that these results generalize to our engagement with novels and other forms of literary narrative (Speer et al. 2009). However, an evaluation of these claims is beyond the scope of the current paper.

We also expect that our results can make a direct contribution to discussions of embodied cognition in cognitive science and the philosophy of mind. Proffitt and his colleagues argue that energetic and emotional costs effects show that perception is an embodied processes. However, there is a critical aspect of their model that differentiates it from standard philosophical accounts of embodied cognition. Witt argues that although information sufficient for direct perception is present in sensory inputs, the visual system draws on a range of other behavioral resources as well (Witt and Proffitt 2008). In this sense, the visual system is opportunistic, cooperative, and representational. It draws on any resources, environmental or cognitive, that support the efficient representation of environmental features sufficient for action planning and execution. Therefore, although Proffitt and his colleagues embrace a Gibsonian approach to perception, their model is pragmatic not direct. Our results support this model. However, again, discussion of these issues is beyond the scope of the current paper.

1 Simulation, Recognition, and Narrative Engagement

Participant accounts borrow the notion of simulation from the philosophy of mind. Simulation theory was developed as an alternative to theory-theory accounts of our capacity to understand and predict the mental states and behaviors of others.[2] Theory-theory accounts argue that as a child matures, he or she acquires a large body of knowledge about the behavior of other people. This knowledge functions as an implicit theory of human behavior: it enables agents to understand and predict the mental states and behaviors of others inferentially, much as one would use a scientific theory to predict and understand other target phenomena (Gopnik and Wellman 1992). However, the range of information that one would need to have readily available to accurately infer the mental states of individuals and the environmental dynamics of their actions is staggeringly large. Simulation theorists argue, as a consequence, that theory-theory accounts place an unrealistic burden on our cognitive capacities. They propose, alternatively, that we use our own cognitive processes to model target actions and mental states under certain constrained conditions (Currie 1995; Goldman 2006). How do we do this? We put ourselves in the shoes of the target individual. We use environmental cues and prior knowledge to generate a scenario, or constrained set of conditions, under which to entertain a target mental state, and then we imagine how we would respond. For instance, premotor areas are used in motor planning to generate a forward model of the bodily and perceptual consequences of a particular action (Haggard 2008; Schubotz and Von Cramon 2003). These processes play a critical role in helping us orient our bodies and direct our attention to features of the environment salient to a particular task.[3] The same set of processes can be used to simulate the potential actions of

[2] See Goldman (2006) and Nichols and Stich (2003) for reviews of the range of theoretical positions involved in this debate.

[3] See Seeley and Kozbelt (2008) for a discussion of the relationship between motor simulation, attention, and perception.

others (Decety and Grèzes 2006). In these contexts we adopt the perspectives (e.g. vantage point and goals) of target individuals and use motor simulation to generate a forward model of their projected behavior. This facilitates our capacity to track the attention and predict the actions of target individuals. Of course, some prior knowledge of human behavior is needed to accomplish these tasks (e.g., a set of appropriate goals, beliefs, and motor programs).[4] The critical difference is that the simulation process is a process of modeling, not inference: in motor simulation the cognitive system is provided with a set of starting points (e.g., a target visual space, goal, and motor program) and used to model changes in visual perspective and bodily orientation associated with a potential action.[5]

The purpose of a novel, drama, film, or narrative picture is, at bare minimum, to present a set of cues that carry the information needed to recognize, comprehend, and in some cases reconstruct the actions and events depicted. These cues function as sign posts that direct what we imagine to be the case as we engage with a narrative. In some contexts this involves imagining something about the experience of a character (e.g., contexts where understanding the motives or affective states of a character are critical to making sense of his or her behavior). In these contexts, proponents of participant accounts argue that narratives prompt us to simulate the depicted event from the vantage point and psychological perspective of characters. The advantage of participant accounts in these contexts is putatively two-fold. First, this type of empathic reenactment of narrative events enhances a deep understanding of the qualitative experiences of characters and explains why we are so intimately invested in the events of a narrative. Second, and as a consequence, it enables us to make sense of the behavior of characters from the inside, or as necessitated by a range of occurrent goals and mental states (Neill 1996). Simulation, therefore, provides us with information critical to narrative appreciation that is not explicitly represented in the work.

Observer accounts emerge from the observation that information sufficient to recognize the mental states of characters is nearly always explicitly represented in an artwork. This model for narrative engagement is analogous to a standard story about object recognition. Our capacity to perceptually recognize objects and events in ordinary contexts does not depend on a full spatial model of the local environment. Rather, perceptual systems quickly and efficiently match sparse sets of environmental cues to stored knowledge of the shapes and functions of general object types or particular individuals (Schyns 1998). Carroll and Kieran argue similarly that the conjunction of narrative cues and learned schema for character and event types suffice to enable readers and spectators to recognize the mental states of depicted characters and predict their actions (Carroll 1997/2001; Kieran 2003). Therefore,

[4] A motor program specifies the kinematics and dynamics of a particular movement (i.e., the spatial features of a movement, the angles through which joints will move, and the forces required to move the joints). Complex motor programs are constructed from movement primitives, or schema that encode elemental joint movements with stereotyped spatial and temporal characteristics (Kandel et al. 2000).

