Fixation Disparity and its Effect on Suprathreshold Stereopsis

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Introduction

There have been many studies demonstrating the effects of the amount and direction of heterophoria on stereopsis[1,2] as well as the amount of associated phoria on stereopsis[3] but most of these studies focused on stereoscopic threshold. While there is value in determining these factors and their affect on the threshold of stereopsis, this is not the type of stereopsis people use in normal everyday situations. With this in mind, we wish to investigate how the amount and direction of fixation disparity influences suprathreshold stereopsis.

Although the previously mentioned studies dealt mainly with stereoscopic threshold, their results have implications for our study. In Shippman and Cohen's study[2], they found that patients who perceived more Wirt rings in uncrossed disparity tended to be esophoric while a majority of patients who were more sensitive to crossed disparity were exophoric. From the data, they concluded that esophoric patients are significantly more sensitive to uncrossed disparity than exophores. On the other hand, exophores are likely to perceive crossed disparity better than esophores. It is also important to note that more than half of the phoric patients in the Shippman and Cohen study showed no preference for crossed or uncrossed disparity. Knowing that stereopsis occurs in Panum's fusional areas in front of and behind the horopter, the authors believe the difference in sensitivity between esophores and exophores is due to an asymmetric distribution of Panum's areas about the horopter. This suggests that esophores who prefer uncrossed disparity would have more of Panum's area in front of the fixation plane while exophores who are more sensitive to crossed disparity would have more of Panum's fusional area behind the fixation plane. This effectively places the fixation plane in a crossed disparity region for exophores and in an uncrossed disparity region for esophores. Knowing that exophores typically have exo fixation disparity and esophores have eso fixation disparity, we would anticipate that patients with exo fixation disparity would prefer a suprathreshold scene to be in crossed disparity and a person with eso fixation disparity to prefer the scene to be in uncrossed disparity.

In Saladin's study of heterophoria and stereopsis[1], he concluded that moderate amounts of exophoria did not affect Howard-Dolman stereopsis while even small amounts of esophoria degraded this same stereopsis. This difference is related to fixation disparity's expected relationship to heterophoria (see figure 1). Subjects with moderate amounts of exophoria, are expected to have minimal exo fixation disparity. However, there is an almost 1:1 relationship between the amount of esophoria and the expected minutes of arc of eso fixation disparity. Another explanation for the difference in stereoscopic threshold between esophoria and exophoria rests on the relative strength of the slow vergence adaptation mechanisms[4] (see figure 2). The positive slow vergence adaptation mechanism is much more developed and stronger than the negative slow vergence adaptation mechanism. This means that exophores can easily use their slow vergence adaptation mechanism to overcome their phoria. Unfortunately, esophores cannot do the same with their much weaker negative slow vergence adaptation mechanism.

Perhaps the mechanism involved in stereopsis is much different. While investigating how subjects defined the depth of crossed, uncrossed and monocular disparities as well as how they matched the depth of the disparities that were presented, Richards discovered some interesting things from stereoanomolous individuals.[5] He found that over a large disparity range, they are not able to discriminate any disparity. This led him to conclude that three separate detector mechanisms are involved in normal depth perception: one set of detectors pool crossed disparity, another pools uncrossed disparity, and a third that pools the magnitude but ignores the sign of the disparity. So depth is perceived by using combined input from the three detector mechanisms such that the strength of the depth percept is based on the activity in one or more of the detectors. It is possible that a preference for crossed or uncrossed disparities with the suprathreshold cards can be explained with an understanding of detector mechanisms as proposed by Richards. A preference for crossed disparities may indicate an inherent strength of the crossed disparity detectors over the uncrossed detectors. Likewise, a person who prefers uncrossed disparities may have a stronger uncrossed disparity detector mechanism.

In a recent study investigating associated phoria's affects on stereopsis with random-dot stereograms, it was found that as the amount of the associated phoria increases, the disparity range over which stereopsis operates decreases.[3] This means that there is a reduction in the size of retinal correspondence zones and/or a decrease in the physical space over which perception of stereopsis is possible. Since the fixation disparity angle and the associated phoria are related by the fact that the associated phoria is the prism amount that neutralizes fixation disparity, it is likely that increasing amounts of fixation disparity would also degrade suprathreshold stereopsis. The authors did not find any correlation between the eso or exo direction of the associated phoria and its affect on stereopsis but felt this was due to a small number of subjects in the study. However, they pose an interesting possibility that is further investigated by Mullins and Saladin.[6]

Although the original intent of the study[6] was to find a suitable test and task that used fixation disparity and suprathreshold stereopsis, some interesting discoveries were made in the process. For subjects with larger amounts of eso fixation disparity, a stereoscopic set of cards was arranged with a preference for the reference plane to be in the front of the scene and the remainder of the scene to be in uncrossed disparity. On the other hand, most subjects with exo fixation disparity ordered the suprathreshold cards with a preference for the reference plane toward the back of the scene such that most of the scene was in crossed disparity. Lastly, patients with small fixation disparity amounts did not show a preference for the reference plane to be in front or in back of the scene. The goal of our study was to gather more data on subjects that would either support or refute the results found in the previous study[6]. By doing this, we hope to gain better insight into the mechanism that relates fixation disparity and suprathreshold stereopsis.

Methods

Two sets of stereoscopic anaglyphs were created using photographs of an outdoor scene. These photographs were made into anaglyphs by using a computer program to create and superimpose the blue and red pairs. The first set of anaglyphs, called the IPD set, used photographs that were made by setting the stereo base separations between the two cameras at 0, 3, 6, 9, and 12 cm respectively. This set is called the IPD set because the separations between the cameras mimics the interpupillary distance between the eyes. When the stereoscopic models were set up, a point in the middle of the scene was chosen for exact overlap; that is, the reference plane was in the middle of the front-to-back scene. The second set of anaglyphs, known as the reference plane set (RP), used a constant stereo base separation of 6 cm between the two cameras. For the first anaglyph in the RP set, the reference plane and exact overlap was at the front of the scene. For the second, the reference plane was between the front and the middle of the scene. The middle of the scene was the reference plane for the third anaglyph while for the fourth, it was between the middle and back of the scene. Lastly, the reference plane for the fifth anaglyph was at the back of the scene. Measurements of the disparity taken in a previous study[6] showed that the actual outdoor scene has a maximum disparity of about 18' of arc. Using this same method, the maximum disparity of either set of anaglyphs held at a 40 cm viewing distance is about 12' of arc. This demonstrates that the anaglyphs are a good representation of the actual scene in terms of the disparity. Furthermore, this amount of fixation disparity indicates the task is suprathreshold in nature.

The anaglyphs were 3" x 4" in size, mounted on 6" x 8" black paper, and covered in an acetate material for protection. When viewing the anaglyphs at a 40 cm distance, they are held against a white background consisting of a large piece of poster board. The illumination falling on the anaglyphs in the room where measurements were taken was 85 foot candles of fluorescent lighting.

The subjects in the study were nine optometry students and one non-student. Data were obtained at three different sessions with each session occurring within 10 days of the previous one. Each data session consisted of three measurements of the subject's horizontal fixation disparity using the Disparometer followed by the ordering of the two sets of anaglyphs two times. The subject began by first reading a set of 20/30 letters on the Disparometer held at approximately 40 cm to stabilize accommodation. The subject then aligned the two randomly offset nonius lines so that they were in a vertical line or as close to vertical as possible. Once completed, the amount and direction of the fixation disparity measurement was then recorded in minutes of arc. The subject was then instructed to order the IPD set of anaglyphs from most depth to least depth within a reasonable time period (about two minutes) while holding the cards at the same distance as the Disparometer unit. This ordering was done through a series of comparisons between the cards and having the subject select the card that they perceived to have the most depth first, then the one with the next most depth, all the way down to the card with the least depth. The IPD set was ordered first so that the subject could get an understanding of the task and what was meant by most depth to least depth. After the IPD set of anaglyphs was ordered, the ordering of most depth to least depth was repeated within the two minute time period with the RP set. The process was repeated with another fixation disparity measurement on the Disparometer and again ordering the IPD set of anaglyphs followed by the RP set of anaglyphs. Before the data session was completed, one last horizontal fixation disparity measurement was taken.

Analysis

After the subject had ordered the cards, his/her ordering score was calculated and recorded for both the IPD and RP sets in the following manner. For the IPD set, a number value of 1 through 5 was given to each card. The card with the 12 cm camera separations was given a value of 5, the card with the 9 cm camera separations had a value of 4, and so on all the way down to the card with 0 cm camera separation which had a value of 1. The same 1 through 5 numerical values were assigned for the RP set of cards. In this case, the card with the reference plane at the front of the scene was given a value of 5, the card with the reference plane between the front and middle of the scene was given a 4, all the way down to the card with the reference plane at the back of the scene which was assigned a value of 1. The ranking order preference of the subjects was also assigned a 1 through 5 numerical value with the card he/she felt had the most depth all the way down to a 1 for the card the subject felt had the least depth. The score was calculated by multiplying the numerical value of the card with the subject's rank order position of that card, and adding the five separate products together.

