

# Action video game training for cognitive enhancement

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Here we review the literature examining the perceptual, attentional, and cognitive benefits of playing one sub-type of video games known as ‘action video games,’ as well as the mechanistic underpinnings of these behavioral effects. We then outline evidence indicating the potential usefulness of these commercial off-the-shelf games for practical, real-world applications such as rehabilitation or the training of job-related skills. Finally, we discuss potential core characteristics of action video games that allow for wide learning generalization.

## Addresses

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## Introduction

For as long as there have been studies of human perceptual and cognitive capacities, there has been simultaneous interest in whether these capabilities can be improved [1,2]. And although it is true that nearly all humans will show clear improvements on an extensively practiced task, it is typically the case that little to no benefits of this training are seen on new tasks — even if the new tasks appear on the surface to be quite similar to the highly practiced task [3–5]. This general phenomenon has been observed across domains — from perception (where for instance, training to identify a target in one part of the screen may not transfer to a different part of the screen [6]), to cognition (where training on one working memory task may not transfer to a different working memory task [7]), to motor control (where learning to overcome one type of motor perturbation may not transfer to a different type of perturbation [8]). Such lack of generalization across tasks represents a significant

obstacle to the goal of producing real-world training benefits.

Over the past decade though, instances of much broader training effects, often engendered by ‘real-life activities’ such as aerobic activity, participation in sports, meditation, music training, or, the focus of this review, playing certain types of video games, have begun to permeate the literature [9–12]. Indeed, there is now substantial evidence showing that playing one sub-genre of video games, so-called ‘action video games’, leads to improvements in a broad set of behavioral abilities that extend well beyond the confines of the games themselves [13,14]. Here we provide a brief review of this literature with a particular emphasis on the breadth of the benefits, the possible mechanistic underpinnings of the observed enhancements, the potential for such video games to be used in practical applications, and the critical characteristics of action video games that allow for such far-reaching effects to be realized.

## What are action video games?

The superordinate category label ‘video game’ encompasses an incredibly wide variety of experiences — so much so that to some extent, the term has no predictive value at all. Little to nothing can be inferred by merely knowing that an individual plays ‘video games,’ as ‘video games’ can mean anything from simplistic matching of colored blocks on a mobile device up through navigating highly complex, laboriously designed virtual worlds on the newest consoles [15]. Researchers across psychology have thus typically focused their investigations at the level of specific game genres, wherein games are grouped by, among other things, commonalities in format, content, dynamics, and mechanics. In terms of the potential to alter basic perceptual, attentional, and cognitive abilities, the majority of the research has centered on the ‘action video game’ genre. Games within this genre are characterized by complex 3D settings, quickly moving and/or highly transient targets, strong peripheral processing demands, substantial amounts of clutter, and the need to consistently switch between highly focused and highly distributed attention all while making rapid, but accurate actions [16].