[5] Research on perspective taking in social neuroscience demonstrates that simulations of the beliefs and affective states of others are underwritten by similar processes, that play a similar role in our ability to understand and predict the behavior of others, and draw on the same sets of premotor and somatosensory areas (see Decety and Grèzes 2006, for a review).

simulation is not, in most cases, necessary to adequately comprehend the mental states and behaviors of a character. Ordinary cognition will do.[6]

The fact that simulation is not necessary for narrative understanding or appreciation does not entail that people do not use it when they engage with a narrative. Simulation is a tool that can be used to understand the behavior of characters whether or not information about the goals, motives, and mental states of characters is explicitly available. Nonetheless, there are significant asymmetries between characters and consumers of narratives that have been thought to count against it (Carroll 1997/2001; Kieran 2003). First, audience responses to suspenseful scenes in horror films do not parallel the affective states of participants in depicted events. Spectators are anxious and apprehensive in these contexts because they know what is coming next. Protagonists are most often calm, relaxed, or at least momentarily collected, because they are oblivious to their fate. Second, protagonists are often unaware of explicitly represented narrative facts that influence the probability that they will be able to realize their goals. In both of these types of cases, the tension between the local goals of the protagonist and the global knowledge of consumers drives the dynamics of the narrative (e.g., it is often exactly because we don't share the perspectives of characters that we recognize the humor in a frustrating situation or are apprehensive about an impending fictional event). This narrative device is putatively at odds with simulation accounts. On the one hand, knowledge of global narrative facts would seem to preclude the possibility of successful simulation. On the other hand critical asymmetries would be obscured if we were to simulate depicted events from within the perspectives of characters. As a result, proponents of observer accounts argue that simulation more often than not impedes narrative understanding and appreciation.

These are compelling concerns. However, epistemic asymmetry need not threaten participant accounts. The core claim of simulation theory is that we use our own cognitive processes to model target actions and mental states under certain constrained conditions. This entails that a consumer can use simulation to model discrete aspects of the local behaviors of characters where this information would contribute to his or her understanding or appreciation of the narrative (e.g., where knowledge of the qualitative aspects of a character's experience would sharpen the cognitive and affective asymmetries that drive a narrative) (Currie 1995). This model is consistent with a general pluralistic bias in the literature (Carroll 1997/2001; Giovannelli 2008; Kieran 2003; Neill 1996). Very few (if any) researchers see the issue of simulation and perspective taking as an all or nothing matter. Rather, they view it as a question of the epistemic and aesthetic requirements of particular narrative contexts. Observer accounts argue that, for the range of reasons articulated, simulation plays little, if any, significant role in narrative engagement. Participant accounts grant it a broader role, directed largely at an understanding of the experiences of characters. As a consequence, we interpret the central question in the debate between participant and observer accounts to be a question about the relative role of first-person imaginative experience in our engagement with narratives.

[6] It is important to note that this is not a theory-theory account of character engagement (Carroll 1997/2001). The claim is simply that no mediating mental reconstruction of a character's experience is needed to understand and appreciate the events and actions depicted in a narrative.

2 Energetic Costs, Imagination, & Motor Simulation

Slope perception provides a striking example of energetic costs effects in ordinary perceptual contexts. Proffitt and his colleagues used verbal assessments, visual matching tasks, and haptic matching tasks to measure the perceived slopes of a range of hills (Fig. 1). In visual matching tasks participants adjusted the pie shaped segment of a customized disk to match the slope of the hill. In the haptic matching tasks participants placed their palms flat on a board that could be tilted forward and back (like the plate of a photographer's tripod) and adjusted its angle while continuously looking at the hill. Participants exaggerated the slopes of hills in their verbal and visual estimates. They judged 5° slopes to be about 20°, and 10° slopes to be about 30°. However, their haptic assessments tended to be accurate. Finally, participants were also asked to set the visual matching disk to a variety of angles between 0° and 90°. Participants performed this control task with high accuracy demonstrating that differences between verbal/visual and haptic assessments cannot be attributed to any general difficulty explicitly reporting angles in degrees.

The types of misperceptions observed by Proffitt and his colleagues are not errors. They are cognitive shortcuts, task specific modifications of the spatial metric of perception that directly encode the relative energetic and emotional costs of particular types of actions (Proffitt 2006). In this regard one can think of them as constructive misperceptions that enhance the efficiency of explicit action planning by enhancing the perception of affordances and other task related environmental features. Comparisons of the response functions for verbal, visual, and haptic matching performance can be used to illustrate this claim. Verbal and visual assessments were statistically indistinguishable between 0° and about 30° (Fig. 2). Visual overestimation falls off steadily past this point. Verbal overestimation continues to climb steadily past 30° (although the rate of overestimation falls off relative to the angle of slope). Haptic assessments are accurate between 0° and 25° after which participants underestimate the angles of slopes in their haptic measures. 30° is a critical measure. It is about the limit at which a normal, healthy individual can ascend an incline without using his or her hands. The shared threshold for visual

