4. DISCUSSIONS

4.1 DSGCs have various responses under different motion background context

From the results, DSGCs displayed interesting behaviors to changing motion background. Cells have quite variable responses among trials (Fig. 5B) but this variation neither comes from the gradually raising mean luminance due to sequentially displayed stimulus nor comes from the randomness of the motion background (Fig. 8). Instead, DSGCs respond differently to the dynamic motion background context. Basically, three distinct types of DSGCs are present in the retina. These types have no DSI difference and distribute more or less equally (Table 1). All three types of DSGCs may have similar synaptic connecting morphology but differ in their functional responses to the dynamical environment.

4.2 Surround inhibition vs. surround excitation

Although surround inhibition is the mostly known and studied, an excitatory surround is also observed in a few cases. Surround inhibition seems to be an economical way of detecting changes that using fewer spikes compared to an excitatory surround. From the information coding point of view, a rare event encodes more information. A

decreasing firing pattern can emphasize the happening of something important in the environment. Then, why the cell needs an excitatory surround？ In spatial scale experiment, surround excitation exhibits only in small squares for type III cells (Fig. 9C). This indicates that inhibitory surround and excitatory surround may be driven by different scales of subunit. In other words, there might be two parallel mechanisms corresponding to different spatial scales. For different types of cells, a signal comes from a small spatial scale subunit can induce completely different response. Besides, surround inhibition is mostly formed in classical receptive field compare to the extra-receptive field excitatory surround. As a result, surround inhibition could be applied for local edge detecting and surround excitation provides a broader detection of moving signal, respectively.

Inhibition dominates in the immediate surround, while excitation is concentrated on the outer surround. From the results of spatial scale experiment (Fig. 9), it seems that there are some kinds of subunit responding to specific spatial size of stimulus and these subunits spatially distributed unevenly. Unbalance spread of subunit sizes and functions across immediate surround and outer surround may cause these different responses. An antagonism is likely to occur in the immediate and outer surround between inhibitory and excitatory subunits. Inhibitory subunits have a stronger strength in the immediate surround that they dominate the suppressive action. On contrary, outer surround is

governed by excitatory subunits that provide the facilitative action. In fact, the immediate surround facilitation has been found in DSGCs (Amthor et al., 1996) and the outer surround inhibition is well known. It has been shown that excitatory and inhibitory subunits are normally distributed in all the surround area (Passaglia et al., 2001) but different strength of synaptic connections accomplish spatial tuning responses (Fig. 12). To form a fast and long range transmission of excitatory inputs, wide field amacrine cells may provide signals between DSGC and outer excitatory surround via gap junction connection. Wide field amacrine cells have been proposed to play an important role on object and background segregation (Olveczky et al., 2003). A polyaxonal amacrine cell connecting with ON-direction selective ganglion cell through gap junction has also been brought up (Ackert et al., 2007). On the other hand, narrow or medium field amacrine cells might play the role of immediate surround inhibition.

4.3 Living in a real world

In the rabbit's natural habitat, generally a wild field, a major task of vision is to detect the predators. The ON-OFF DSGC has been proposed to signal the local motion, specifically, to detect moving object such as prey, predators and conspecific, and this information may be used to inform spatial-attention mechanism (Vaney et al., 2001). An extreme case may illustrate the functions of surround excitation and the DSGC properties.

In peacetime, a global inhibition presents a state of no predator or no surprising. As a predator, for instance, an eagle, suddenly gets into the visual field of a rabbit and causes a motion surround inhibition, it is a warning of danger. The effective way to respond is trying to let the surround dis-inhibit to track this event. The special property of type III DSGCs is used to cause a dis-inhibited surround and makes cells transfer as much information as they can. The increasing of firing rate from inhibitory to dis-inhibitory surround may induce spatial-attention mechanism and keep the animal, a rabbit here, paying more attention on this emergency. Furthermore, different spatial coverage can be considered as background complexity. A higher spatial coverage refers to a more complicated environment, which animals have to pay more attention to the outside world. Thus, a strong excitatory surround of type III DSGC is needed. Finally, spatial scale can be translated as viewing distance; small scale of background dots refers to a long distance object. A small scale background refers to a place without shelters, which puts the rabbit in a dangerous situation to be seen. A type III cell having excitatory surround in small background dot size can fit the condition that the increasing of the firing rate contributes the raising of the attention.