A correct ordering of the IPD set would give a score of 55, which indicated the subject understood the test. However, if the subject ordered the cards exactly backwards, a score of 35 was obtained. A subject who preferred uncrossed disparity in the scene would score 35 on the RP set while a subject who preferred crossed disparity in the scene would score 55. If the subject had no preference for crossed or uncrossed disparity in the scene, then the score would be about 45.

In a similar previous study[6], a series of possible scores and their distribution were obtained by tossing five pennies numbered 1 through 5, 100 times. The average score was 45 in a Gaussian distribution showing that the scoring system implemented did not influence the results.

Results

The data for each subject have been put in a table and a graph of the average fixation disparity (FD) and the RP score was generated. The table shows the data gathered from each of the three sessions. Because each session contained three fixation disparity measurements, the first and second as well as the second and third measurements were averaged. In this way, a fixation disparity value could be associated with each IPD and RP score. An additional table summarizes the overall mean fixation disparity, mean IPD score, and mean RP score along with their associated standard deviations for all the subjects. Since a previous study showed that fixation disparity varied an average of +/- 1.5' of arc over a five-minute period and that repeated measurements every five days for a two week period showed an average variation of +/- 2.0' of arc[7], we hoped that by averaging all the fixation disparity measurements we would account for this variation. A corresponding graph shows the overall mean fixation disparity and associated mean RP score for all the subjects.

The summary table shows that four out of the ten subjects had a mean exo fixation disparity. Only two of these 4 subjects had a mean exo fixation disparity greater than 4' of arc. Therefore, six out of the ten subjects had a mean eso fixation disparity. Only one of these four subjects had a mean eso fixation disparity greater than 4' of arc.

Unlike the similar previous study[6], all subjects did well on the IPD set and no subject complained of difficulty doing this portion of the test. On the other hand, those individuals with small amounts of mean eso or exo fixation disparity complained of difficulty with the RP set. This is to be expected if we hypothesize that subjects with small fixation disparities would not have a preference for uncrossed or crossed disparities. The mean RP score for the exo subjects was 48.68 with a standard deviation of 4.29. The mean RP score for the eso subjects was 46.76 with a standard deviation of 4.20. The unpaired student t-test showed this was not a significant difference at the $0.05<P<0.1$ level.

When looking at patterns in the data, it is interesting to note that subject I with a mean exo fixation disparity of 5.7' of arc had a mean RP score of 53.7. This shows that this subject had a strong preference for crossed disparities as is expected by his/her larger amount of fixation disparity. On the other hand, subject E with a mean eso fixation disparity of 4.2'of arc had a mean RP score of 50.3. This score reflects no preference for either crossed disparity or perhaps a slight preference for crossed disparities, which goes against the expected pattern. For subjects with larger amounts of eso fixation disparity, we would expect a preference for uncrossed disparities. Another interesting finding was that the two subjects (subjects D and H) who showed a preference for uncrossed disparities (with mean RP scores of 38.7 and 39.5 respectively), had mean fixation disparities of 0.2' arc eso and 2.0' arc exo. This is unexpected for subjects who have such small amounts of fixation disparity. One wonders if they were not operating with an eso fixation disparity during the ordering task in spite of the fixation disparity that was measured.

Conclusion

As indicated in the results section, there was no significant difference between the RP scores for the eso and exo fixation disparity subjects. This suggests that overall, individuals with eso and exo fixation disparities do not have a preference for the reference plane to be in a certain location and therefore, show no preference for uncrossed or crossed disparities. These results can be explained by the fact that most of the subjects in our study had small amounts of fixation disparity (defined as between 4' arc eso and 6' arc exo). We would anticipate that subjects who have normal amounts of fixation disparity would not show a preference for crossed or uncrossed disparities. Knowing that the number of subjects with a given fixation disparity decreases as the fixation disparity amount increases[3], we would need to test more individuals and only look at the data of those with larger amounts of fixation disparity or by only including individuals with larger amounts of fixation disparity in the study. Needless to say, many more subjects need to be tested in future studies.

When the data were looked at on a subject by subject basis, both expected and unexpected results were found. As anticipated, the subject with a larger amount of exo fixation disparity had a strong preference for crossed disparity. On the other hand, a subject with a larger eso fixation disparity showed no preference for either crossed or uncrossed disparity, which goes against the normal pattern. Unexpectedly, two subjects with normal fixation disparity showed a preference for uncrossed disparities. Perhaps these results can be explained by the fact that the fixation disparity we measure with the

Disparometer is not the same fixation disparity the subject is using when ordering the RP set of cards. Determining if this is the case would be extremely difficult.

The results found in this study may also shed some light on the neural mechanisms involved in fixation disparity and suprathreshold stereopsis. Looking at the oculomotor control system model[2], Richards' proposal of three different disparity detectors[5], and other neurophysiological studies[8], we see that there are indeed at least two separate mechanisms for detecting disparity in normal individuals—crossed and uncrossed disparity detectors which work independently and in parallel. The possibility also exists for a third disparity detector mechanism known as the zero disparity detector which confuses the sign of the disparity but not its magnitude. The presence of this third mechanism could help explain the lack of preference for crossed or uncrossed disparities that many of the subjects demonstrated.

On the other hand, some subjects may have a preference for crossed or uncrossed disparities not based on the fixation disparity that they have as adults but the fixation disparity present as a child. The fixation disparity present in the formative years when the crossed and uncrossed disparity detectors are developing may determine the preference or lack of preference for crossed or uncrossed disparity regardless of the fixation disparity present as adults. However, the belief that these two or three mechanisms are separate and independent may not be correct. It is well known that there are inhibitory interactions between the crossed and uncrossed disparity detectors, but these interactions are not symmetrical and reciprocal in nature.[8] This suggests that the mechanisms may integrate the input from the crossed, uncrossed, and zero disparity detectors so that all have a role in suprathreshold stereopsis, whatever their proportions of input may be.

Neurophysiological evidence and the control system model suggest there are three additional disparity detectors in addition to the crossed and uncrossed detectors. One class (tuned-excitatory and tuned-inhibitory) is designed to make fine/small depth discriminations and is the most numerous of the three. The other two classes are near and far cells, which are specialized for detecting large/coarse disparities in front of the fixation plane (near cells) and large/coarse disparities behind the plane of fixation (far cells). The tuned-excitatory cells are activated when the disparity is in a small range near the fixation plane while the tuned-inhibitory cells suppress disparity detection in the range beyond the fixation plane when the tuned-excitatory cells are activated. The near cells are stimulated by disparity in front of the fixation plane and inhibited by disparities behind it. The far cells are activated when disparity is behind the fixation plane and inhibited when disparity is in front of the plane.[8]

In our study, the fixation disparity task involves the use of the fine disparity detectors, as would any suprathreshold task, since the disparity is on the magnitude of 30" of arc or less. The fine disparity detectors usually take longer to be stimulated so would involve observation times greater than one second, as was the case in our study. On the other hand, since our task was suprathreshold in nature (12'-18' or arc), it is likely that at least some of the coarse disparity detectors are activated. To ensure that only the coarse disparity detectors are activated, subjects would only be allowed one second or less to judge which card had more depth. This would be nearly impossible especially for those subjects who already had a difficult time with the RP set given adequate time to judge depth. So based on the tasks in our study, it is likely both the coarse and fine detectors are activated. The activation of the far and near cells would depend on where the subject puts their fixation plane in the scene. Perhaps a preference for crossed or uncrossed disparities involves the crossed/uncrossed detectors, the coarse/fine detectors, and the near/far detectors all together. It has been proposed that there may be multiple neural disparity selective pools besides the three suggested by Richards which operate to bring information about depth impressions and eye movement control in large disparity situations.[8] Such pools could be involved with the large disparities seen with our suprathreshold cards but there has been no neurophysiological data to substantiate this claim.

It may be the case that fixation disparity is not the only factor involved in disparity processing. Perhaps the system is much more complex and we are trying to oversimplify it by just looking at the affects of fixation disparity on suprathreshold stereopsis. For example, an individual with good base in and base out vergence ranges would not strictly have fixation disparity controlling his/her stereopsis. We would anticipate that someone with eso fixation disparity and poor base in ranges to compensate for it would likely prefer uncrossed disparities. Similarly, an individual with exo fixation disparity and poor base out ranges would likely prefer uncrossed stereopsis.

Another mechanism that could be at work on top of fixation disparity is selective-spatial-attention. Although this mechanism was found to be responsible for improvements in stereoacutiy with repeated exposure to random-dot-stereograms[9], this mechanism could also come into play as subjects judge the depth of the RP cards. Another study suggests that preattentive factors may be responsible for stereoscopic disparity.[10] The preattentive process involves differences in the display "popping out" as well as visual search tasks where the time required to find a disparity target at a certain plane is not affected by the number of distractors at different disparity planes. Rather than fixation disparity being the main determinant in ordering the cards, it is very possible that subjects order the cards based on how the scene pops out at them through preattentive mechanisms or uses selective attention to determine depth.