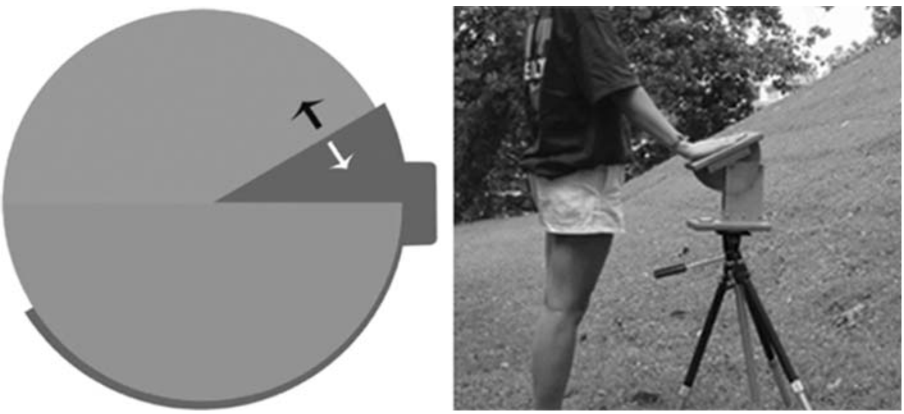

Fig. 1 Visual matching disk (*left*) and haptic palmboard (*right*) (Proffitt 2006, pp. 111–112)

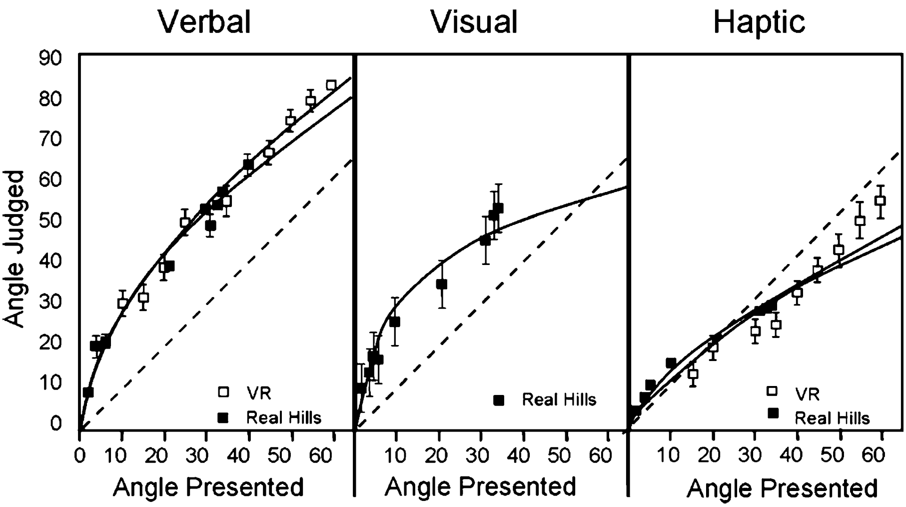

Fig. 2 Response functions for verbal, visual, and haptic slope assessments for a range of real hills and slopes presented in virtual reality displays (Proffitt 2006, p. 112)

and haptic responses at about 30° therefore encodes the behavioral significance of a feature of the distal environment critical to action planning.

The change in rate of visual overestimation also reflects the energetic costs of actions. Rate of visual overestimation rises steeply between 5° and 10° (from 10° to 30°), falls off steadily between 10° and 30° (≈ 30° to 45°), and then begins to flatten out until, at 50°, participants begin to underestimate the slope of the hill. These results reflect changes in the energetic costs of climbing as hills get steeper. The difference in energetic costs for ascending a 5° and a 10° slope is quite large, the difference between a 10° and a 30° hill is still large, but not as significant. The differences between a 30° and 50° hill are behaviorally insignificant since they are at or beyond the limit of what can be reasonably ascended. A similar explanation can be constructed for the haptic matching results, once the slope of a hill exceeds ≈30°, the point at which haptic underestimation begins, the plausibility of climbing it in ordinary contexts decreases significantly, as does the utility of accurate visuomotor assessment.

The above examples demonstrate that changes in the energetic costs of action due to variability in local geography influence the spatial metric of perception. The same is true of changes in energetic costs due to the physiological and psychological states of actors (Proffitt 2006). The apparent slopes of hills increase when participants are fatigued after a long run or encumbered by a heavy backpack. Likewise, apparent egocentric distance to a target increases when participants wear a backpack or are asked to throw a heavy ball to it. These effects generalize to fitness, aging, the emotional costs of actions,[7] and are correlated with self-reports of physiological health. Finally, purposiveness is a key variable in the production of these types of effects. Witt et al. (2004) divided participants into throwers and walkers relative to

[7] See above, p. 3. Emotional costs of actions cause agents to scale their actions to avoid perceived risks related to general fears (e.g., fear of heights) or dangerous environmental conditions (e.g., anxiety about descending a steep slope on a skateboard).

the types of actions they anticipated performing. Prior to making their distance assessments participants either walked on a treadmill or tossed a heavy ball to a target. The treadmill adaptation influenced apparent egocentric distance to a target if participants anticipated walking to it, but not if they anticipated throwing a ball to it. The throwing adaptation influenced apparent egocentric distance to a target if they anticipated throwing a ball to it but not if they anticipated walking to it. Therefore, the effects of energetic and emotional costs on the spatial metric of perception are limited to the energetic and emotional costs of actions perceivers intend to perform themselves.

