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EDITORIAL

Linking Contemporary Research to the Classics: Celebrating 125 Years at APA

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APA is celebrating 125 years this year and at the journal we are commemorating this milestone with a special issue. The inspiration came from our editorial team, who wished to acknowledge the links between game-changing articles that have influenced our research community in the past—we call them classics for short—and contemporary works. The main idea was to feature the work of nine contemporary research teams, while at the same time drawing readers' attention to their links with the classics. In this introduction, we have organized the articles according to several broad themes: active perception, perception for action, action alters perception, perception of our bodies in action, and acting on selective perceptions. As all who have read and contributed to the journal over the past few years have come to realize, it is no longer possible to study perception without considering its role in action. Nor is it possible to study action (formerly called *performance*, as reflected in the journal title) without understanding the perceptual contributions to action. These nine articles each exemplify, in their own way, how these dynamic interactions play out in contemporary research in our field.

Perception Is Active

To take in the visual world, our eyes must make a series of short pauses (fixations) and rapid eye movements (saccades). The purpose of these eye movements is to bring detailed information into the fovea (the center 2° of vision), where visual acuity is greatest and fine details can be discerned. Although these basic characteristics of eye movements were known long ago, it was not until the mid 1970s that it became technically feasible for perception scientists to study this process in an interactive way, by altering the visual display contingent on where a participant was currently fixated. In a highly influential paper, Rayner (1975) introduced what is now known as the gaze-contingent boundary paradigm to examine how much visual information can be obtained outside of the fovea (i.e., parafoveally) before a target word is fixated. Using this method, a reader's eye position is monitored and an invisible boundary is placed in the text being read. Prior to the eye crossing the boundary during a saccade, a preview of a target word is displayed in the parafovea. Once the reader's eyes cross the boundary the preview is replaced by the correct target word. All of this can occur outside the reader's awareness because of saccadic suppression (i.e., display changes made while the eye is in flight between fixations usually go undetected). The boundary paradigm thus provides a sensitive way to assess the kinds of information a reader can acquire about a word in the parafovea prior to its actual fixation.

Rayner's (1975) classic study demonstrated that readers obtain useful information about a target word, including information about its beginning letters, up to 12 characters before it is directly fixated. Since then, a large literature has amassed to explore

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parafoveal processing during reading (for a recent review, see Schotter, Angele, & Rayner, 2012). A key question has been to what extent attention can be distributed across multiple words.

Drieghe, Fitzsimmons, and Liversedge (this volume) add to this literature by using the gaze-contingent boundary paradigm to explore how the removal of word spaces, which are a key determinant for word segmentation when reading English sentences, impacts parafoveal processing. The results suggest that when presented with unspaced text, readers use limited distributed processing to aid in word segmentation, followed by a narrowing of their attention to the word that is currently fixated. This article thus highlights the continued utility of Rayner's (1975) gaze-contingent boundary paradigm for gaining insights into the nature of parafoveal processing and the allocation of attention during reading.

It was not long after Rayner's (1975) contribution that researchers widely began to study eye fixations and eye movements in a more general way than in the relatively circumscribed domain of reading text. Tracking the eyes while viewers made even the most cursory explorations of a scene showed that their eye fixations tended to cluster more in some regions than in others. For example, Loftus and Mackworth (1978) asked what makes an area of a scene "informative." They began by noting that people have a tendency to make fixations in the same regions of a scene that other people have rated independently as being the "most informative." From the theoretical perspective in vogue at the time, this meant that viewer's eyes were going to regions of a scene that were "least redundant" in information theoretic terms. In modern language, they were showing that eye movements were guided by the semantics of a scene and so were more likely to be made to regions of a scene containing objects that were semantically inconsistent with the overall gist of the scene. But is this guidance of the eyes based on low-level visual features in a scene that are correlated with semantic information? Or are the eyes guided by a mental model that is independent of the physical salience of each of the regions in a scene? A large literature now addresses these questions (Henderson, 2007; Rayner, 2009).

The new article by Spotorno and Tatler (this volume) continues to study these questions by pitting different levels of semantic information value against different levels of perceptual saliency. These authors vary the relations between scene objects and their background, such that consistent objects central to the understanding of a scene (diagnostic) are compared to objects that are either inconsistent with the scene, or are incidental to the scene (consistent marginally informative). They find that diagnostic objects are prioritized overall; they are fixated sooner than either a consistent or inconsistent object. But interestingly, this prioritization is also modulated by saliency, such that a highly salient inconsistent object is prioritized over a nonsalient diagnostic object. This finding suggests that saliency has an effect that is contingent on the object's semantic relationship to the scene. Moreover, this prioritization depends on the task being performed by the viewer. These dynamic interactions between the various influences on our eye movements indicate that a complete understanding of the relations between the acquisition of new information (eye movements to new locations) and the processing of that information (during fixation) remains a challenge. Spotorno and Tatler's offering of innovative methods for studying these questions continues in the rich tradition pioneered by Loftus and Mackworth (1978).

Perception for Action

The human ability to intercept an approaching ball in a sport such as baseball is truly remarkable, especially given that the difference between the joy of victory and the agony of defeat is only milliseconds in time and millimeters in space. How do we use visual information about the ball in motion to guide hitting and catching? James Todd (1981) addressed this question by first offering a mathematical analysis of the available information in the optic flow field. This analysis showed that the optical information included the ball's angle of approach, its velocity and acceleration changes, its time to collision, and its landing location. Using patterns of dots presented on a small CRT display, Todd next conducted a series of discrimination experiments to test observers' sensitivity to these different information sources. The main finding was that viewers were exquisitely sensitive to some sources (e.g., rate of expansion of the ball's image) but not to all of them (e.g., the ball's acceleration).

Savelsbergh, Whiting, and Bootsma (1991) built on this work with an ingenious experimental method that required participants to catch approaching balloons. These authors demonstrated that we are not only very sensitive to an approaching object's rate of expansion but use that information to control our actions. The results showed that participants closed their hand slightly later when trying to catch a balloon that was releasing air (and thus reducing its rate of image expansion) than when catching a stable balloon (with a constant rate of image expansion).

The article by Sarpeshkar, Abernethy and Mann (this volume) makes a new contribution to this research by presenting the first large scale and in situ study of a ball interception task, in the domain of cricket batting. By examining the eye and head movements for cricket batsmen of different skill levels, the study builds on previous work by asking a critical question: How is the information used to guide the action? A key finding of the study is a failure to support the hypothesis that more skilled batters make earlier predictions about the future location of the ball and use these predictions to initiate early fixations to this location. Instead, skilled batters are found to wait longer to initiate movement, presumably so that more updated ball-flight information can be used prior to action initiation. A second important contribution of this study concerns the role of batter's expectations about the ball flight. Specifically, introducing the possibility of curved trajectories in the ball's path led to significant changes in the visual-motor behavior and hitting performance of skilled batters.

Our visually guided actions have consequences not only for other objects, such as balls we can intercept, but also for the movement of our own bodies within larger spatial environments. For instance, when we walk around, we negotiate obstacles, cope with slippery surfaces, react to sudden changes, and generally put our feet in locations that allow us to move safely and efficiently. Lee, Lishman, and Thomson (1982) launched a research field that addresses how we accomplish this, by introducing what has become known as the rough (or complex) terrain problem. These authors filmed three elite long-jumpers during their sprints to the takeoff board. The jumpers' stride lengths were remarkably consistent for much of their run-up, with standard errors being about 3 cm. Just before the takeoff board, however, strides became more variable, and there was a sharp decrease in the variability of the actual footfall positions. The film sequences suggested that jumpers were regulating their footfall positions just prior to the takeoff board by varying their vertical thrust (and thus, their "flight time"), during each stride. Clearly, this regulation of gait was based on visual information. Because the stride parameter under adjustment was flight time, not stride lengths or distances, the authors argued that jumpers were using visual information about how close they were to the takeoff board in time rather than in distance—that is, they were using visual information about time-to-contact. This article continues to spark imaginative research questions and methodology, with recent research emphasizing more natural walking tasks and fine-grained analysis of what, when, and how often visual input is sampled.

Barton, Matthis and Fajen (this volume) exemplify this trend, with their work making use of a motion-tracking and projection system to present visual targets at different locations in the walking path for participants to step on—with varying amounts of advance notice. These methods allow them to demonstrate that the correlation between one visual variable (time-to-contact) and one action variable (vertical thrust) established by Lee et al. (1982) is not the only determinant of how walkers choose their footholds. In particular, walkers have a strong tendency to choose footsteps in a way that minimize deviations from the passive biomechanics of body motion (i.e., the pendulum-like movement on each stride that evolves naturally after it is set in motion). This work therefore extends Lee et al. (1982) by showing that both visual and physical constraints are used to regulate gait when participants walk in a complex terrain. It also helps explain why vision is relied on more strongly during certain phases of gait than others (i.e., vision is weighted most when it can best be used to minimize deviations from the natural pendulum motions of the leg).

Action Alters Perception

The foregoing studies make it very easy to appreciate how actions as diverse as eye movements, reaching and grasping, navigation, and the active avoidance of (or compensation for) physical dangers, depend upon perception. What is less obvious, at least until Bhalla and Proffitt's (1999) pioneering work on geographical slant perception, is how our actions can reciprocally affect our perception of the environment. In this classic study, people were asked to judge the slant of two hills on the University of Virginia campus. The critical finding was that these hills looked steeper to those who were wearing heavy backpacks, and to those who were fatigued by previous exercise, those in poorer general health, or even the elderly. From these demonstrations, the authors argued that people perceive the world in terms of their own physiological potential for action. They were soon not alone; similar findings would be observed among several psychophysical properties of the world including distance, size, and speed and in tasks as wide-ranging as parkour, video gaming, tool-use, and virtual-reality. With this perspective gaining increasing theoretical appeal, coupled with a rising interest in embodiment within psychological science more generally, a new theory of perception emerged that has come to be known as the "action-specific account of perception." Its broad claim: Our mental processing of the visual world is not independent of our physical actions within it.

The action specific account of perception has not been, and is not now, without its skeptics. While demonstrations of action-specific effects have mounted, a clear mechanism for them has remained elusive. At the crux of the debate lies a central question: Do action-specific effects arise from an interaction between perception and action—as proposed by Bhalla and Proffitt (1999)—or do they result from other nonperceptual mechanisms related to cognition more generally, such as attentional control or response biases? Jessica Witt (this volume) summarizes and explores several of these alternative accounts for action-specific effects and the evidence both for and, ultimately, against them. Witt then critically assesses the hypothesis that information about action is weighted and integrated with visual information in a forward model—that is, one that makes predictions about the likely outcomes of action, both in terms of effects on the environment and effects on the individual. Witt reasons that because these outcomes vary according to one's circumstances, so too should the weights assigned to these sources of action information. As a result, systematically changing the outcomes of action within an individual should likewise systematically enhance or reduce accompanying action specific effects. In the work presented here, Witt uses a video game environment to take control of action away from participants by disconnecting volitional movement and corresponding environmental outcomes. With reduced weight on the information related to action, action-specific effects are indeed reduced in this study, thereby providing support for an integration mechanism that combines information about both the external environment and the body and its potential for action. Because of this integration, perception reflects both the causes and the consequences of intended actions.

Perception of Our Bodies in Action

Thirty years ago *Journal of Experimental Psychology: Human Perception and Performance* published a ground-breaking paper on the topic of how perception of our own bodies is calibrated with respect to the environment it moves in. Warren and Whang (1987) asked their study participants to walk through doorways that varied in width, ranging from those that could be easily fit through to those that were less than shoulder-width. A critical measurement in the study was that point at which participants would begin to turn sideways to clear the aperture. It turned out that this point was not constant, as might be expected for a static representation of one's own body, but it varied as a function of both individual body size and eye-height. The theoretical perspective in which these data were interpreted was Gibsonian, sometimes also referred to as *direct realism*, according to which objects in the world are perceived without intermediary cognitive processes, which require a mental representation of world coordinates (Gibson, 1979).

A few years later, Loomis, Da Silva, Fujita, and Fukusima, (1992) published a seminal paper that highlighted a distinction that today runs through a large swath of research on perception and action. Perceptual reports of perceived spatial extents are often systematically different from spatial extents when measured via a direct action task. Moreover, direct action tasks are often more veridical (true to physical measurements of spatial extents) than are perceptual reports. In the Loomis et al. (1992) study, participants indicated perceived spatial extents in the frontal and sagittal planes (relative to their own ego-center) by either making perceptual matches (equating distances in the two extents) or by blindwalking each of the two extents. Their main finding was a systematic distortion in the matching task (foreshortening in perceived depth) but not in the walking task. The authors considered several possible theoretical accounts for these differences. Most importantly, they emphasized that visually guided actions have been calibrated by direct experience in the world in a way that perceptual matching has not.

Rieser, Pick, Ashmead, and Garing, (1995) built on the idea of direct experience contributing to perceptual-motor calibration of large-scale distance perception. These authors tested whether perception-action calibration can be "globally" generalized to other types of actions. They also asked whether the generalization is functionally specific (i.e., to actions serving the same goal), or whether it is anatomically specific (i.e., only to actions using the same effectors). It is notable that both Loomis et al. (1992) and Rieser et al. (1995) studied space perception and action in large-scale real world environments, using groundbreaking methods. One of the highlights of Rieser et al. involved the clever decoupling of visual and biomechanical information for self-motion by pulling an actor walking on a treadmill with a tractor!

One of the technologies that allows today's researchers to answer new questions about the relation between large-scale space perception and action is that of immersive virtual environments (VEs). A pervasive question that arises from their use is the extent to which users (study participants) behave in them as though they are acting in physical space. A refrain that sounds familiar to those who know the seminal work of Loomis et al. (1992) is that actors in VE tend to underestimate distances in immersive virtual environments compared to matched environments in the real world, at least within action-relevant distances of 10 m or less (Bergmann et al., 2011).

The new article by Kelly, Siegel and Cherep (this volume) draws on the theory and methodology of Rieser et al. (1995) to examine the question of the generalizability of feedback and calibration of perceived spatial extents within virtual environments. These authors address a controversial question in the current literature about whether feedback received within the VE leads to effects on visually guided actions that are specific to recalibration of action, or whether the effects are more generalizable to a rescaling of perceived space. This work has theoretical implications for understanding the mechanisms underlying feedback in virtual environments. It also informs applied questions concerning the veridicality of space perception in VEs and the impact and generalizability of training, which may be particularly important with new commodity-level VE technologies emerging.

Other modern researchers may be studying action-space relations at spatial scales and in different sensory modalities, but their work is still visibly influenced by the classics of Warren and Whang (1987); Loomis et al. (1992), and Rieser et al. (1995). For example, Longo and Golubova (this volume) continue in the tradition of studying body-space perception, but they do so on a different body scale (perception of the hand), a different sensory system (tactile perception), a different methodology (multidimensional-scaling of reported distances between touches), and a different theoretical perspective (unabashed neurologically inspired theorizing about mental representations). It turns out that we do not know the back of our hands as well as its front. Their main finding is that whereas the palm of the hand (palmar space) maps beautifully onto the physical stimulation space, the back of the hand (dorsum space) is mapped in a systematically distorted way. Specifically, the mental geometry of the hand's dorsum is exaggerated in width (i.e., it is stretched along the medio-lateral hand axis). The authors go on to interpret these distortions as arising from the nature of the receptive fields of individual neurons in the somatosensory cortex. Thus, from their perspective, the geometry of tactile space is shaped by the geometry that is instantiated in the neurons used to represent space.

Acting on Selective Perceptions

The distinction between all potential perceptions that are possible in a given environment and those perceptions that are critically needed in order to perform a specific action is often referred to as selective attention. And it is not difficult to argue that the study of selective attention was influenced more by Treisman and Gelade (1980) than any other paper. This paper introduced us to feature integration theory, with its proposal that spatial attention functions to integrate multiple features into object representations as we perceptually analyze complex scenes crowded with visual information. This provided an explanation for the ubiquitous observation that observers' response times increased as people searched for targets that were defined by a conjunction of multiple features, among nontarget objects that had multiple features.

Why did this seemingly simple idea capture the imagination of cognitive scientists? The most powerful aspect of feature integration theory (Treisman & Gelade, 1980) was that it made a concrete proposal about the computations performed by selective attention. Until this time, researchers had generally focused on the idea that attention played a modulatory role in the perception of sensory input, such as increasing the perceived brightness of stimuli (Helmholtz, 1866; James, 1890; Posner, 1980), or ensuring their entrance into memory stores (Deutsch & Deutsch, 1963). However, Treisman and Gelade (1980) proposed an elegantly simple idea in which objects composed of multiple features needed to be bound together by the focus of attention, whereas targets defined by a single feature needed no such attentional binding. This explained why people could apparently search very efficiently for single-feature targets, and very slowly for targets that were a conjunction of these highly discriminable features. This elegant explanation pushed other researchers and theorists to test the claims of feature integration theory (Duncan & Humphreys, 1989; Wolfe, 1994), and continues to propel the attention literature forward to this day (Madden et al., 2017).

Becker et al.'s (this volume) new study provides an excellent example of the enduring legacy of Treisman and Gelade (1980). These authors show that searching for conjunction targets is inherently relational, in that the relationship between the target defining features and the rest of nontarget features determines which items are selected, challenging the classic notions of feature integration theory. Another important aspect of the Treisman and Gelade (1980) paper was its use of converging evidence for the conclusions. The current article of Becker and colleagues follows in these footsteps, providing both behavioral and electrophysiological evidence for the conclusion that it is the relation of the searched-for feature to the rest of the feature space that guides attention efficiently. Thus, Becker and colleagues provide an excellent example of how the ideas and approach put forward by Treisman and Gelade (1980) continue to guide our understanding of visual attention over 35 years later.

The prioritization of some perceptual information for immediate action, while assigning other perceptual information for delayed action, is necessary for many tasks that have an inherently sequential structure (e.g., making a peanut butter sandwich). Visual working memory (VWM) is our temporary online system for storing and mentally manipulating visual information. Although this system supports many fundamental aspects of visual cognition, such as visual search, mental imagery, perceptual comparison, and inhibition, the storage capacity of VWM is highly limited. With such limitations, how are we able to use VWM to effectively support these abilities? Major progress in understanding this question was sparked by Vogel and Machizawa (2004). These authors discovered a neural signature of VWM-related activity—the contralateral delay activity in the scalp-recorded EEGs of participants—whose amplitude was modulated by the amount of information stored in VWM. Using this signature, Vogel, McCollough, and Machizawa (2005) were able to demonstrate why some individuals perform better on VWM tasks than others. When asked to remember, for example, blue visual stimuli presented amid distracting red stimuli, only high performers were able to effectively ignore the distractors (such that adding distractors did not lead to an increase in neural amplitude). This finding, along with similar fMRI evidence (McNab & Klingberg, 2007), revealed that the effective use of VWM relies on the ability to use feature-based attention to filter out irrelevant, distracting information. This filter account was made popular by analogy to nightclubs: Feature-based attention is the "bouncer in the brain" that keeps unwanted guests out of VWM (Awh & Vogel, 2008).

About 10 years later, our knowledge of VWM capacity and architecture has advanced, with much of the conversation now surrounding the control we have over how we represent the information being stored. The article by Dube, Emrich, and Al-Aidroos (this volume) revisits the filter account of how feature-based attention regulates VWM performance; with a focus on exploring strategic control over the strength of the filter, and specifically, the role of feature-based attention in modulating the precision of memory representations in VWM. The authors report an extension to the influential filter account, where feature-based attention is not only the bouncer in the brain, but also the hostess responsible for distributing the club's resources based the priority of the guest.

We the editorial team sincerely hope you enjoy these nine new articles as much as we enjoyed inviting and editing them for you. The featured author groups are among the best our field has to offer, even though they would be the first to acknowledge that they merely represent a vast community of related researchers. The field of human perception and performance today feels to us as editors to be much more like a rushing river than a slowly growing mountain. It is our intent that these nine articles will give you a glimpse of our experience standing in that rushing river over the past 5 years.

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Call for Nominations

The Publications and Communications (P&C) Board of the American Psychological Association has opened nominations for the editorships of the *Journal of Experimental Psychology: Animal Learning and Cognition, Neuropsychology,* and *Psychological Methods* for the years 2020 to 2025. Ralph R. Miller, PhD, Gregory G. Brown, PhD, and Lisa L. Harlow, PhD, respectively, are the incumbent editors.

Candidates should be members of APA and should be available to start receiving manuscripts in early 2019 to prepare for issues published in 2020. Please note that the P&C Board encourages participation by members of underrepresented groups in the publication process and would particularly welcome such nominees. Self-nominations are also encouraged.

Search chairs have been appointed as follows:

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Prepared statements of one page or less in support of a nominee can also be submitted by e-mail to Sarah Wiederkehr, P&C Board Editor Search Liaison, at swiederkehr@apa.org.

Deadline for accepting nominations is Monday, January 8, 2018, after which phase one vetting will begin.