In conclusion, we did not find the strong correlation between higher amounts of eso and exo fixation disparity and a preference for uncrossed or crossed disparities because most of our subjects had smaller, more normal amounts of fixation disparity. More subjects with larger amounts of fixation disparity need to be tested in order to support or refute this previous correlation. At this point, there may be complex relationships between disparity detectors that are influenced by fixation disparity and which together affect suprathreshold depth perception. There may also be more than just fixation disparity influencing this depth perception. Clearly, more information is needed to determine what mechanism or mechanisms are at work in suprathreshold stereopsis.

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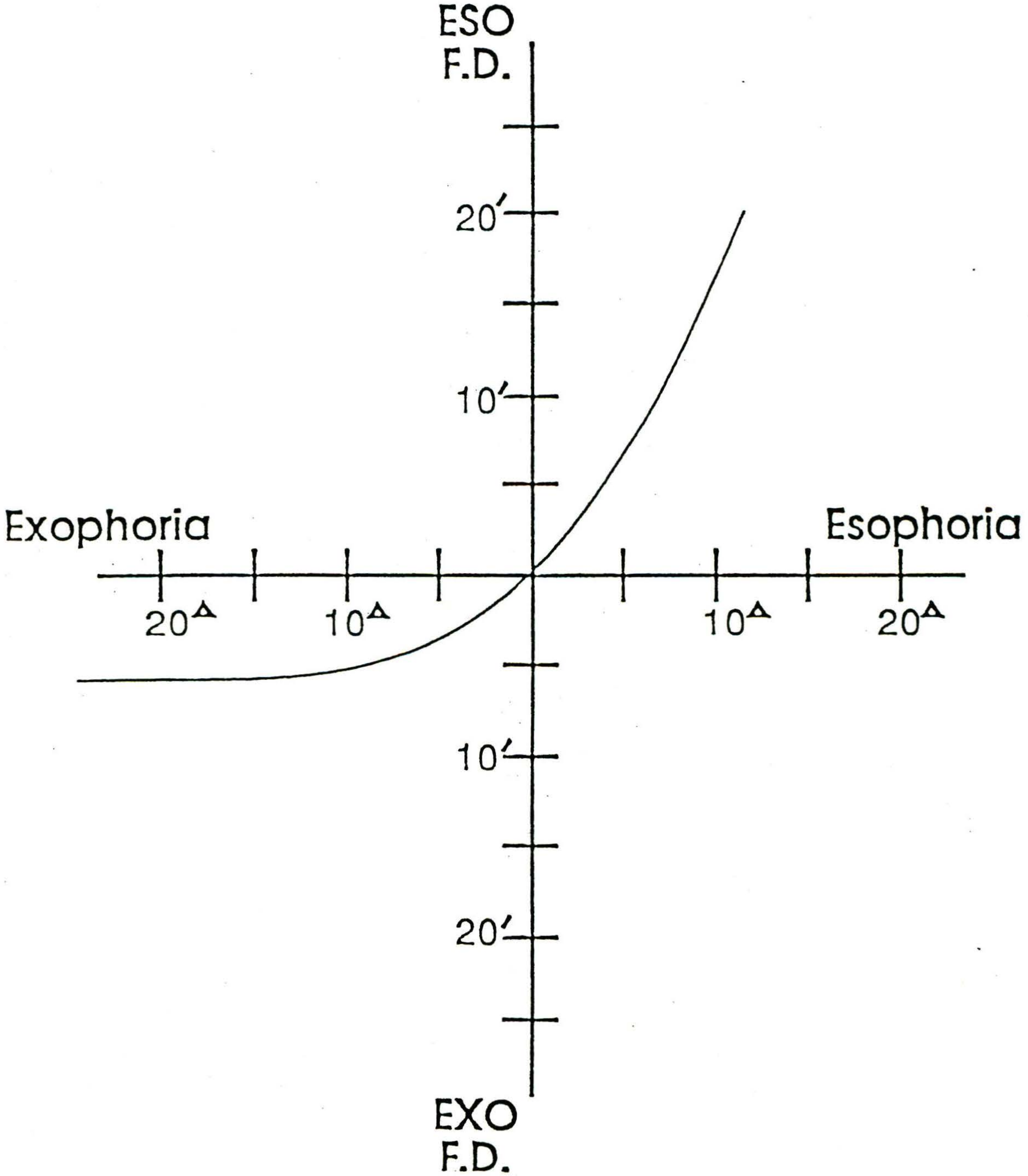