## Studying the effects of action video games

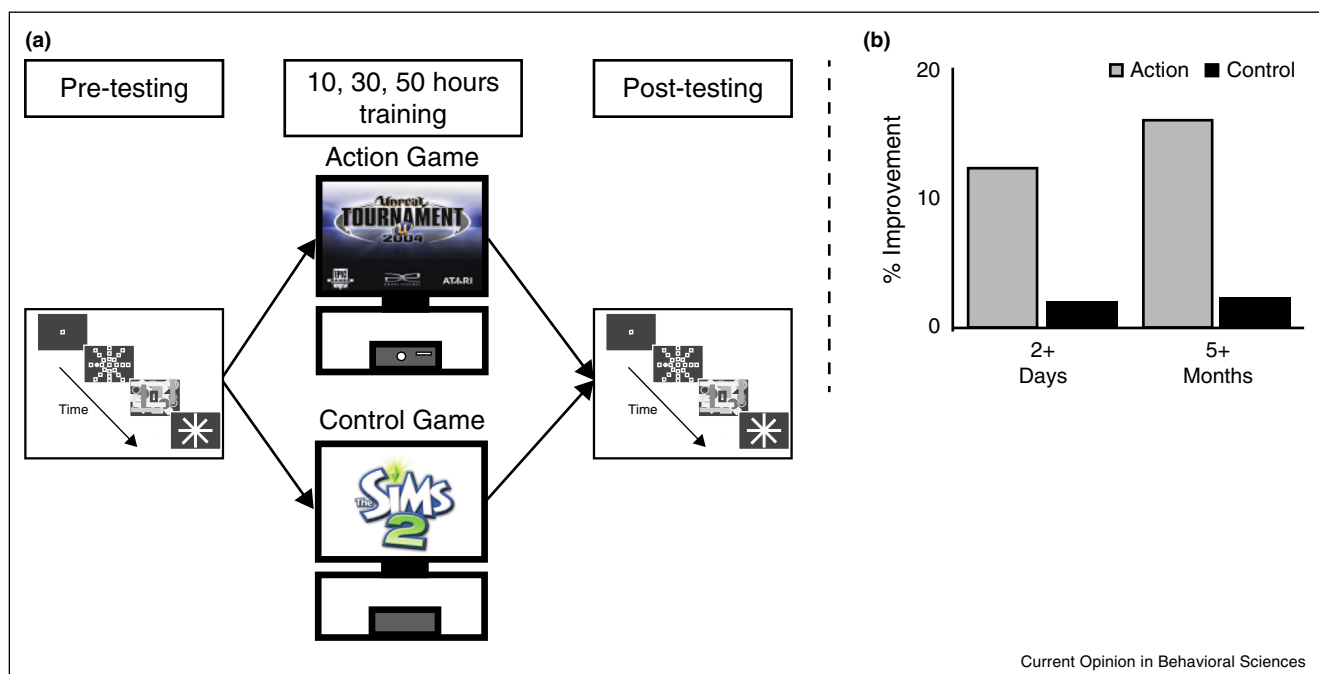
Before outlining the actual effects of playing action video games, it is worth quickly discussing how studies in this domain are conducted and conclusions are reached [17]. As is true of the literature on music, aerobic activity, meditation and sports training — because it is the case that some individuals, as part of their daily life, choose to

engage in substantial amounts of action video game play, while others totally refrain from video game play — it is thus possible for researchers to conduct cross-sectional ‘experiments of nature’ wherein the perceptual, attentional, or cognitive skills of avid action gamers are compared against those of their non-action game playing peers. However, while such studies can demonstrate an *association* between choosing to play action games and enhanced performance, they cannot establish that the relationship is *causal*. For this, intervention studies are conducted wherein individuals who do not naturally play video games are first pre-tested on measures of interest before being randomly assigned to play either an action video game or a control video game (a commercial game matched for general interest, flow, arousal, among others, but lacking all action components — see Figure 1). Participants then play their assigned game for a set period of time; work in the field has utilized training durations from 10 to 50 hours spaced over the course of weeks to months — as video game training, like all other forms of learning is far more effective when practice is distributed rather than massed [18,19]. Finally, at least 24 hours after the final play session (the delay ensures that any transient effects of game play are eliminated as potential

concerns), the individuals are post-tested on the measures of interest with the critical question being whether the action trained group improves more from pre-test to post-test than the control video game trained group.

There are of course many challenges in evaluating the efficacy of any intervention where it is necessarily the case that the participants cannot be kept blind to the content of the intervention — something that is true of all behavioral interventions, whether the intervention is based on video games, aerobic exercise, meditation, athletics, or music. For instance, there is always the possibility that it is not the content of the intervention that leads to improvements per se, but it is instead the participants’ expectation that they should improve that causes improvements. And although in the case of action video games, the preponderance of the evidence to date has suggested that these confounds cannot explain the effects observed in the field (e.g. studies where participants are recruited in such a way that they do not know their gaming is of relevance tend to show the same effects as studies where participants are overtly recruited based on their gaming [20–25]), there is nonetheless always virtue in improving methodology to minimize the

Figure 1



Intervention studies to assess a causal relationship between action video gaming and improved behavioral abilities. (a) Participants with little to no action video game experience, and little overall video game experience, are first pre-tested on the psychological measures of interest (here the Useful Field of View task — left). The participants are then randomly assigned to play either an action entertainment video game (middle, top) or a control entertainment video game (middle, bottom) for a specified period of time (typically between 10 and 50 hours, with sessions properly spaced to avoid the deleterious effects of massed practice). Finally, at least 24 hours after the last gaming session, individuals take the same psychological measures again. (b) The critical measure is whether individuals in the action group improved more from pre-test to post-test than individuals in the control group. Here, in the case of the UFOV task, this is true not only a few days after the last video game training session (2+ days), as the effects persist for at least 5 months. \*Data replotted from [28,30].

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