



# Efficiency of electronically monitored amblyopia treatment between 5 and 16 years of age: New insight into declining susceptibility of the visual system <sup>☆</sup>



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## ABSTRACT

The notion of a limited, early period of plasticity of the visual system has been challenged by more recent research demonstrating functional enhancement even into adulthood. In amblyopia (“lazy eye”) it is still unclear to what extent the reduced effect of treatment after early childhood is due to declining plasticity or lower compliance with prescribed patching. The aim of this study was to determine the dose–response relationship and treatment efficiency from acuity gain and electronically recorded patching dose rates, and to infer from these parameters on a facet of age dependence of functional plasticity related to occlusion for amblyopia. The Occlusion Dose Monitor was used to record occlusion in 27 participants with previously untreated strabismic and/or anisometropic amblyopia aged between 5.4 and 15.8 (mean 9.2) years during 4 months of conventional treatment. Group data showed improvement of acuity throughout the age span, but significantly more in patients younger than 7 years despite comparable patching dosages. Treatment efficiency declined with age, with the most pronounced effects before the age of 7 years. Thus, electronic recording allowed this first quantitative insight into occlusion treatment spanning the age range from within to beyond the conventional age for patching. Though demonstrating improvement in over 7 year old patients, it confirmed the importance of early detection and treatment of amblyopia. Treatment efficiency is presented as a tool extending insight into age-dependent functional plasticity of the visual system, and providing a basis for comparisons of effects of patching vs. emerging alternative treatment approaches for amblyopia.

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## 1. Introduction

Amblyopia is a, usually unilateral, impairment of visual functions originating from abnormal visual experience during development. Being induced by strabismus (squint), anisometropia (unequal refractive power of the two eyes) or visual deprivation, it is a frequent cause of visual loss in childhood (Attebo et al., 1998). Occlusion (patching) of the nonamblyopic eye is still the mainstay of treatment (Loudon & Simonsz, 2005; Wong, 2012).

Amblyopia and its treatment have served as natural model situations for studying the susceptibility of the visual system to altered visual input (for reviews see e.g. Daw, 1998; Sireteanu, 2000). Both clinical experience with treatment and extrapolations from animal models (e.g. Hubel & Wiesel, 1970) led to the notion that successful amblyopia treatment is confined to the first 6–8 years of life (Von Noorden & Crawford, 1979). More recently, the concept of a rigid adult visual system lacking plasticity has been challenged (e.g. reviews by Gilbert, 1998; Levi, 2005; Spolidoro et al., 2009). A large number of (sometimes quite controversial) psychophysical, neurophysiological and clinical studies suggested varying degrees of susceptibility to change beyond school entry age (Daw, 1998; Epelbaum et al., 1993; Scheiman et al., 2005; Wandell & Smirnakis, 2009).

Amblyopia treatment lacks standardization concerning not only dosage, but also age limits. This is reflected in textbooks with age limits between “about 8” (Von Noorden & Campos, 2002) and 12 years (Haase & Graef, 2004) and in clinical guidelines (American Academy of Ophthalmology: until 2007 “10 years”,

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**Table 1**  
Baseline characteristics of the patients.

Patient no.	Age (years)	Eye	Refraction [D]	Angle of squint (near) [PD]	Initial acuity crowded Landolt [logMAR]	History
1	5.4	RE*	+8.0 –2.0/170°	±0	0.8	Untreated
		LE	+4.75 –0.75/0°		0.2	
2	5.6	RE*	+8.0 –0.5/0°	+10	1.3	Untreated
		LE	+7.75 –0.25/44°		0.5	
3	5.7	RE*	+2.0	+14	1.7	Untreated
		LE	+2.25		0.2	
4	6.0	RE*	+3.0	±0	0.3	Untreated
		LE	+1.0		0.1	
5	6.0	RE	+0.75	±0	0.0	Untreated
		LE*	+6.5 –0.5/160°		1.0	
6	6.0	RE	+5.5	+2	0.1	Untreated
		LE*	+5.25 –0.5/0°		1.0	
7	6.6	RE*	+2.25	+16	0.8	Untreated
		LE	+2.75		0.2	
8	6.9	RE	+2.25 –0.5/140°	+6	–0.1	Untreated
		LE*	+4.75 –1.0/20°		1.0	
9	7.1	RE*	–1.25 +1.25/100°	±0	0.3	Untreated
		LE	–0.25		0.1	
10	7.2	RE	+1.5	±0	–0.1	Untreated
		LE*	+5.25 –0.75/156°		0.7	
11	7.2	RE	0.0	–VD 2	–0.1	Untreated
		LE*	+1.25 –0.75/155°		0.3	
12	7.3	RE*	+6.0 –2.0/170°	Micro	1.0	Untreated
		LE	+5.75 –2.0/180°		0.1	
13	7.7	RE*	+5.5 –1.5/100°	Micro	1.0	Untreated
		LE	0.0		–0.1	
14	8.9	RE*	+3.5 –3.75/175°	±0	0.6	Untreated
		LE	+0.5		0.1	
15	9.0	RE	+0.75 –0.75/0°	+8	–0.1	Untreated (occlusion prescribed at 4–5 yrs., not done)
		LE*	+6.75		1.1	
16	9.1	RE	+2.5	±0	0.1	Untreated
		LE*	+7.0 –3.5/0°		0.4	
17	10.4	RE*	+3.25 –0.75/160°	+35	1.1	Untreated
		LE	+3.25		0.3	
18	10.6	RE*	+2.0 –4.5/175°	±0	0.2	Untreated
		LE	0.0 –0.25/5°		–0.1	
19	11.4	RE	+1.0 –1.0/10°	±0	–0.1	Untreated
		LE*	+6.0 –0.5/175°		0.8	
20	11.6	RE	0.0	±0	–0.1	Untreated
		LE*	+2.0 –1.5/180°		0.3	
21	11.7	RE	+0.5 –0.5/5°	±0	–0.1	Untreated (occlusion prescribed earlier, not done)
		LE*	+1.25 –3.0/0°		0.1	
22	12.1	RE	–0.75 –0.25/62°	Micro	0.1	Untreated
		LE*	0.0		0.8	
23	12.4	RE*	+4.5 –2.5/10°	Micro	0.9	Untreated (occlusion prescribed at 7 yrs., not done)
		LE	+4.0 –2.5/0°		0.0	
24	13.1	RE*	+2.75 –0.25/30°	+6	0.8	Untreated (1 month occlusion at 4–5 yrs. “tried”)
		LE	+1.5 –0.25/0°		–0.1	
25	13.6	RE*	+3.0 –1.75/165°	+10	0.6	Untreated (occlusion prescribed earlier, not done)
		LE	0.0 –0.75/5°		0.0	
26	14.3	RE	–0.5 –0.5/171°	±0	0.0	Untreated
		LE*	–1.5 –2.25/6°		0.3	
27	15.8	RE	+1.5 –0.5/60°	+18	–0.1	Untreated
		LE*	+3.75 –0.5/25°		1.7	
Means:	9.2			Means NAE:	0.04	
SD:	3.1			SD NAE:	0.15	
				Means AE:	0.77	
				SD AE:	0.42	

D = diopter, PD = prism diopter. The asterisk marks the amblyopic eye. RE = right eye; LE = left eye; VD = vertical deviation, NAE = nonamblyopic eye; AE = amblyopic eye; SD = standard deviation.

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