Figure 1: Fixation Disparity Curve

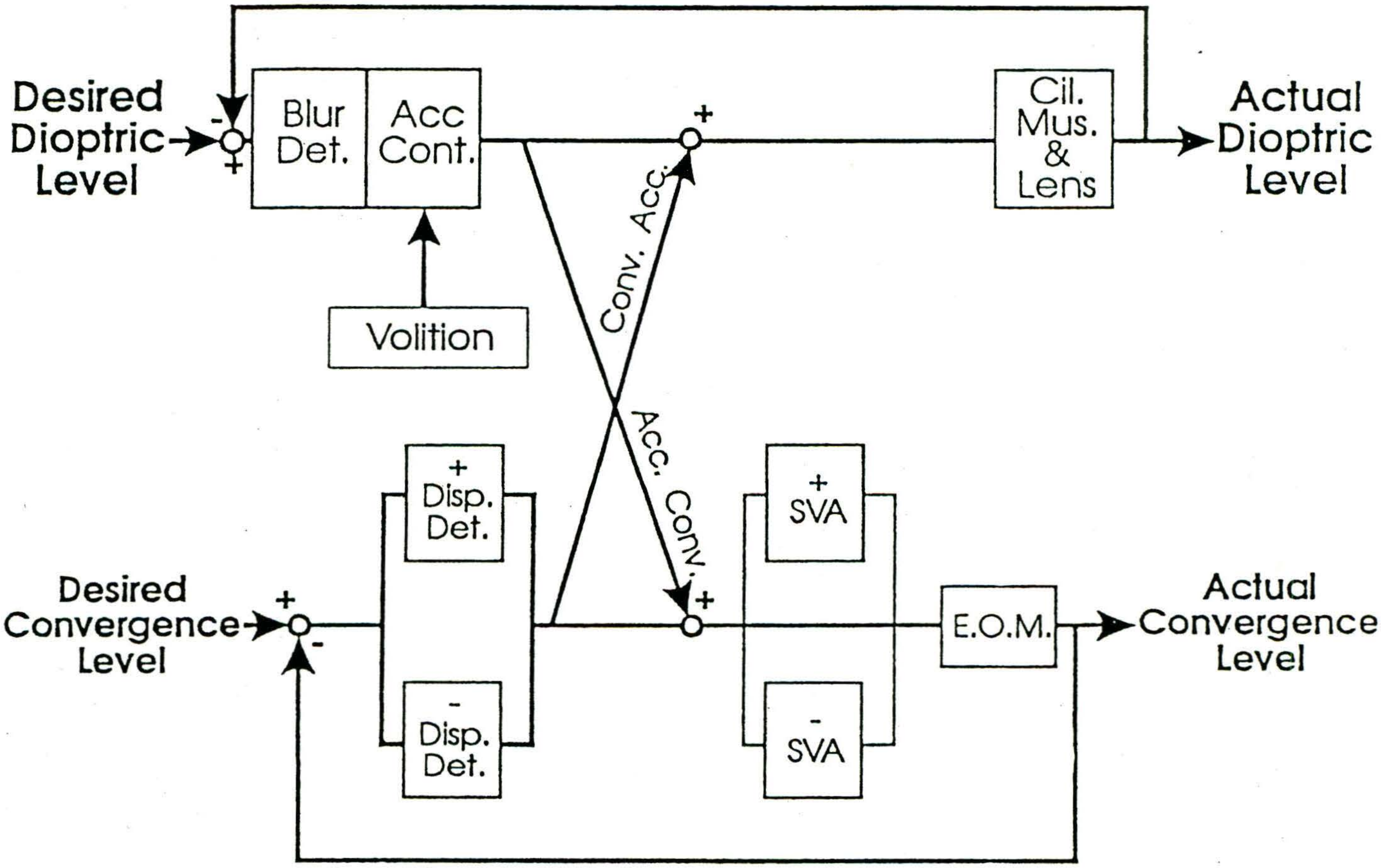


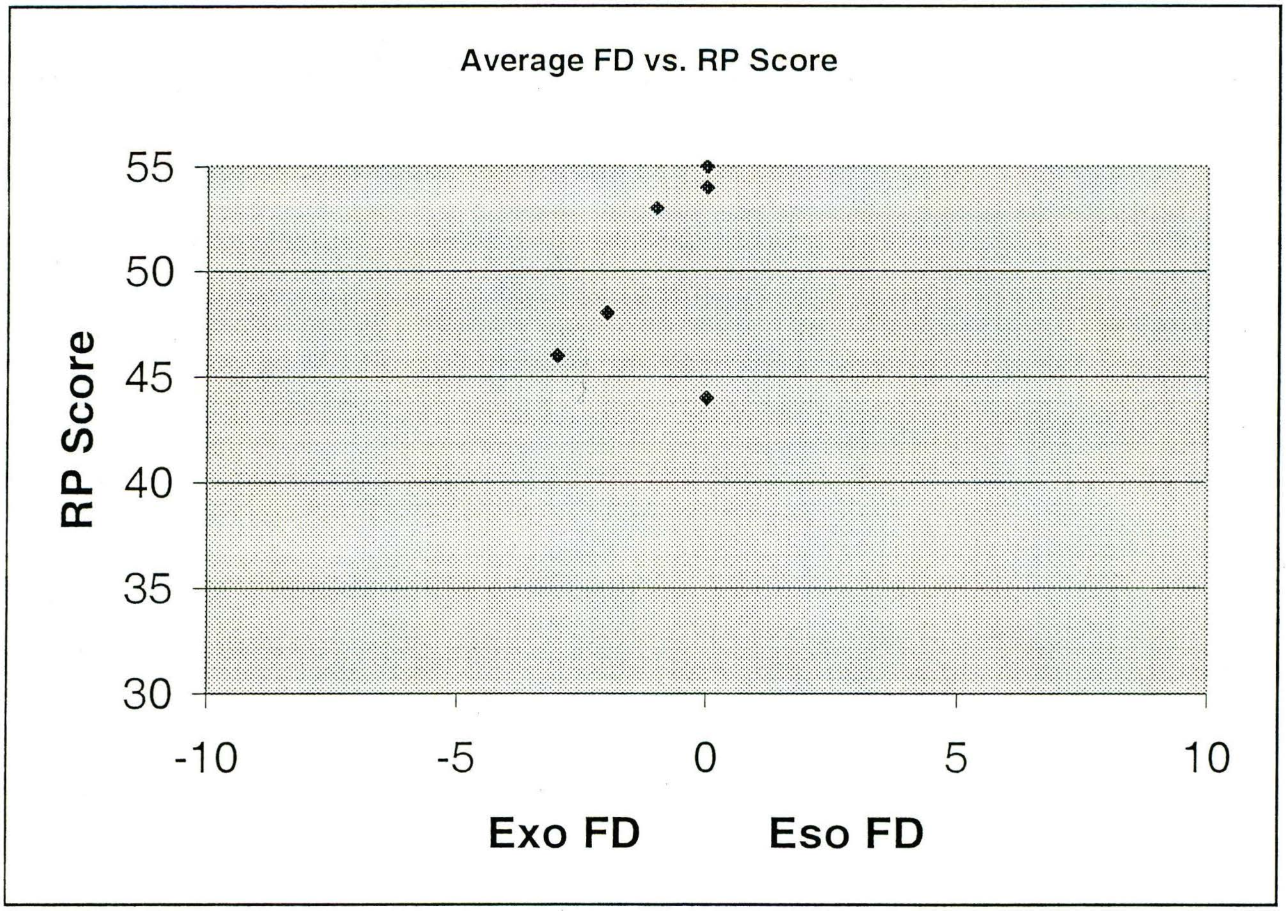
Figure 2: Control Systems Model

Data Summary: Subject A

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	0	-2	0
	IPD	55	55	55
	RP	54	48	55
	FD2	0	-2	0
	Average FD	0	-2	0
Group # 2	FD2	0	-2	0
	IPD	55	55	55
	RP	53	46	44
	FD3	-2	-4	0
	Average FD	-1	-3	0

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject A

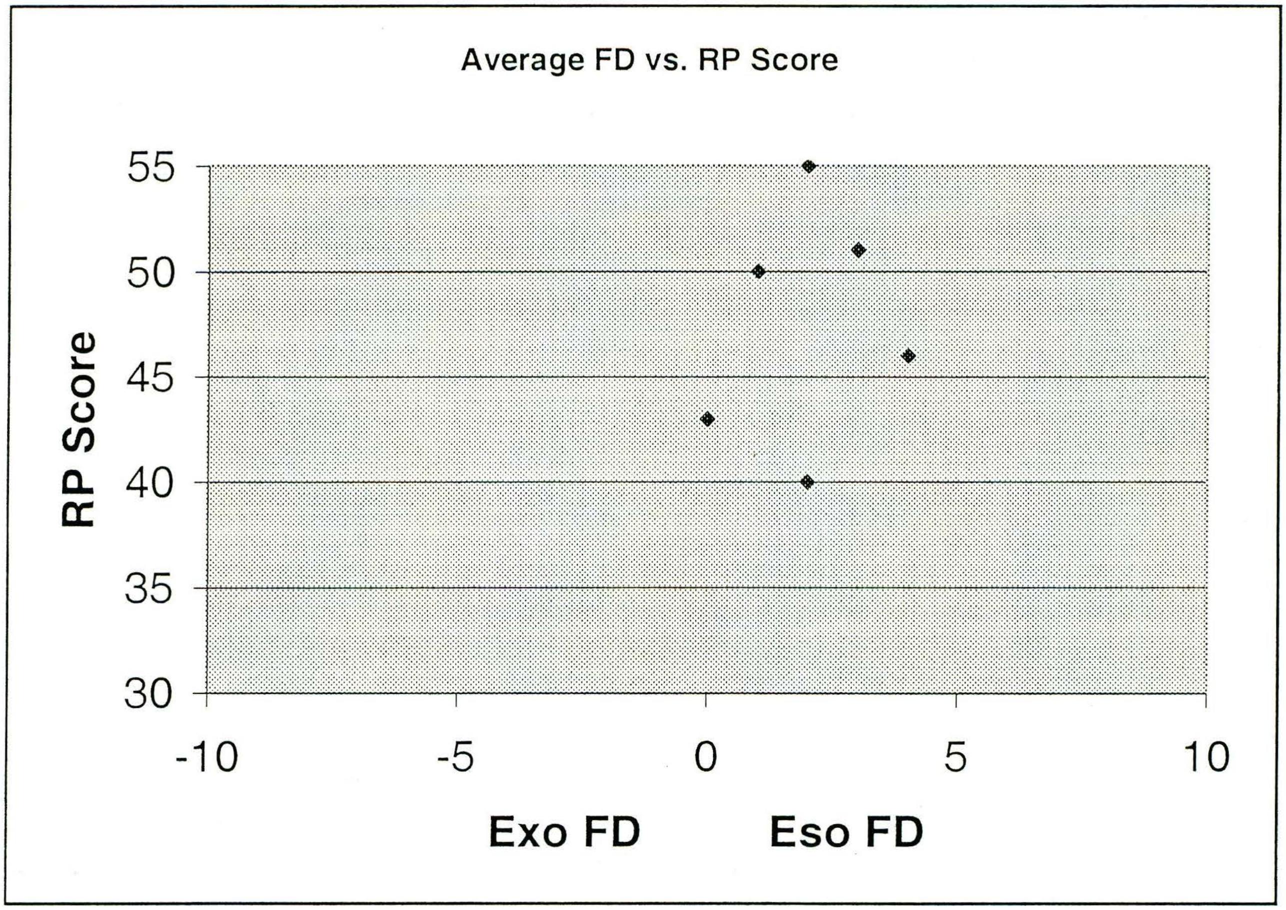
	FD	RP	IDP
T1G1	0	54	55
T1G2	-1	53	55
T2G1	-2	48	55
T2G2	-3	46	55
T3G1	0	55	55
T3G2	0	44	55
AVG.	-1.0	50.0	55.0
STDEV.	1.3	4.6	0.0

Data Summary: Subject B

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	6	0	2
	IPD	54	55	54
	RP	46	43	55
	FD2	2	0	2
	Average FD	4	0	2
Group # 2	FD2	2	0	2
	IPD	55	54	55
	RP	51	50	40
	FD3	4	2	2
	Average FD	3	1	2

