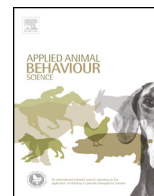




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Is interactive technology a relevant and effective enrichment for captive great apes?

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ABSTRACT

All non-human great apes are endangered, and for these animals, captive individuals play an important role in the species' conservation management plan. Therefore, information about their current enrichment activities is essential for maintaining a healthy captive population. This paper reviews research where digital media is used as cognitive enrichment for great apes with a particular focus on orangutans, and assesses its appropriateness and relevance for current and future enrichment programs. The paper provides a holistic overview of topical issues surrounding primates in captivity, including a discussion of primate cognitive abilities, current institutional enrichment strategies and practices, and a chronological review of how digital media technologies have performed within this paradigm. The paper also covers issues in enrichment such as the concept of the power of control, natural versus non-natural enrichment, naturalism/anthropomorphism, stimulation versus stereotypy, and respecting individualism in great apes. This review reveals that as technologies advance interactive digital applications will become increasingly relevant for captive great apes and other primates because of its ability to provide improved solutions where traditional non-digital enrichment may have either failed or proven less efficient. It also highlights the importance of considering the preferences and differences in cognitive abilities of each individual when selecting particular digital enrichment activities. A wide variety of factors including life history, species, sex, age, previous enrichment experience, training routines and methods, and housing conditions will all affect the success of digital media enrichment. With this in mind, this paper identifies gaps in current knowledge, highlighting the need for further studies.

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1. Introduction

Institutions and sanctuaries often implement a range of methods that are designed to improve captive animals' physical and mental welfare. These methods can range from alterations to the physical or social environment, or changes to husbandry routines that may elicit species appropriate behaviours (Young, 2003; Wells, 2009; Cocks, 2007). These broad types of methods are collectively termed 'environmental enrichment' (Woolverton et al., 1989; Newberry, 1995).

The term "environmental enrichment" is used widely in various contexts and concepts, and its definition depends on constantly evolving animal welfare attitudes and animal ethics. Environmental enrichment can be broken into multiple categories of sensory enrichment, including social, feeding, physical or spatial enrichment (Honeess and Marin, 2006; Wells, 2009).

There are many challenges when considering enrichment within animal welfare contexts. One major challenge that institutions face is mitigating habituation as animals can quickly adapt to previously novel objects, sounds and smells if they are presented repeatedly. This requires animal carers to constantly change activities to maintain their efficacy. Another challenge is in our ability to measure the effects of enrichments provided. As in any scientific study or captive management strategy, upon introduction of a novel enrichment, both physical and psychological effects should be measured before and after the environmental changes have occurred in order to measure its effects (Irwin et al., 2013; Martin and Bateson, 2007). However, due to time, cost and resources, measuring and monitoring is often lacking, making informed improvements and decisions difficult.

Table 1
 Published, peer and non-peer reviewed non-human primate enrichment or behavioural studies using digital technology (i.e. any study involving one or more digital medium/s to study the behaviour of primates) e.g. digital touchscreen devices, projected visual stimulation, digital handheld device computer activities, embedded microchips that automates changes in environments.

	Species	No. of articles	No. focused on digital enrichment	Peer reviewed?	Reference
GREAT APES	Orangutan	5	3	No	Boostrom (2013)*; Tabor (2000)*; Wirman (2013a,b)*; Wirman et al. (2011)*
		5	3	Yes	Mallavarapu et al. (2013)*; Perdue et al. (2012)*; Tarou et al. (2004)*; Renner et al. (2016); Vonk (2014)
	Chimpanzee (<i>Pan troglodytes</i>)	15	3	Yes	Ravignani et al. (2013)*; Yamanashi and Hayashi (2011)*; Sakuraba et al. (2016)*; Inoue and Matsuzawa (2007, 2008, 2009); Tanaka (2007a,b); Martin et al. (2011, 2013, 2014a,b); Hattori et al. (2013); Yamanashi and Matsuawa (2010); Martinez and Matsuzawa (2009)
	Gorilla (<i>Gorilla gorilla</i>)	2	0	Yes	Kano and Call (2012); Ross (2009)
	Rhesus Macaques (<i>Macaca mulatta</i>)	1 6	0 0	No Yes	Sams et al. (2015) Scott et al. (2003); Gazes et al. (2013); Platt and Novak (1997); Washburn et al. (1989); Washburn et al. (1994); Washburn and Rumbaugh (1992)
OTHER PRIMATES	Pigtailed Macaques	1	0	Yes	Lincoln et al. (1994)
	Japanese Macaques (<i>Macaca fuscata</i>)	3	0	Yes	Ogura and Matsuzawa (2012); Ogura (2012); Adachi et al. (2009)
	Cynomolgus Macaque (<i>Macaca fascicularis</i>)	1	0	No	Sutcliffe and Hutcheson (2012)
	Marmoset (<i>Callithrix jacchus</i>)	1	0	Yes	Kangas et al. (2016)
	Capuchin Monkeys (<i>Cebus apella</i>)	1	0	Yes	Drayton and Santos (2014)
	Guinea Baboons	1	0	Yes	Fagot et al. (2014)
	Grey Mouse Lemur (<i>Microcebus murinus</i>)	1	0	Yes	Joly et al. (2014)
	Non-species specific	3 3	0 0	No Yes	Coe (1997); Sebastian (2011); Smith (2011) Ma (2015a,b); Nelson and Fijn (2013)
GENERAL	Total	49	9		

*Studies that focus on digital enrichment.

There is growing empirical support demonstrating that captive animals have improved welfare, if they can exert control over their environment (Cocks, 2007). With advances in touchscreen and other digital technologies such as touchscreen tablets, motion sensor activities and video devices, researchers have begun to explore the possibilities that these new technologies can offer by providing a virtual space where animals can exert environmental controls and thereby improve animal welfare. This paper reviews digital enrichment currently used in captive animal institutions. This includes outlining the different types of digital enrichment used and research conducted in this space to date, as well as providing insights into the findings and controversies arising from such studies. Due to their highly complex cognitive abilities (Russon, 1998), we focus on great apes. Although there are numerous studies of non-human primates using digital touchscreens in cognitive behavioural studies, there is a distinct lack of peer-reviewed and/or published literature looking at its use as an enrichment tool in great apes (Table 1).

Our review of the literature reveals that studies on welfare, and in particular, the potential for increasing freedom of choice using technology have been limited and sporadic (Honeess and Marin, 2006; Wells et al., 2006; Wells, 2009). Of the 49 published studies that address digital technology use in non-human primates uncovered by our search, approximately half (27 papers) were about great apes and the majority are peer-reviewed (10 non-peer reviewed papers) (Table 1). At first glance these figures seem promising regarding the prevalence of digital technology usage. However, closer examination reveals that for studies using digital technology as enrichment, only nine papers of which six were peer-reviewed.¹ This is perhaps not surprising given that the use of interactive digital technology is itself an emerging area.

¹ A desktop literature research was conducted using ANU open library that encompassed multiple search engines. Although all effort has been made to include a comprehensive list, some literature may be missing.

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