Energetic costs effects also generalize to cases in which participants imagine performing an action. In a series of experiments Witt projected a small 2 cm target circle onto a table in front of participants (Witt and Proffitt 2008). The targets were in reach only if participants held a conductor's baton. The conductor's baton functioned as a tool that changed their physiological potential and, consequently, the energetic costs of engaging with the local environment. Participants were asked to either reach to the target and touch it with the baton, or to extend their arm as far as they could and point to (while reaching for) targets that were out of reach. Prior to reaching or pointing two comparison circles were projected onto the table, one to either side of the target. Participants used the arrows keys on a keyboard to adjust the comparison circles in a fronto-parallel plane until the distance between them matched the egocentric distance to the target. All participants reached/pointed with their right hands and used their left hands to manipulate the keypad. Participants were assigned to one of four conditions: in the hold-tool condition they held the baton in their hands while making their distance assessments, after which they reached and touched the target with it; in the no-tool condition they extended their arms and reached for (pointed to) the target after making their distance assessments; in the anticipate-holding-tool condition they made their distance assessment with the baton sitting on the table beside them, after which they picked up the baton and reached to touch the target; in the imagine-holding-tool condition they reached and imagined touching targets with the baton while it lay on the table beside them. The targets were out of reach in the imagine condition so that participants had to imagine holding the baton to accomplish the task. Participants in the no-tool group perceived the target to be farther away than participants in each of the other conditions. The differences between the no-tool condition and each of the hold, anticipate, or imagine conditions were significant. The differences among the hold, anticipate, and imagine conditions were not statistically significant.

Kinesthetic imagery (imagine), motor preparation (anticipate), and action execution (reach) draw on the same neural mechanisms and cognitive processes as motor simulation (Decety and Grèzes 2006). Witt argues, as a result, that the correlations among the imagine, anticipate, and hold conditions demonstrate that motor simulation is the mechanism responsible for energetic and emotional costs effects. One means to test this hypothesis is to ask participants to perform a concurrent action that would interfere with the capacity for motor simulation while they make distance assessments. If motor simulation is responsible for energetic cost effects in perception, then this type of motor interference task should eliminate changes in physiological potential conferred by the anticipated use of the baton. The procedures for the experiment Witt used to evaluate this claim were identical to procedures for the anticipate condition with the exception that half of the participants applied light pressure to a rubber ball with their reaching hand while making distance assessments (Witt and Proffitt 2008). Participants in the squeeze group, as predicted, perceived the target to be farther away than the participants in the no-squeeze group.

3 Materials, Methods, & Results

We hypothesized that, if participant accounts are sound, and viewers simulate actions depicted in static images from a first person perspective, then energetic and emotional costs effects should generalize to picture perception. We chose two paintings by Andrew Wyeth, Christina's World[8] and Winter, 1946,[9] to test this hypothesis. Naïve viewers often report that the subject of Christina's World, Christina Olsen, is a normal individual lying in a field looking at a house in the distance.[10] However, she suffered from an undiagnosed muscular disorder as a small child that had left her unable to walk. Wyeth reports that she is actually depicted crawling home in the painting. Naïve viewers report that Winter, 1946 depicts a boy playing in a bleak winter landscape. However, Wyeth's father, N.C. Wyeth, and young nephew were run over by a train just beyond the crest of the hill in the painting. The painting actually depicts the neighbor's son, who witnessed the accident, running down the hill with reckless abandon and symbolizes the anxiety Wyeth felt after losing his father and chief mentor. We predicted that the introduction of this biographical information would alter the interpretation of the action depicted in the paintings along with associated energetic or emotional costs, and consequently cause viewers to perceive the slopes of hills in the paintings as steeper and the egocentric distance to key landmarks as longer.

3.1 Materials & Methods

Participants Ninety-two participants were recruited from the general Franklin & Marshall College population, divided into an energetic costs experiment group (EN) and an emotional costs experiment group (EM) (61 EN and 31 EM; 28 males and 64 females; 83 undergraduates and 9 faculty), and compensated with lab credit or paid $5 for their participation. All participants gave consent.

[8] See retrieved August 31, 2008: http://moma.org/collection/browse_results.php?criteria=O%3AAD%3AE%3A6464&page_number=1&template_id=1&sort_order=1

[9] See retrieved August 31, 2008: http://www.humanitiesweb.org/human.php?s=g&p=c&a=p&ID=1239

[10] I am perennially surprised by the number of students and colleagues who tell me they never noticed that Christina Olsen is depicted as disabled, or realized that she is depicted crawling home, and so never really understood the psychological dimension of the painting. This type of naïve misperception of the work is reflected in a June 30, 2006 Letter to the Editor from the Lancaster Intelligencer Journal. The writer described the paintings in the Wyeth retrospective at The Philadelphia Museum of Art as celebrations of rural American life which symbolize the same kind of moral virtues as Norman Rockwell's Saturday Evening Post paintings. It is also supported by survey data from our study. 91% (51/56) of participants described Christina Olsen as lying in the field in surveys completed after their first drawings (i.e. prior to the introduction of biographical information), and only one participant spontaneously described Christina Olsen as suffering from psychological distress (i.e. "lying, upset, helpless"). Likewise only 7% (2/28) describe the subject of Winter, 1946 as exhibiting psychological distress prior to the introduction of biographical information.

Materials We used four Wyeth paintings that are similar in luminance profile and hue: Brown Swiss[11] (practice), East Waldoboro[12] (practice), Christina's World (energetic costs), and Winter, 1946 (emotional costs). Christina's World and Winter, 1946 are similar in compositional structure. Images were projected onto a screen using a ceiling mounted VGA projector and presented 25″ x 40″ on a black field in a darkened room for either 30-seconds, 1-min, or 3-min. Participants sat at a large utility table seven feet away from the screen. The center of the image was located approximately 18″ above their line of sight. Participants made their drawings on 24″ x 36″ sheets of rough newsprint using soft (8b) drawing pencils. Each participant was given four sharpened pencils, an Artgum eraser, and a pencil sharpener. The projected size of each image was scaled to roughly match the visual size of the drawing sheet.