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject B

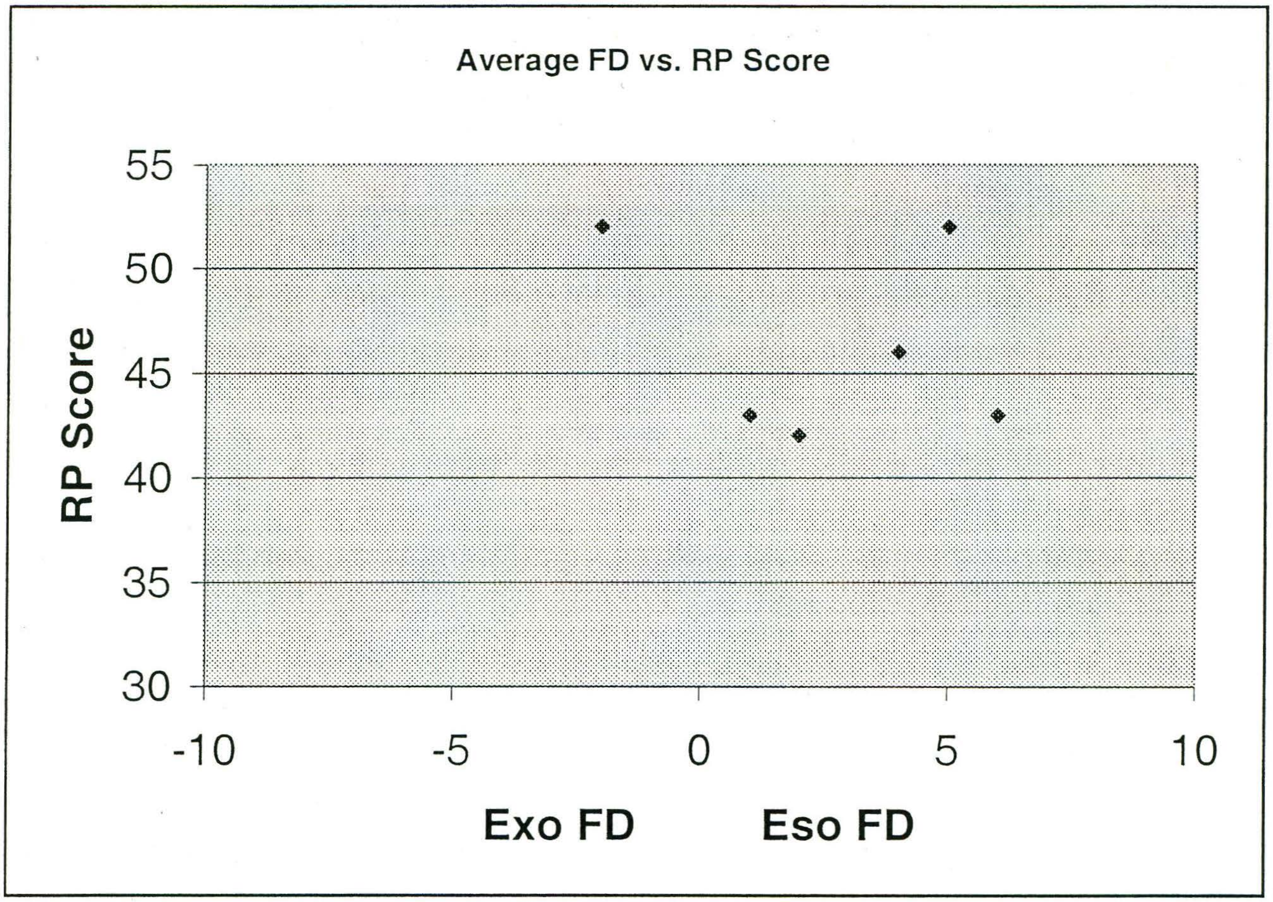
	FD	RP	IDP
T1G1	4	46	54
T1G2	3	51	55
T2G1	0	43	55
T2G2	1	50	54
T3G1	2	55	54
T3G2	2	40	55
AVG.	2.0	47.5	54.5
STDEV.	1.4	5.5	0.5

Data Summary: Subject C

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	6	0	-2
	IPD	55	55	52
	RP	43	42	52
	FD2	6	4	-2
	Average FD	6	2	-2
Group # 2	FD2	6	4	-2
	IPD	55	55	54
	RP	52	46	43
	FD3	4	4	4
	Average FD	5	4	1

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject C

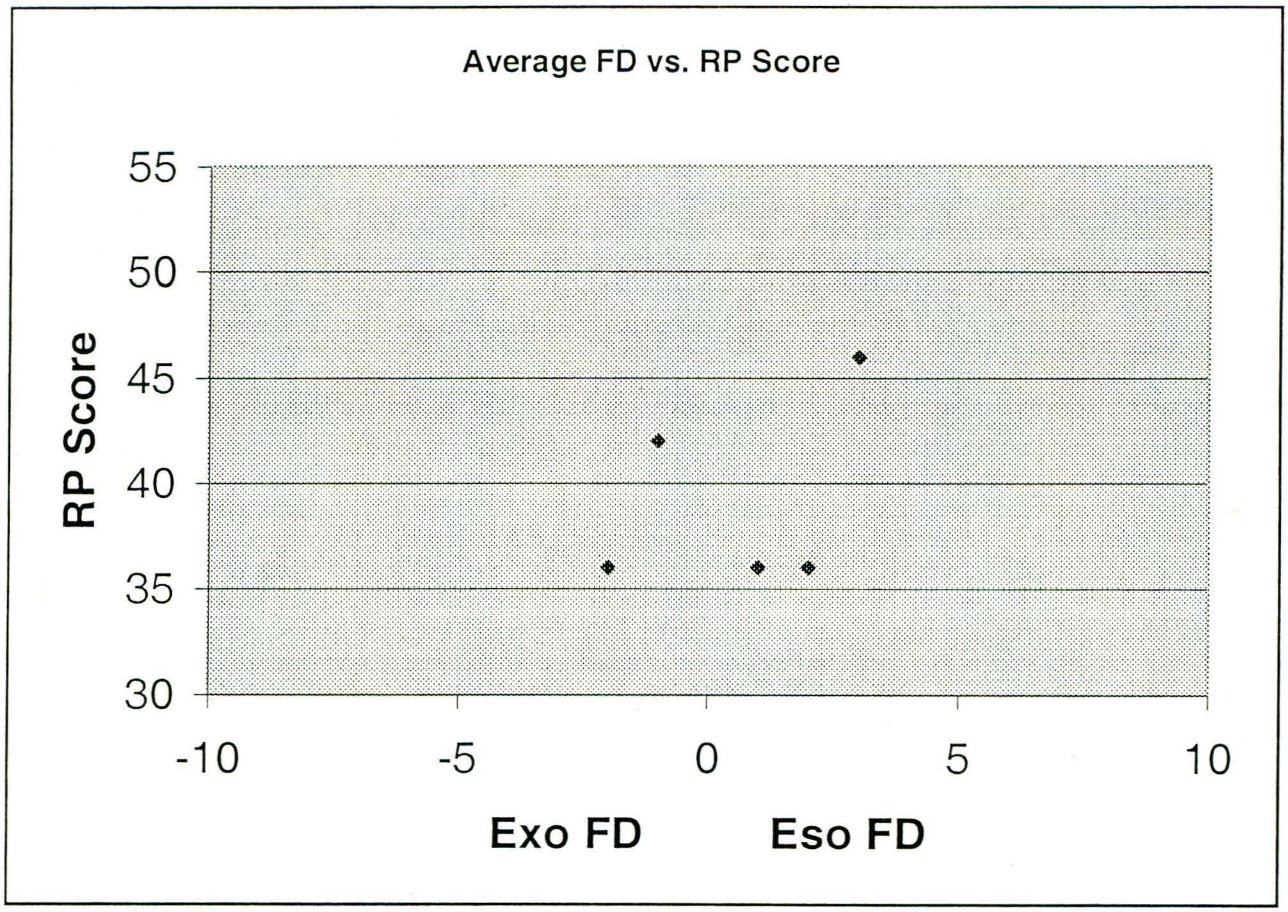
	FD	RP	IDP
T1G1	6	43	55
T1G2	5	52	55
T2G1	2	42	55
T2G2	4	46	55
T3G1	-2	52	52
T3G2	1	43	54
AVG.	2.7	46.3	54.3
STDEV.	2.9	4.6	1.2

Data Summary: Subject D

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	-6	-6	0
	IPD	54	55	54
	RP	36	36	36
	FD2	2	2	2
	Average FD	-2	-2	1
Group # 2	FD2	2	2	2
	IPD	55	55	54
	RP	36	42	46
	FD3	2	-4	4
	Average FD	2	-1	3

