Neural recording and electrical stimulation results suggest that the dorsomedial frontal cortex (DMFC) of macaque is involved in oculomotor behavior. We reversibly inactivated the DMFC using lidocaine and examined how saccadic eye movements and fixations were affected. The inactivation methods and monkeys were the same as those used in a previous study of the frontal eye field (FEF), another frontal oculomotor region. In the first stage of the present study, monkeys performed tasks that required the generation of single saccades and fixations. During 15 DMFC inactivations, we found only mild, infrequent deficits. This contrasts with our prior finding that FEF inactivation causes severe, reliable deficits in performance of these tasks. In the second stage of the study, we investigated whether DMFC inactivation affected behavior when a monkey was required to make more than one saccade and fixation. We used a double-step task: two targets were flashed in rapid succession and the monkey had to make two saccades to foveate the target locations. In each of five experiments, DMFC inactivation caused a moderate, significant deficit. Both ipsi- and contraversive saccades were disrupted. In two experiments, the first saccades were made to the wrong place and had increased latencies. In one experiment, first saccades were unaffected, but second saccades were made to the wrong place and had increased latencies. In the remaining two experiments, specific reasons for the deficit were not detected. Saline infusions into DMFC had no effect. Inactivation of FEF caused a larger double-step deficit than did inactivation of DMFC. The FEF inactivation impaired contraversive first or second saccades of the sequence. In conclusion, our results suggest that the DMFC makes an important contribution to generating sequential saccades and fixations but not single saccades and fixations. Compared with the FEF, the DMFC has a weaker, less directional, more task-dependent oculomotor influence.

Key words  Saccadic eye movements  Fixations  Dorsomedial frontal cortex  Supplementary eye field  Frontal eye field  Reversible inactivation

Introduction

The oculomotor properties of cortex near the frontal midline of macaque were first examined in detail by Schlag and Schlag-Rey (1987). They named this region the supplementary eye field. We and others (Mann et al. 1988; Bon and Lucchetti 1992; Heinen 1995) use the anatomical designation, dorsomedial frontal cortex (DMFC) (issues of nomenclature are reviewed by Tehovnik 1995 and Schall 1997). Regardless of terminology, the areas near the frontal midline that have been studied by oculomotor physiologists overlap with one another (Fig. 1A; for a more detailed comparison see Tehovnik 1995). The experiments of this report were specifically carried out on the DMFC as mapped using electrical stimulation (Tehovnik and Lee 1993; see Fig. 1A); this defines an area that includes large portions of the regions examined by other investigators.

In this report, we focus on the contribution of the macaque DMFC to the generation of saccades and fixations. Results of single unit recording and electrical stimulation studies, as reviewed below, suggest that the DMFC plays a role in these behaviors. However, the extent to which the DMFC contributes to saccadic and fixational behavior is unclear, because no studies have examined the oculomotor effects of temporarily silencing this region. The present report is the first to document these effects.

Many DMFC neurons increase their discharge before or during saccadic eye movements (Brinkman and Porter...
In general, these neurons are poorly tuned for saccade direction (Schall 1991a). Of those that are tuned, a small majority prefer contraversive saccades (Schall 1991a). Other DMFC neurons fire throughout fixation, and many of these begin discharging before or during the saccade that leads to the fixation (Schlag et al. 1992; Lee and Tehovnik 1995). These fixation neurons are topographically distributed (Lee and Tehovnik 1995): neurons in rostral DMFC fire most vigorously for contralateral fixation, neurons in caudal DMFC fire most vigorously for ipsilateral fixation, neurons in medial DMFC fire most vigorously for downward fixation, and neurons in lateral DMFC fire most vigorously for upward fixation.

Electrical stimulation of DMFC can evoke saccades (Schlag and Schlag-Rey 1987; Mann et al. 1988; Schall 1991b; Bon and Lucchetti 1992; Russo and Bruce 1993; Tehovnik and Lee 1993). It can also fix the eyes, delaying visually-guided saccades (Tehovnik and Lee 1993; Tehovnik et al. 1994). The general effect of stimulating