Design & Procedure We used a between subjects factorial design to measure the effects of change in the interpreted costs of depicted actions (costs) and drawing time (time) on the apparent extent of the target images. We tested for energetic and emotional costs effects separately. Participants within each of the energetic and emotional costs experiments were divided into experimental and control costs groups. Participants in the energetic costs experiment were assigned to either a 30-second, 1-min, 3-min, or Reverse (1-min) drawing condition. Participants in the emotional costs experiment were assigned to either a 30-second or 1-min drawing condition. All participants were instructed to copy the spatial arrangement of the key features in the scene depicted as accurately as possible. They were instructed not to worry about how realistically their copies matched the original paintings and encouraged to use abstractions to facilitate their drawings (e.g. rectangles for buildings and stick figures for people). They were told that the goal was to produce the kind of sketch one would use to register the relative positions of key figures on a canvas at the start of an oil painting. These instructions were reinforced before each drawing.

Participants in each drawing time condition made two practice drawings after which they copied either Christina's World or Winter, 1946 twice. Participants in the experimental groups made drawings of the target painting in a naïve condition (drawing 1) and an educated condition (drawing 2) after reading biographical information salient to the depicted action. Participants in the 30-second, 1-min, and 3-min energetic costs drawing conditions read a biographical passage that described Christina Olsen's disability and explained that she was depicted crawling home from a rare visit to her parents' graves. Participants in the emotional costs experimental group read a passage that described the boy running down the hill as anxiously fleeing the train accident that killed N.C. Wyeth and explained that the painting symbolized Wyeth's anxiety about his future at the time. Participants in the Reverse Energetic Costs condition were asked to read the biographical information about Christina Olsen prior to drawing 1. They were then asked to read a second passage designed to lessen their interpretation of the energetic costs of the event depicted in Christina's World prior to drawing 2. The story that participants in the Reverse

[11] See retrieved August 31, 2008: http://www.museumsyndicate.com/item.php?item=15617
[12] See Corn 1973, p. 100.

condition read prior to their second drawings debunked the myth that Christina was crawling home from a visit to her parents' graves, described her as actually returning from her vegetable garden, and explained that Christina and her brother farmed the blueberries that grew in the field. Participants in the control groups did not read the salient information about the depicted events between drawings 1 and 2.

Participants were told that their first two drawings were for practice and that they might see the same image twice. However, they did not know in advance that they were going to make two copies of the target painting. Participants' filled out a written survey after completing drawing 1 to screen for drawing skill, general knowledge of art history, and their interpretation of the energetic/emotional costs of the action depicted in the painting. Participants filled out a written survey after completing drawing 2 to screen for familiarity with the painting, familiarity with Wyeth's work, familiarity with biographical knowledge salient to the events depicted in the paintings, and their interpretation of the energetic/emotional costs of the action depicted in the painting. All participants took an enforced, 2 min break between the first survey and drawing 2 that served as a distracter task to take their minds off of their first drawings of the target image. Biographical information about the paintings were presented to participants in the experimental groups at the end of the break.

3.2 Results

We defined the extent of Christina's World as the area of the triangle formed by the head of the figure, the front corner of the house (the target of the depicted action), and the point where a vertical line bisecting the head of the figure intersected with the horizon. We defined the extent of Winter, 1946 as the area of the triangle formed by the head of the figure, the center of the bush at the point where the road meets the horizon (the target of the depicted action), and the peak of the hill. These area measures enabled us to capture changes in both the extent of the slopes of depicted hills and the egocentric distance between the subjects of the painting and the targets of their actions. Distances appear longer on hills and exaggerations of distance on hills are correlated with changes in apparent slope. We hypothesized, therefore, that the apparent distance to the tops of depicted hills would vary with apparent slope even though the peak of the hill was not the immediate target of the depicted action. We threw out drawings in which any of these features were omitted. There were 84 remaining pairs of drawings following this procedure (56 EN; 28 EM). We used the 1-min energetic costs target group as control measures for the Reverse group. We reversed the sign for area and egocentric distance measures for the Reverse condition in data analysis so that we could compare the magnitude of change among the different energetic costs drawing conditions.

3.2.1 Energetic Costs[13]

A 2 (costs) x 4 (time) between subjects factorial ANOVA was calculated comparing the change in extent (in^2) between the energetic costs experimental and

[13] We used a Bonferroni adjusted alpha level of 0.017 (0.05/3) for each of the analyses of the energetic costs results.