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject D

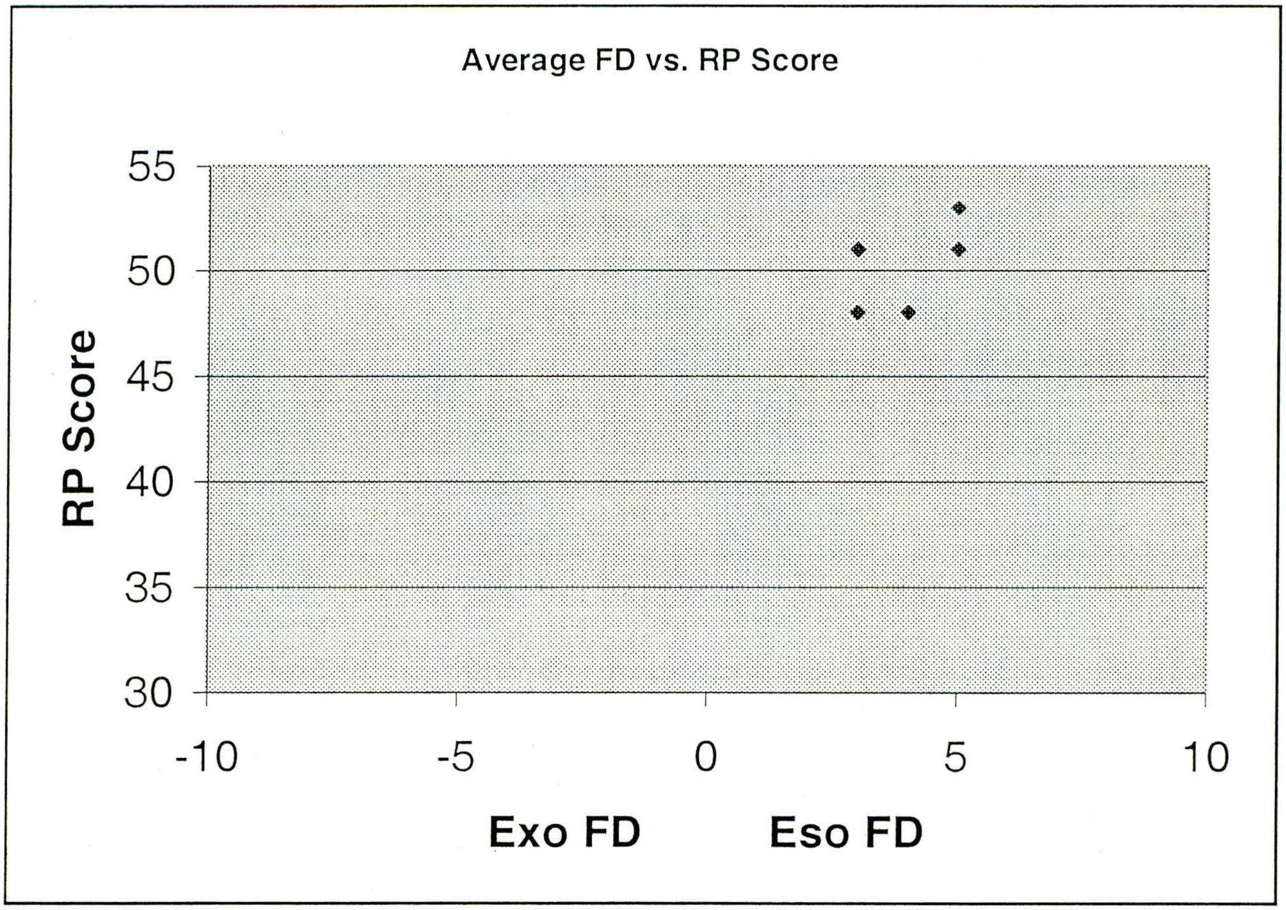
	FD	RP	IDP
T1G1	-2	36	54
T1G2	2	36	55
T2G1	-2	36	55
T2G2	-1	42	55
T3G1	1	36	54
T3G2	3	46	54
AVG.	0.2	38.7	54.5
STDEV.	2.1	4.3	0.5

Data Summary: Subject E

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	4	4	6
	IPD	55	55	55
	RP	51	48	53
	FD2	6	2	4
	Average FD	5	3	5
Group # 2	FD2	6	2	4
	IPD	55	55	55
	RP	51	51	48
	FD3	4	4	4
	Average FD	5	3	4

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject E

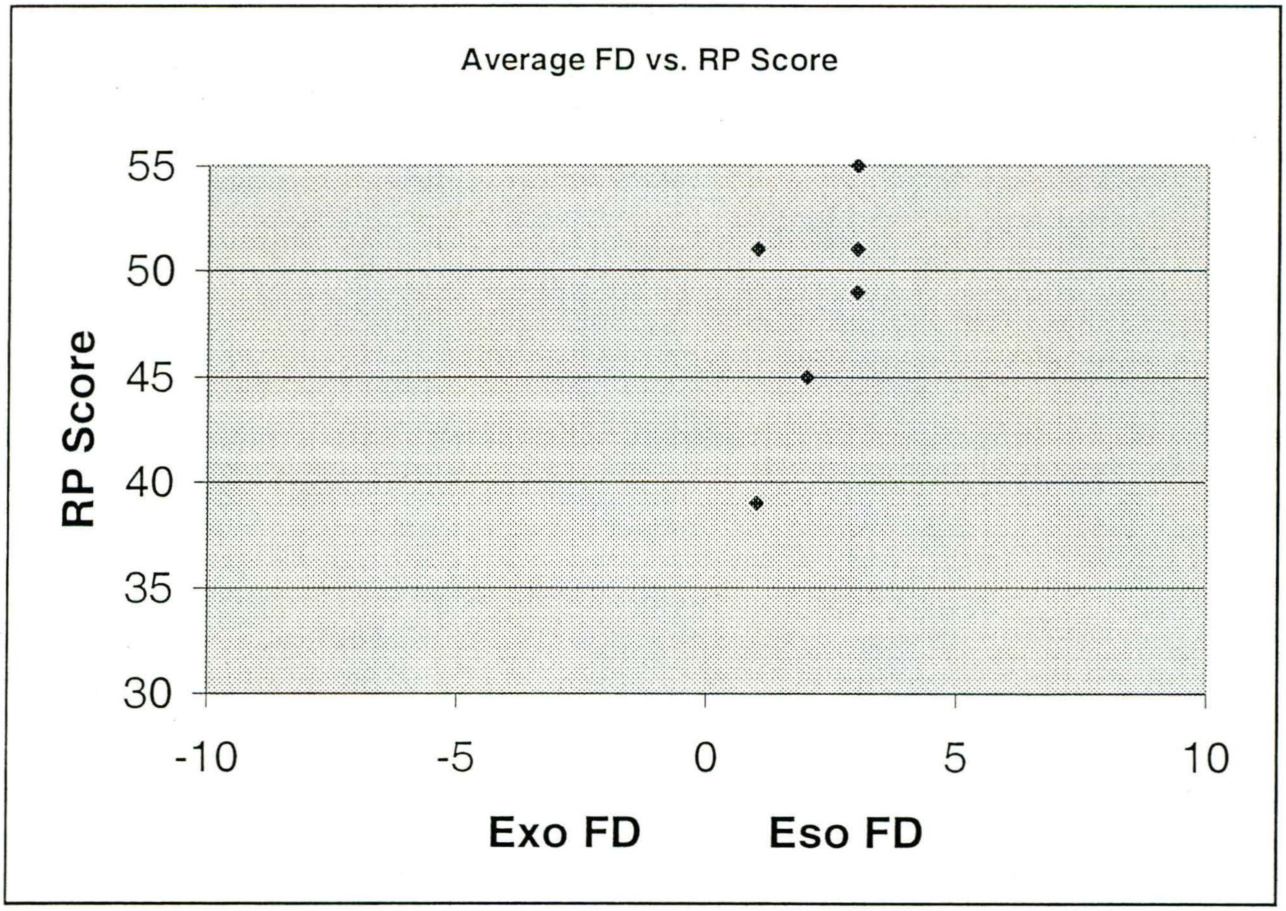
	FD	RP	IDP
T1G1	5	51	55
T1G2	5	51	55
T2G1	3	48	55
T2G2	3	51	55
T3G1	5	53	55
T3G2	4	48	55
AVG.	4.2	50.3	55.0
STDEV.	1.0	2.0	0.0

Data Summary: Subject F

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	2	4	2
	IPD	52	51	55
	RP	45	55	51
	FD2	2	2	0
	Average FD	2	3	1
Group # 2	FD2	2	2	0
	IPD	55	55	54
	RP	51	49	39
	FD3	4	4	2
	Average FD	3	3	1

