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Using the Principles of Animation to Predict Allocation of Attention

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ABSTRACT
The purpose of this paper is to introduce a range of animation principles that the authors believe may be used to predict audience eye movements and responses, and to propose how a combination of practice-based and empirical research could lead to an enhanced understanding of how to create animated cues to allocate viewer attention. These insights inform the prediction of attention in deictic gaze cuing contexts where the convergence of motion stimulus, agent presence, and facial and gestural cuing has the potential to create an engaging interactive experience and long term affiliation.

Categories and Subject Descriptors
H.5 INTERFACES AND PRESENTATION H.5.1 Multimedia Information Systems, Animations; J.4 SOCIAL AND BEHAVIORAL SCIENCES *Psychology*

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Performance, Design, Experimentation, Human Factors, Theory, Attention, Animation, Believability, Motion, Games.

1. INTRODUCTION
Viewer's allocation of attention and direction has been carefully observed and quantified by successive experimental psychological phases of research in tandem with theoretical spotlight analogies [1]. Active vision approaches have highlighted how the context of the viewer and the task requirements at hand modulate and in many cases predict the location of eye gaze fixation based on known expertise and experience. For example, Posner [2] (1980, p. 4) defined the *orienting* of attention as "the aligning of attention with a source of sensory input or an internal semantic structure stored in memory". Its primary means are foveating eye movements with a focal point centering the area of interest, while other procedures include a covert shift of the focus of attention occurring with no eye and head movements.

Posner's orienting cues prove that people can quickly orient visual attention to particular areas in space. The different locations of cues used in these studies (peripheral [2] and central [3]) are respectively associated with involuntary (automatic) or voluntary (conscious) orientation toward a spatial location or salient feature. It is crucial for this work to understand that orientation may contribute to stimulus *detection* in the particular area, and influence reaction time (RT) by the validity of the cue: valid cues benefit shorter times and by contrast misleading cues provoke longer times. More recently, the attentional processes occurring in human interaction with digital environments has become recognized as a mutual area of interest to cognitive science and designers of computer interfaces. Predicting perceptions in these complex unpredictable environments is critical to efficient machine use [1].

Animators have received standardised training in the prediction of viewer eye movements for over seventy-five years. The principles of animation, developed by the Disney Studio from the late 1920s until the late 1930s, are widely regarded in the film and games industries as the fundamental components of any successful animation. The book that first popularised the principles of animation and that documented the Golden Era of the Disney Studio - *the Illusion of Life* [4] - is so highly regarded that it has been considered one of the most important books ever written on animation [5].

2. PRINCIPLES OF ANIMATION
The principles of animation were developed through what is now more commonly known as practice-based research in visual art and design [6] or performative research [7], rather than through application of the scientific method. The refinement of the techniques that produced an acceptable standard of animation was brought about through repeated and systematic observation, analytical drawing, and practical experimentation. It was the value judgments of the expert practitioners at Disney that determined which techniques had the best effects, not measurement of audience response. Those techniques that resulted in animated movements that were pleasing to the eye, and that most concisely communicated the meaning and emotion of a story, became known as the principles of animation. The principles proved to have an almost instantaneous effect on the quality of the resulting animated films, with the Disney Studio pioneering feature-length animations starting with *Snow White and the Seven Dwarves* in 1937. In the latter half of the 20th century, as the demand for computer-generated animation began to exceed the demand for traditional animation, it was the Pixar studio that adopted and adapted the principles of animation for 3D, again through practice-based research.