Table 1 Mean change in extent (in^2) between drawing 1 and drawing 2

	Experimental		Control		df	F-stat	sig.
Group	m	sd	m	sd			
Energetic Costs (all)[a]	4.842	11.778	−4.798	15.654	1,58	13.896	0.000
30-seconds	1.455	15.027	8.284	8.138			
1-minute	8.990	9.651	−16.944	6.615			
3-minutes	4.079	9.776	−16.199	13.950			
Reverse	2.806	19.023	8.990	9.651			
Emotional Costs (all) [b]	8.1117	20.160	−5.185	24.806	1,23	1.986	0.172
30-seconds	9.309	19.722	−5.505	30.011			
1-minute	6.627	21.964	−4.785	20.967			

[a] Mean change in extent (in.)^2 for the combined 30-second, 1-min, 3-min and Reverse energetic costs drawing conditions

[b] Mean change in extent (in.)^2 for the combined 30-second and 1-min emotional costs drawing conditions

control groups. There was a significant main effect for costs, F(1,58)=13.896, $p<0.001$. Participants in the experimental group expanded the extent of the landscape in drawing 2 relative to drawing 1 to a greater extent than participants in the control group (Table 1). There was no main effect for time, F(3,58)=2.637, $p=0.029$, however the interaction between costs and time was significant F(3,58)= 6.355, $p<0.001$ indicating that energetic costs effects were influenced by the amount of time participants had to make their drawings (Fig. 3).

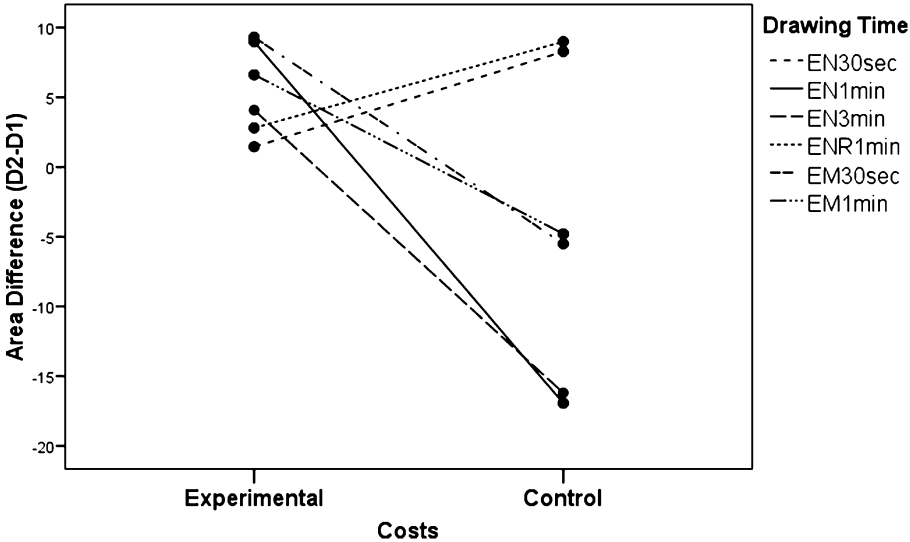

Fig. 3 Mean change in extent (in.^{2}) for the energetic and emotional costs groups (the figure reflects the actual measures for the Reverse energetic costs experimental and control groups)

We ran a between-subjects ANOVA comparing the values of the costs variable among the drawing time conditions within each of the experimental and control groups in order to evaluate the interaction between costs and time. There was no significant difference in the mean change in extent among the 30-second, 1-min, 3-min, and Reverse experimental conditions, $F(3,33)=1.164$, $p=0.338$. However, the differences in the mean change in extent between the control conditions were significant, $F(3,25)=10.923$, $p<0.001$. The mean difference between the 30-second control condition and each of the 1-min (md=25.288, se=5.375, $p<0.001$), 3-min (md=24.483, se=5.375, $p<0.001$), and Reverse control conditions (md=17.274, se=4.428, $p=0.001$) was significant. The mean differences among the 1-min, 3-min, and Reverse control conditions were not significant. These results demonstrate that the interaction between condition and time is explained by the performance of the 30 s energetic costs control condition.

We also ran a 2 (costs) x 4 (time) between subjects factorial ANOVA comparing the change in egocentric distance (in.) from Christina Olsen to the house in order to confirm that the observed energetic costs effects were associated with the depicted action. There was a significant main effect for costs, $F(1,58)=6.770$, $p<0.012$. Participants in the experimental group expanded the distance between Christina Olsen and the house in drawing 2 relative to drawing 1 to a greater extent than participants in the control group (Table 2). There was no significant main effect for time, $F(3,58)=2.217$, $p=0.096$. The interaction between costs and time was not significant, $F(3,58)=2.565$, $p=0.063$ indicating that energetic costs effects on egocentric distance were not influenced by the amount of time participants had to make their drawings.

3.2.2 Emotional Costs

A 2 (costs) x 2 (time) between subjects factorial ANOVA was calculated comparing change in extent (in^2) between drawing 1 and drawing 2 for participants in the emotional costs experimental and control groups. No significant main effect was found for costs, $F(1,23)=1.986$, $p=0.172$. Although participants in the experimental group expanded the extent of the landscape in drawing 2 relative to drawing 1 to a greater extent than participants in the control group (Table 1), the difference was not significant. There was no significant main effect for time, $F(1,23)=0.011$, $p=0.917$. The interaction between costs and time was not significant, $F(1,23)=0.033$, $p=0.857$.

Table 2 Mean change in egocentric distance (in) between drawing 1 and drawing 2

	Experimental		Control		df	F-stat	sig.
Group	m	sd	m	sd			
Energetic Costs (all)[a]	0.298	1.824	−0.758	1.878	1,58	6.770	0.012
30-seconds	0.553	1.353	0.444	1.267			
1-minute	0.863	2.064	−2.050	1.685			
3-minutes	0.400	1.875	−1.425	1.769			
Reverse	1.018	1.698	0.863	2.064			

[a] Mean change in egocentric distance (in) for the combined 30-second, 1-min, 3-min and Reverse energetic costs drawing conditions

4 Discussion: Imagining Crawling Home

The results of our study demonstrate that energetic costs effects generalize to picture perception. Information sufficient to recognize Christina Olsen as a character of a particular type with a range of task specific goals, beliefs, and affective states was explicitly represented in the passage read by participants in the energetic costs experimental condition. Observer accounts predict that simulation is otiose in this type of case. Nonetheless, we observed energetic costs effects in participants' drawings indicating that participants simulated Christina's psychological perspective while engaged with the painting (Fig. 3). We don't explicitly recognize the scaling effects of energetic costs in ordinary perception. This entails that we lack the knowledge needed to recognize how the landscape would appear to Christina across changes in energetic costs from the perspective of an observer. This information would be readily available if one were to use motor simulation to generate a forward model of the bodily and perceptual consequences of performing the depicted action oneself. Therefore, we interpret our results to demonstrate that participants imagined what it would be like to anticipate crawling home across the field in the painting from Christina Olsen's vantage point and psychological perspective. However, we do not interpret our results to establish that first person perspective taking is the primary means of engagement with narratives. Rather, given the fact that participants simulated the depicted event despite the fact that there was putatively no need to, we believe that our study demonstrates that simulation plays a greater role than countenanced by observer accounts.

We initially expected that participants in the 3-min energetic costs experimental group would have ample time to analyze the spatial layout of the painting and correct for recognizable copying errors related to either task difficulty or the energetic costs of depicted actions. We predicted, as a result, that participants in the 1-min energetic costs experimental condition would expand the landscape to a greater extent than participants in the 3-min condition and that the 3-min drawings would be closer to accurate. This was the case, but with a caveat (Table 3). The performance of the 3-min group reflects the natural influence of energetic costs on the spatial metric of perception, not the spatial layout of the painting. As in the case of slope, increases in the energetic cost of actions cause increases in apparent egocentric distance. However, unlike the case of slope, perceivers underestimate distances in ordinary perceptual contexts, and overestimations of distance due to increases in energetic costs more closely approximate the actual distance to the target. Participants in the 3-min group underestimated the extent of the landscape in their naïve drawings and were

Table 3 Mean extent (in^2) in the 1-min and 3-min energetic costs experimental group drawings and Christina's World

	1 Min	3 Min	Christina's World
Naïve	41.42	36.24	40.22
Educated	50.41	40.32	

accurate in their educated drawings. In contrast, participants in the 1-min energetic costs group exaggerated the extent of the depicted landscape in both their naïve and educated drawings. Therefore the performance of participants in the 3-min condition more accurately reflects the energetic costs of the depicted actions for Christina Olsen than participants in the 1-min group. We take these results as further evidence that participants adopted the vantage point and psychological perspective of Christina Olsen and simulated the depicted action.

One could argue that the processes underlying energetic costs effects are low level simulation processes, and so are not candidates for the type of perspective taking central to participant accounts of narrative engagement. Our results challenge this objection. Low level simulation refers to automatic and unconscious mirroring processes that are involved in coordinating responses to the behaviors of others (e.g., the activation of mirror neurons in response to facial expressions or goal directed hand movements) (Goldman 2006). Low level simulation is contrasted against high level simulation processes, like perspective taking, which are often subject to voluntary control, conscious, and involve explicitly entertaining the mental states of others. The performance of the energetic costs groups is not consistent with the types of automatic processes implicated in low level simulation. Physiological and postural cues diagnostic for Christina Olsen's action and disability are explicitly represented in the painting (e.g. the forward cant of her posture, her gnarled hands, contorted pose, and emaciated wrists and ankles). If mirroring processes were responsible for observed energetic costs effects, the written passages read by participants in the experimental group prior to their educated drawings should be redundant, and one would not expect to find significant differences between the experimental and control groups in drawing 2 (Fig. 4). This was not the case. The introduction of information that explicitly identified Christina Olsen as disabled and crawling home produced significant energetic costs effects. We suggest that this demonstrates that perspective-taking draws on both high and low level processes in narrative contexts: we use high level simulation to identify a target set of mental states and goals and then use low level simulation to model their perceptual and behavioral effects.

We were not able to reverse the effects of the interpreted energetic costs of the action depicted in Christina's World. Although participants in the energetic costs Reverse condition did not expand the landscape to as great an extent as participants in the 1-min energetic costs experimental condition, they did expand the landscape in drawing 2 relative to drawing 1 (Table 1). We expect that these results are related to difficulties with the two stories that we used in the reverse condition. The story that participants read prior to drawing 1 reported that Christina Olsen had been severely disabled since early childhood and described her as crawling home from a rare visit to the family graveyard. The story that participants read prior to their second drawing debunked the myth that she was crawling home from the family graveyard, reported that she and her brother farmed the blueberries that grew in the field, and described her as returning from their vegetable garden. However, it also reinforced the fact that Christina Olsen had been severely disabled since early childhood. It is possible that, as a result, contrary to our prediction, participants did not rate the latter task as easier than the former. They may even have thought it would be harder to work the fields than to visit the family plot once in a while,

Fig. 4 Examples of drawings from the 1-min energetic costs drawing condition: drawing 1 (*top*) drawing 2 (*bottom*). We found no perspectival effects associated with the expansion of the extent of the depicted landscape. However, participants tended to draw a more pronounced crown to the hill in the educated condition. We interpreted this effect to represent an increase in the depicted slope of the hill. Notice also that Christina is depicted with her arm outstretched as if crawling in the educated drawing and that her ankles are rendered more accurately as emaciated

which would account for the slight increase in mean change in extent in drawing 2. One way to test this hypotheses would be to change the story we used prior to the second drawing. Wyeth used his wife Betsy, who was 30 years old and in the peak of health at the time, as the model for the painting. One could omit mention of Christina Olsen from the second story and report that it is actually Betsy who we see crawling across the field.

It is also possible that the initial impression produced by the first story was simply difficult to override, particularly because we reinforced knowledge of her disability in the second story. This explanation is consistent with a significant omission in the energetic costs literature. We know of no studies in the literature evaluating cases in which one experiences an increase in the energetic costs of an anticipated action followed by a subsequent decrease. It may simply be the case that it is difficult to reverse or override energetic costs effects. This would make sense from an evolutionary perspective. It is also consistent with the optimality model for costs/benefits analyses of behavior that Proffitt adopts from behavioral ecology in his explanations of energetic costs effects (Proffitt 2006; Krebs and Davies 1987).[14] "False positives" that overrate the potential risks and energetic costs of actions would have greater survival value than false negatives in these contexts.

The drawings from the emotional costs groups did not support our hypothesis. There are several possible explanations for these results. First, participants drawings suggest that they had difficulty copying Winter, 1946. Cohen (2005) has identified gaze frequency as a source of drawing difficulty for naïve copyists. Individuals with advanced drawing experience adopt systematic gaze strategies that enable them to look back and forth from the subject to their copies efficiently. Individuals who lack drawing experience exhibit irregular gaze strategies that preclude looking back and forth efficiently between their copies and the original at drawing times shorter than 1 min. The boy in the painting is both running towards, and looking at, the viewer. We speculate that the eyes of the figure engaged the attention of viewers, and that this had a negative impact on their gaze strategies (we also hypothesize that inefficient gaze strategies account for the performance of participants in the 30 second energetic costs control group). Second, emotional costs effects in perception are limited to the costs of anticipated actions (e.g., anxiety directed at the risks associated with descending a steep slope). The emotional costs story we used describes the figure in the painting as anxiously fleeing. However the target of the anxiety depicted in this story is not the slope, but rather a past event that transpired beyond the crest of the hill. The conjunction of these factors suggests that complications with the stimulus explain the performance of participants in the emotional costs group.

The results of our study do not have any direct bearing on discussions of the cognitive and behavioral asymmetries between consumers and characters. However, the energetic costs research indirectly supports our model for participant accounts in these contexts. Witt's squeeze/no-squeeze experiment demonstrates that energetic costs effects in perception are specific to the effectors involved in the performance of the target intended action (e.g. the specific muscles involved in squeezing the ball and holding the baton). Participants' in the study used left hand key presses to

[14] Optimality models seek to explain adaptations in terms of cost/benefit tradeoffs that would yield the maximum benefit to an individual.

manipulate the comparison circles throughout the process of distance assessment. Nevertheless, only the concurrent squeezing action with their reaching hands interfered with distance assessment. This entails that, at least in the case of motor simulation, we only model discrete local aspects of target behaviors germane to the epistemic needs of particular, narrowly construed scenarios. Given that energetic and emotional costs effects are correlated with explicit self-reports of physiological health and emotional states respectively, we expect that this is also true of simulations directed at understanding the relationships between the mental states and behaviors of others. Therefore, we interpret these results to support the claim, discussed above (see page 10), that readers and spectators use simulation to model discrete aspects of the local behaviors of characters where this information would contribute to his or her understanding or appreciation of the narrative. If sound this would support our claim that asymmetry problems need not threaten participant accounts of narrative engagement.

Finally, there is no direct evidence in the present study to verify that motor simulation is the mechanism responsible for the observed energetic cost effects. Surface electromyography (EMG) suggests an indirect means to test whether our inference is sound. Motor simulation is, as discussed above, associated with the activation of premotor cortex. Activation of premotor areas in motor simulation produces low level electromyographic signals in target muscles (Tassinary et al. 2007). If motor simulation is the mechanism responsible for energetic cost effects in picture perception, one would expect to find measurable electromyographic signals in target muscles associated with the actions Christina is depicted performing in the painting, (i.e. whether she is depicted lying in the field or crawling home). Therefore, surface electromyography could potentially be used to evaluate whether participants adopt the perspectives of characters in picture perception. A second means to test our hypothesis is already present in our discussion of the Reverse condition. We could use larger image sets and generate more variants of the stories that we tell participants in order to tease out the relationship between interpretation of energetic cost and picture perception. This would also enable us to more carefully control for exactly what participants are imagining when they engage with narratives. It is critical to narrative understanding that we simulate the mental states and behaviors of characters from their depicted psychological perspective, not our own (e.g., that we simulate Christina Olsen's perspective as that of a disabled person and not a marathon runner). One way to verify that participants do this would be to vary the information presented about the beliefs, desires, and physiological health of characters. Potential correlations between energetic costs effects and variations in the story would establish that viewers simulate the actions depicted in static images from the perspectives of their characters.

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