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject F

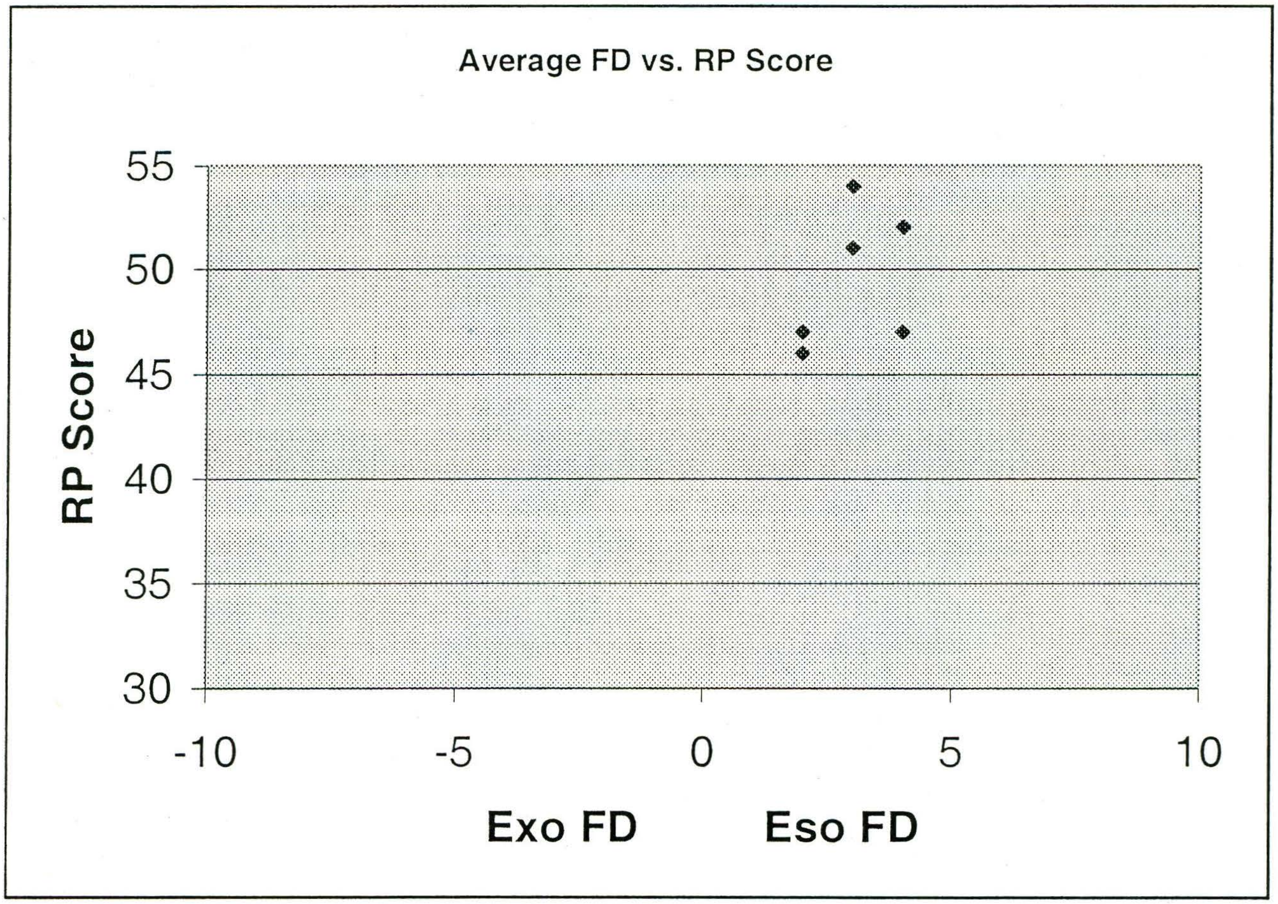
	FD	RP	IDP
T1G1	2	45	52
T1G2	3	51	55
T2G1	3	55	51
T2G2	3	49	55
T3G1	1	51	55
T3G2	1	39	54
AVG.	2.2	48.3	53.7
STDEV.	1.0	5.6	1.8

Data Summary: Subject G

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	2	4	4
	IPD	52	55	55
	RP	47	52	54
	FD2	2	4	2
	Average FD	2	4	3
Group # 2	FD2	2	4	2
	IPD	55	55	55
	RP	46	47	51
	FD3	2	4	4
	Average FD	2	4	3

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject G

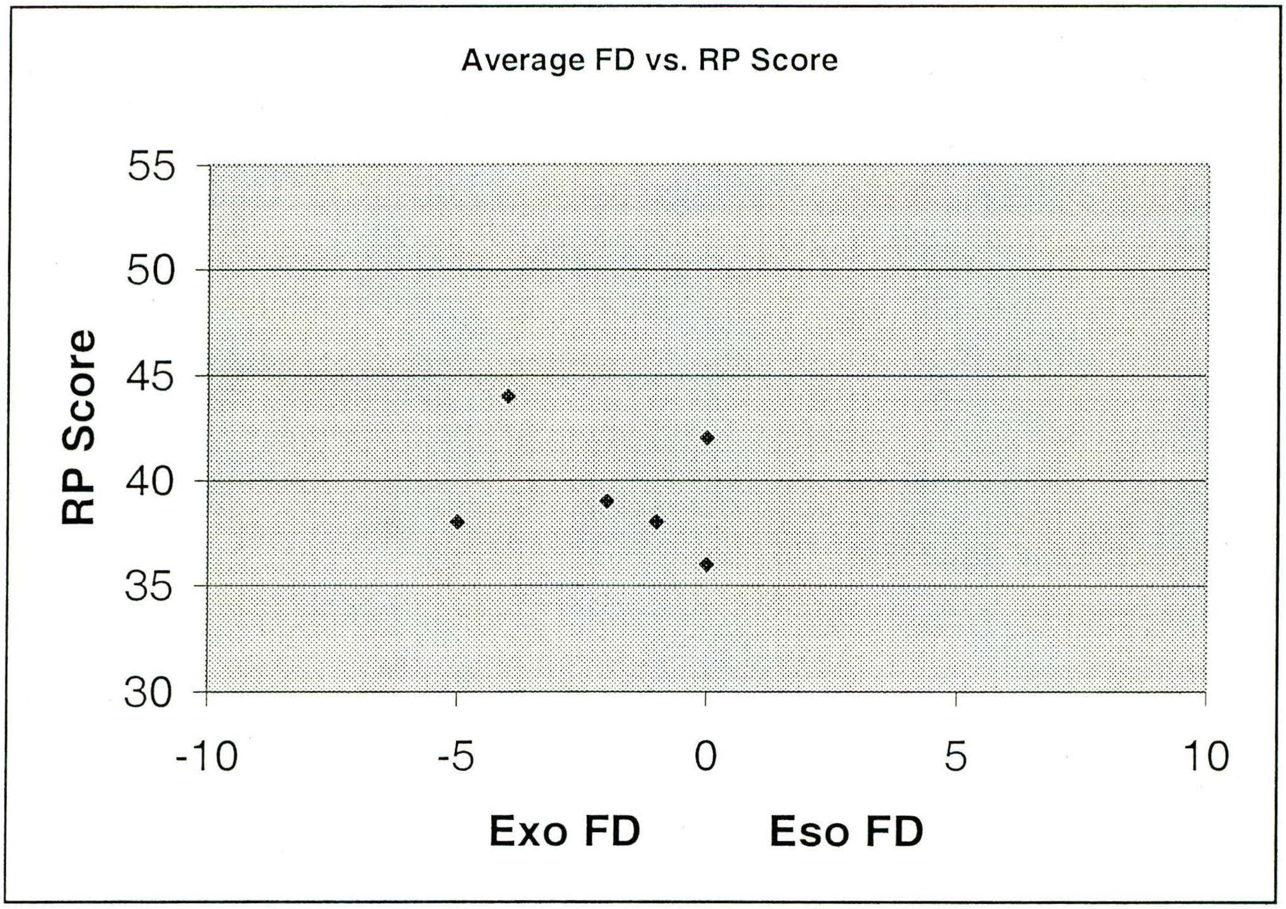
	FD	RP	IDP
T1G1	2	47	52
T1G2	2	46	55
T2G1	4	52	55
T2G2	4	47	55
T3G1	3	54	55
T3G2	3	51	55
AVG.	3.0	49.5	54.5
STDEV.	0.9	3.3	1.2

Data Summary: Subject H

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	0	-6	-2
	IPD	54	55	55
	RP	42	38	39
	FD2	0	-4	-2
	Average FD	0	-5	-2
Group # 2	FD2	0	-4	-2
	IPD	55	55	55
	RP	36	44	38
	FD3	0	-4	0
	Average FD	0	-4	-1