With the principles of animation as a conceptual framework, professional practitioners continue to predict how well animations will guide and hold audience attention, rarely stopping to consider empirical assessment of those predictions. However, this practice-based knowledge of audience observation of animation can be tested and corroborated by quantitative and qualitative research [8]. Animation can be broken down into a series of linked stages, and several of these are of interest in the prediction of allocation of attention from viewers. Fig 1 shows some of the key principles

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of interest; Arcs, Anticipation, Following-through, Overlapping Action, Secondary Action, and Exaggeration. These principles can be likened to findings in Psychological Science: for example Rashbass's [9] discovery of the optimal cue to creating smooth pursuit from a motion onset (by initiating a brief reversal of motion prior to path initiation) is equivalent to Anticipation. The authors suggest that prediction of allocation of attention can be guided by these principles, and that animations designed with reference to the principles will enhance engagement with digital environments.

3. ATTENTION & AGENT GAZE CUING

The allocation of attention with biologically relevant cues such as eye-gaze has been demonstrated in a number of paradigms such as the Posner paradigm and more recently the flicker paradigm [10]. In both main paradigms, the emphasis within the evaluation of attention allocation has been the static pictorial properties of the pictures used as stimuli. With recent research demonstrating that fully-animated cues can have a stronger effect on viewer allocation of attention than static or 2-frame animations [11], it is clear that there is scope for future research into the application of the principles of animation as a means of predicting audience eye movements. A clear prediction from this understanding of the principles of animation is that the optimal stimulus for cuing attention with an animated agent is through exaggeration – a caricature of life that pushes the boundaries of realism (e.g. Fig 1, f). This suggests that video footage or simple motion capture of normal activity from a human may not prove as effective as an animated agent, which has the capacity to stretch beyond the physical limits of its skeleton and musculature. This is currently the subject of enquiry in our laboratory.

4. PREDICTING THE FUTURE

In the context of the user interface, the high degree of functionality and wide range of requirements from stakeholders can lead to confusing and misleading digital environments. As these interfaces increasingly use animated sequences based on motion capture or on digital models of motion, the scope for miscuing increases. Any given attentional cue may result in a positive or negative effect, depending whether the direction attended matches the one pointed to by the gesture. One question that needs to be asked is why cues trigger these different effects. This dichotomy depends on the quality of the signal. Misleading cues are caused by wrong direction pointing or by misinterpreting the recoil part of a dynamic pointing gesture. The most convincing use of gaze cuing comes in the misdirection of attention. In magic tricks, the magician fools the viewer with deft use of hands and gaze cuing [12]. This suggests a solution to the problem of translation of laboratory findings to practical implementation of dynamic attention based cues, signage and procedures in real-world applications and settings.

Using artistic principles of animation, attention to the cue could be directed to the right place. Nevertheless, one of the limitations of these techniques is the measurement of their effectiveness. Traditional measures used in Psychology like RTs can be too small to detect any significant effect. Worse still, if the objective of the interface is engagement and comprehension then simple measures of 'efficiency' of interaction can miss the point. A multilayered approach, extending the 2AFC (Alternative Force Choice) and RT, into a more holistic approach involving qualitative evaluation is one way forward that the authors believe will aid our understanding of the effect of animated agents on users. For instance, differences in 'appeal', 'engagement', 'believability', 'presence' etc. may be revealed through qualitative assessment of user experience in addition to measurement of response. Thus the authors argue that formalized professional practice should be allied with scientific predictions to enhance user experience in digital environments.

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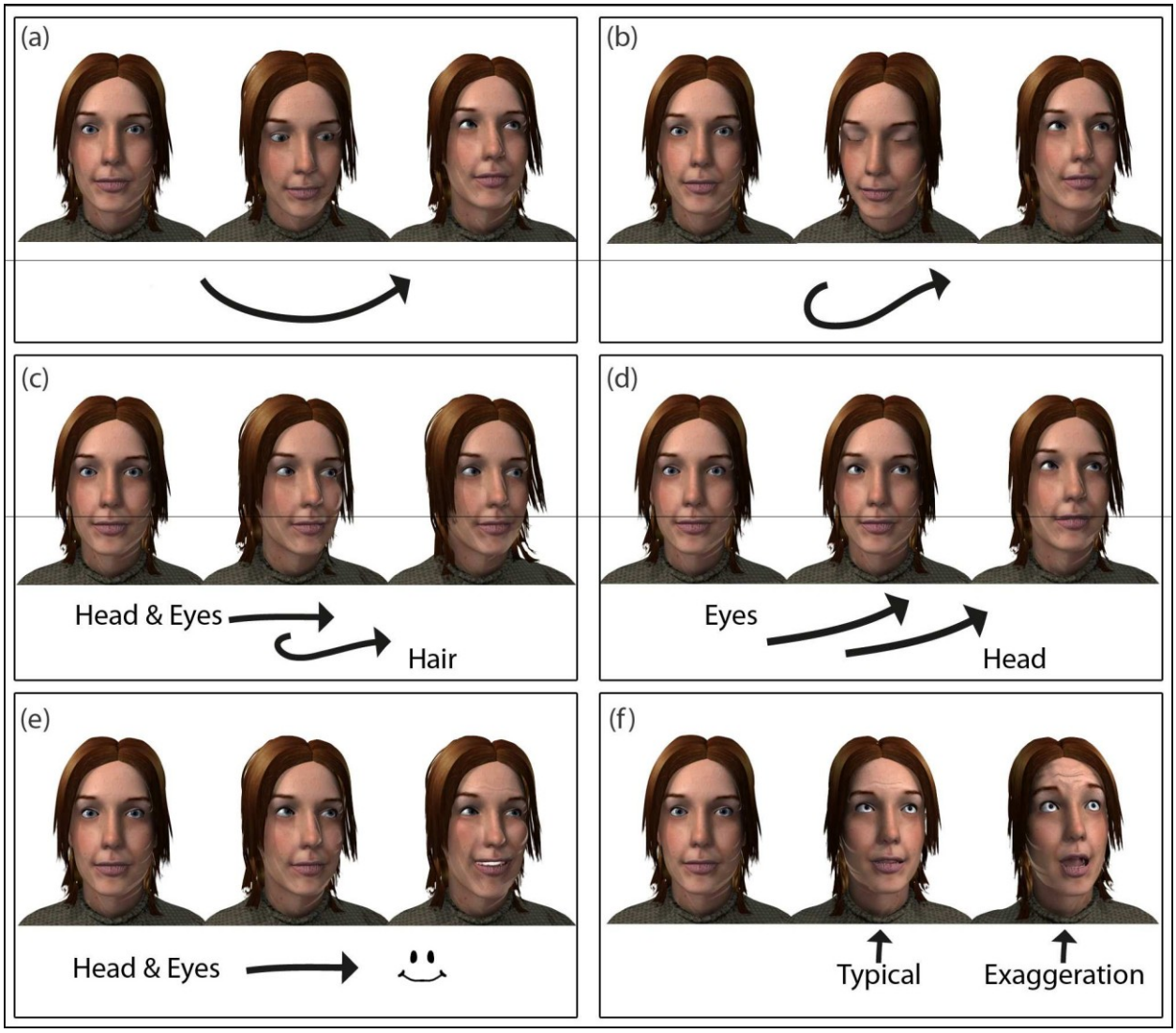

Fig 1 Selected Principles of Animation. Examples of selected principles of animation in action, applied to a 3D character head. (a) Arcs: natural movement tends to follow an arced trajectory, rather than a straight line. (b) Anticipation: used to prepare an audience for an action, anticipation may correspond with a small movement in the opposite direction prior to the primary action. (c) Follow through: loose material on a body will continue to move after the body has stopped, in this example the hair continues to move after the head has stopped. (d) Overlapping action: different parts of a body tend to move at different rates, in this example the eyes move first followed by the head. (e) Secondary action: a secondary action supports a main action providing the animation with life or personality, in this example the movement of the head and eyes is the primary action while the smile is the secondary action. (f) Exaggeration: the principle that a strict imitation can appear lifeless, whereas pushing the boundaries of realism through caricature can create a more appealing animation.