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject H

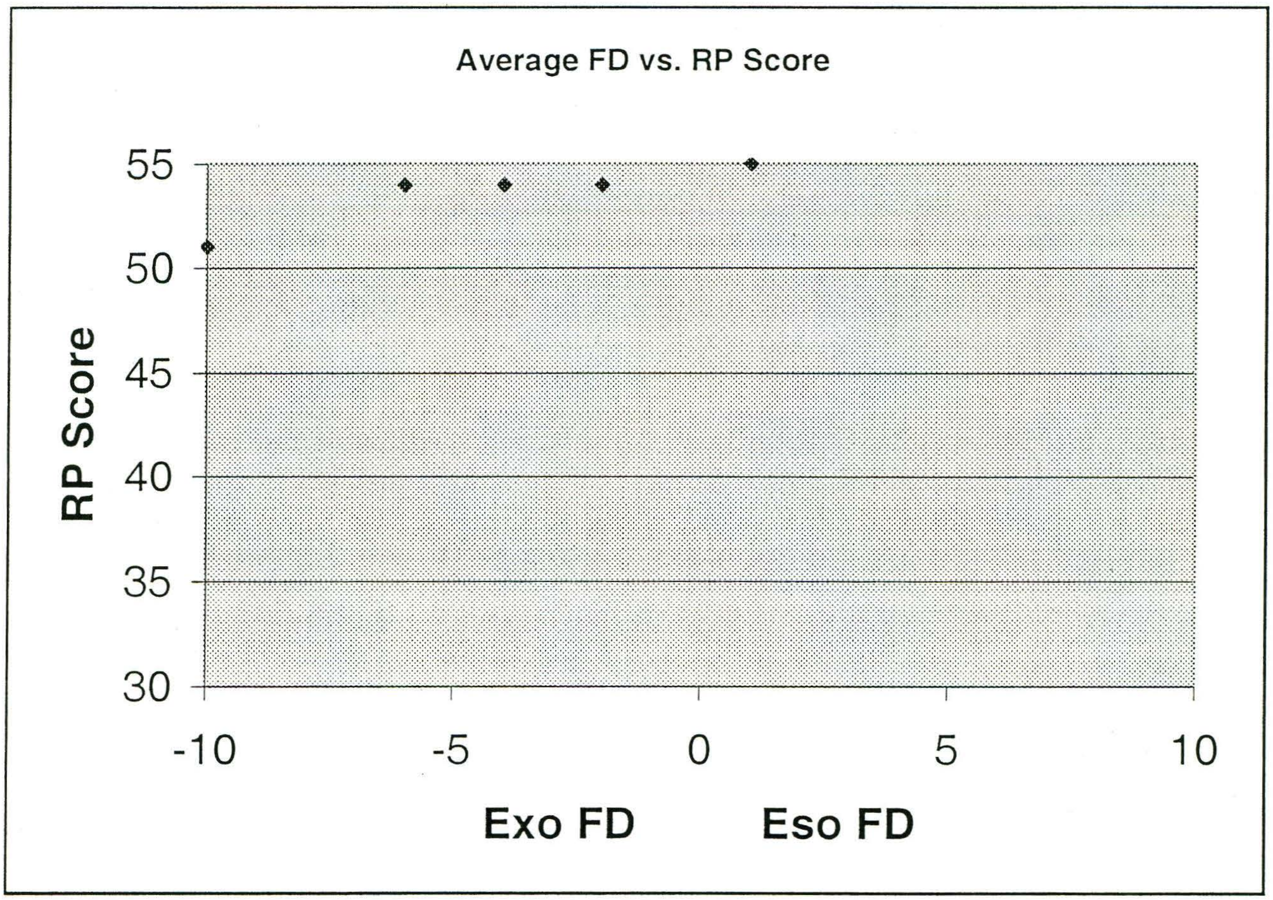
	FD	RP	IDP
T1G1	0	42	54
T1G2	0	36	55
T2G1	-5	38	55
T2G2	-4	44	55
T3G1	-2	39	55
T3G2	-1	38	55
AVG.	-2.0	39.5	54.8
STDEV.	2.1	2.9	0.4

Data Summary: Subject I

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	-4	-14	-14
	IPD	55	55	55
	RP	54	51	54
	FD2	0	-6	-12
	Average FD	-2	-10	-13
Group # 2	FD2	0	-6	-12
	IPD	55	55	55
	RP	55	54	54
	FD3	2	-2	0
	Average FD	1	-4	-6

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject I

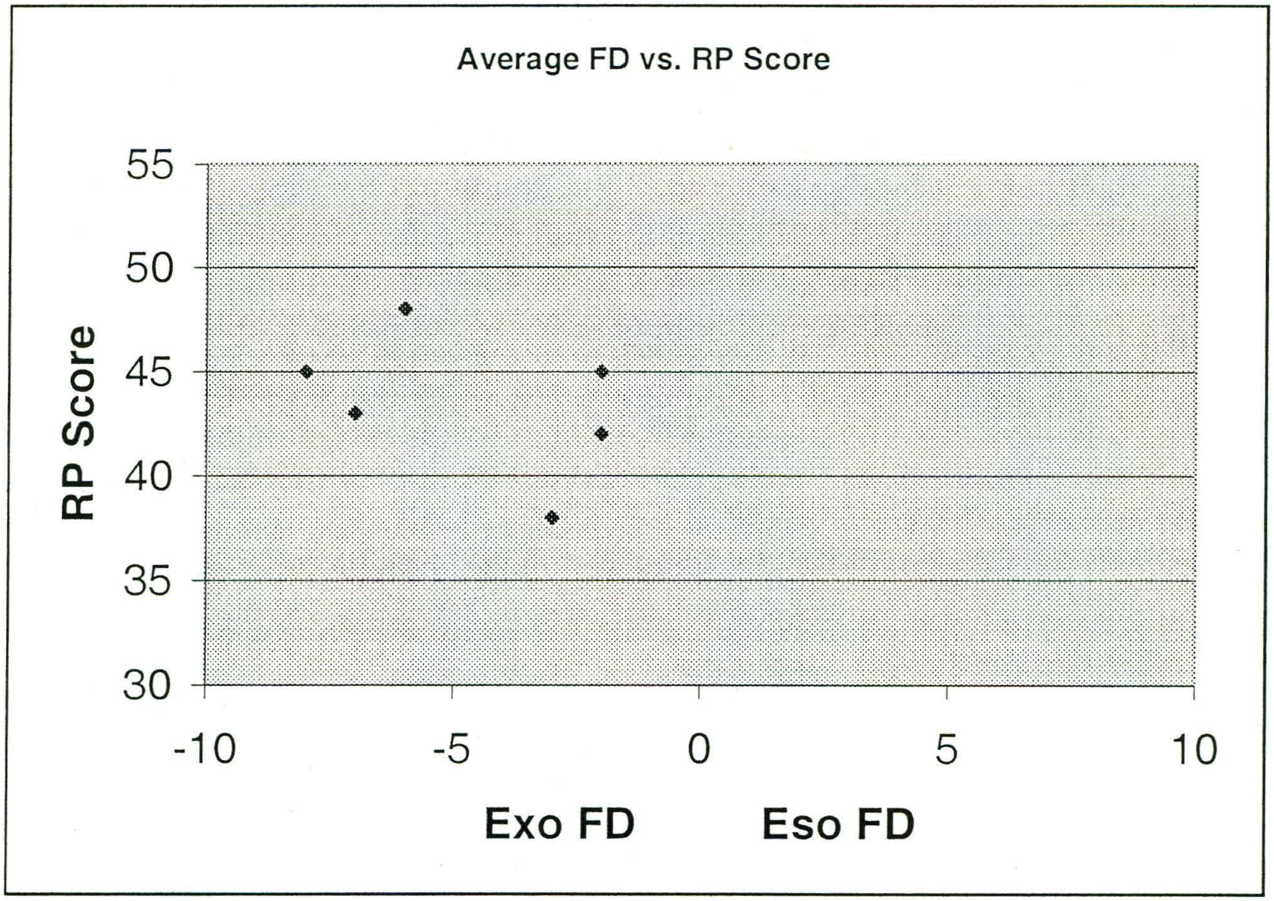
	FD	RP	IDP
T1G1	-2	54	55
T1G2	1	55	55
T2G1	-10	51	55
T2G2	-4	54	55
T3G1	-13	54	55
T3G2	-6	54	55
AVG.	-5.7	53.7	55.0
STDEV.	5.2	1.4	0.0

Data Summary: Subject J

Data:

		Trial # 1	Trial # 2	Trial # 3
Group # 1	FD1	0	-2	-6
	IPD	54	55	54
	RP	43	45	48
	FD2	-14	-2	-6
	Average FD	-7	-2	-6
Group # 2	FD2	-14	-2	-6
	IPD	55	55	52
	RP	45	42	38
	FD3	-2	-2	0
	Average FD	-8	-2	-3

Graph:



Notes:

- FD2 is a single FD measurement that is listed twice for averaging purposes
- A (-) FD number indicates exo FD; a (+) FD number indicates eso FD

Data Summary: Subject J

	FD	RP	IDP
T1G1	-7	43	54
T1G2	-8	45	55
T2G1	-2	45	55
T2G2	-2	42	55
T3G1	-6	48	54
T3G2	-3	38	52
AVG.	-4.7	43.5	54.2
STDEV.	2.7	3.4	1.2

Data Summary: All Subjects

Data:

	Fixation Disparity		IPD Score		RP Score	
Subject	Mean	σ	Mean	σ	Mean	σ
A	-1.0	1.3	55.0	0.0	50.0	4.6
B	2.0	1.4	54.5	0.5	47.5	5.5
C	2.7	2.9	54.3	1.2	46.3	4.6
D	0.2	2.1	54.5	0.5	38.7	4.3
E	4.2	1.0	55.0	0.0	50.3	2.0
F	2.2	1.0	53.7	1.8	48.3	5.6
G	3.0	0.9	54.5	1.2	49.5	3.3
H	-2.0	2.1	54.8	0.4	39.5	2.9
I	-5.7	5.2	55.0	0.0	53.7	1.4
J	-4.7	2.7	54.2	1.2	43.5	3.4

Graph: