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The Influence of Schizotypal Traits on Active Display Recognition

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ABSTRACT

Accurate recognition of changes in scene layout is necessary to function in everyday life. Self-motion sensitivity, comprised of efference copy and afferent signals, is employed to respond to these changes, however little is known about how these signals may influence active display recognition. Previous spatial perception experimentation has shown that individuals with high schizotypal traits perform differently than those with low schizotypal traits while estimating walked distance in non-visual walking and imagined walking tasks (Rohde & Yamamoto, 2013). It is postulated that this result could be attributed to a presumable dysfunction of efference copy associated with schizotypy. It was hypothesized that lack of efference copy may influence other spatial perception tasks involving self-motion. This study investigated the influence of efference copy on active display recognition by comparing accuracy scores of high and low schizotypal groups. Contrary to the prediction, results found no significant difference between groups in accuracy for detecting change in a scene, suggesting that tasks that rely exclusively on body-based information (e.g. non-visual perception of walked distance) may be more susceptible to dysfunction in efference copy, or simply that the degree of possible efference copy dysfunction in the current participants was not large enough. Information from this study can be used to shape continuing research to define the role of efference copy in spatial perception.

Keywords: efference copy, afferent signals, schizophrenia, schizotypy, perceptual aberration scale, spatial updating.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER I

INTRODUCTION

This study extends research on the role of afferent signals and efference copy in spatial perception. Input from both comprises self-motion sensitivity. Afferent signals consist of proprioceptive and vestibular signals that are generated by peripheral sensory organs in response to any body movements. Efference copy is a copy of motor commands that are produced with the mental plan of intentionally carrying out actions. The results of these two processes are expected to align allowing for a correct final action. Both are present when body movement is willfully made making it difficult to create situations that would separate the two. Dysfunction in efference copy could create a scenario where predicted action (efference copy) and physical reaction (afferent signal) would not align, thus creating an incorrect action. In an attempt to observe this potential difference, individuals that were presumed to have dysfunction in efference copy pathway, which may create misalignment to afferent signal, were

sought out and tested in spatial perception tasks. Schizotypal personality disorder provided the opportunity to create this comparison.

Schizotypy is identified as a latent, nonpsychotic schizophrenic-related syndrome, sharing many of the characteristics of schizophrenia (APA, 1968) and genetically linked to schizophrenia (Meehl, 1962). Shared characteristics that were of importance to this study were, delusion of control, the feeling that external forces control body movement even though they are willfully generated actions (Frith, 1992) and body-image and perceptual aberrations (Rado, 1960). These symptoms are thought to be due to dysfunction in cognitive process related to efference copy awareness (Hershberger & Misceo, 1983), which relates to the specific area of interest in this study.

Spatial perception requires the use of both afferent signal and efference copy to assess and navigate the environment. An important aspect of spatial perception is spatial updating, the ability to orient to new viewpoints and recognize changes in scene, which is used in every day actions. Spatial updating is dependent on the accuracy in matching the results of vestibular and proprioceptive information (afferent signals) to predicted outcomes (efference copy). Individuals with dysfunction in efference copy pathway, which results in a misalignment between actual action and predicted action, are susceptible to having difficulty when performing body-based tasks such as those used for spatial navigation. Previous studies have shown that high and low schizotypal groups have performed differently in an imagined and real walking, distance perception task (Rohde & Yamamoto, 2013), leading us to hypothesize that

2

efference copy alignment to afferent signal may play a pivotal role in spatial

perception tasks, particularly when body-based input is processed. To expand

our understanding of the possible effects of dysfunctional efference copy

pathway in spatial perception, additional comparative tasks between high and

low schizotypal groups are required.

1.1 Afferent Signals and Efference Copy

Neurons in sensory organs become stimulated in response to activity

taking place in the environment surrounding us. This process initiates afferent

signals to the central nervous system resulting in perception of stimuli from the

environment and from one's own body movements.
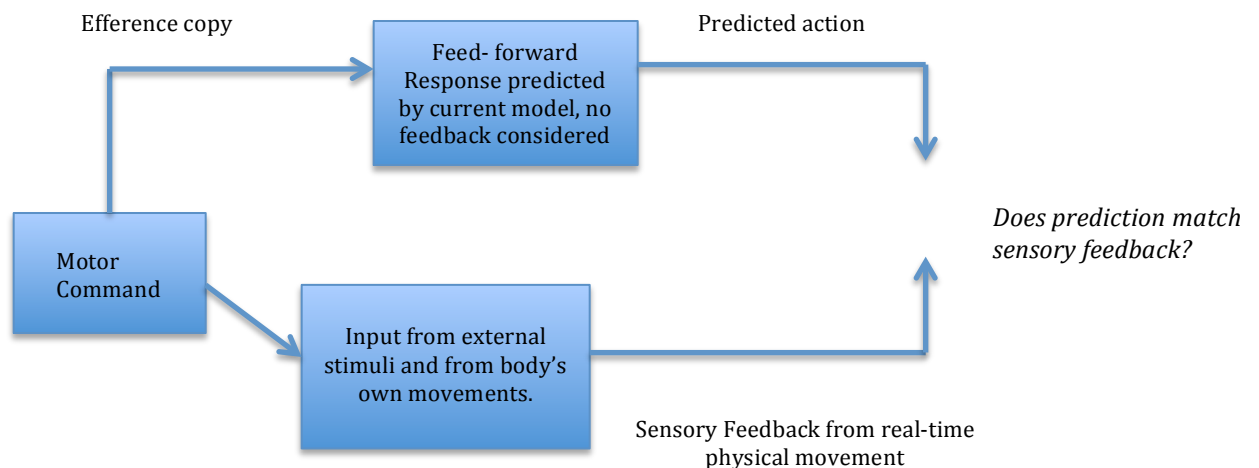
Figure 1. Schematic diagram of afferent and efferent sensorimotor pathways.

Efference copy is produced to create a predicted response reactive to sensory

input; this prediction is expected to align with actual sensory feedback derived

from physical movement (Bays & Wolpert, 2007, Proske & Gandevia, 2012).

Efference copy is generated from the central nervous system through a motor command with the intention or thought of action. A predicted outcome of a movement or response is generated. Simultaneously, the sensory system receives afferent signals that generated from stimuli in the environment as well as movements from the body. The result is a comparison of vestibular and proprioceptive feedback from the individual's actual physical action against the prediction based on efference copy. This process allows a correct intentional (conscious) action to occur (Von Holst & Mittelstaedt, 1950, Von Holst, 1954, see Figure 1). Dysfunction in the efference copy pathway, specifically resulting in a misalignment of efference copy to afferent signals, could create a conflict that may impair one's motor control, and in turn, space perception through action. Symptoms of this impairment could manifest in the form of delusional behavior and abnormal space perception including auditory and visual hallucinations, as well as delusions of control (alien control of actions) and body image distortions. These characteristics can be found in individuals that are diagnosed with formal thought disorders such as schizophrenia. For purposes of this study we chose to consider this condition in persons with schizotypal personality disorder (SPD), a syndrome that is closely associated to schizophrenia.

1.2 Schizotypy

Individuals identified as schizophrenic posses an abnormality in the central nervous system that affects differentiation and discrimination in neural transmissions. This dysfunction is apparent in the derangement of internal

feedback resulting in body-image aberrations (Rado, 1960, Feinberg, 1978,

Lenzenweger, 2006) inducing the belief that external forces may control actions.

Schizotypy is described as a genetically based personality organization

that can be predictive of liability for schizophrenia (Meehl, 1962, 1990). Meehl's

model depicts a single major gene that can influence coding in the central

nervous system during brain development. Other factors such as, social-learning

history, environment, and/or other personality dimensions, create a range of

degrees of symptomology in schizotypal personality disorder.

To determine degree of cognitive-perceptual distortions, self-report

questionnaires are used. The Perceptual Aberration Scale (PAS) developed by

Chapman et al (1978) is commonly used when working with the general

population to discriminate for schizotypal traits and is specifically geared

toward perceptual distortions. The PAS consists of 28 items (true/false), 24 of

which are keyed true for perceptual aberration, 4 keyed false (e.g. "Parts of my

body occasionally seem dead or unreal."; "I have felt that something outside my

body was a part of my body."). For this study, the PAS was adapted to include

questions from the Magical Ideation Scale (MIS). The MIS measures individual

beliefs, influenced by culture, and a person's interpretation of personal

experiences (e.g. "I have sometimes felt that strangers were reading my mind."),

these questions create a distraction that obscures the purpose of the

questionnaire, making it more difficult for participants to manipulate their

responses. Only the scores from the PAS questions were used to determine

schizotypal traits. The authors of the PAS collected data, from 775 male and 840

female Caucasian college students at the University of Wisconsin—Madison and reported norms of $M = 6.87$, SD 6.06 for males and $M = 6.57$, $SD = 5.88$ for females (as cited in Kwapil, Crump, & Pickup, 2002). This test has been found to be valid and reliable, showing a very clear difference in determining levels of schizotypal traits, (Chronbach & Meehl, 1955, Chapman et al., 1978, Chapman et al., 1982).

Alternative methods, such as the Schizotypal Personality Questionnaire (Raine, 1991) could be used and would produce similar results, however the PAS is specifically designed to detect and measure perceptual abnormality, which is the focus of this study.

Schizophrenia and schizotypal disorder have many common behavioral symptoms and characteristics. This includes the feeling of control over one's actions. The feeling of control is comprised of two main components; awareness of sensory input associated with movement and the adjustment of movement associated with this input (Hohwy & Frith, 2004). Failure in this process results in an inability to anticipate an action that should occur and blocks the very rapid error corrections that would normally take place to correct the inconsistency (Frith, 1987). This could result from an efference copy that would not align with afferent signal, which may present as a feeling of not being in control of one's actions. This impairment would be noticeably demonstrated in the performance of tasks associated with body-based movement, such as those associated with spatial navigation and spatial updating.

1.3 Spatial Updating

In the real world, object positioning is constantly changing, either by movement of objects or by movement of the observer. To function properly in our environment, we rely on sensory input from our proprioceptive and visual systems as well as contributions from stored information such as, previous experience, visual and verbal memory and imagination to navigate our surroundings. These processes work seamlessly together and are not always easy to tease apart to determine the specific contributions of each. It has been discovered that proprioceptive and visual input result in more accurate performance during spatial updating tasks (Loomis et al., 1992, Etienne, Maurer & Séguinot, 1996). However, performance was less accurate when performing similar tasks from imagination (i.e. verbal description) indicating a difference in contribution between processes (Rieser et al., 1986, Loomis, et al., 1993, Klatzky et al., 1998).

A study on perceiving real-world viewpoint changes by Simons and Wang (1998) examined the accuracy of scene change recognition in several conditions. These conditions were designed to simulate real world scenarios in which scenes can change, as well as observer viewpoint to those scenes, employing multiple processes for updating spatial information.

Participants were fairly accurate in detecting changes when viewing a "same view" scene from a constant stationary position, however when the scene rotated to create a "different view" accuracy in change detection was reduced. Interestingly, when observers physically changed viewing positions, change

detection accuracy increased in "different view" scenarios, while accuracy for "same view" scenarios remained similar.

These results indicate that best performance in this task was achieved when other mechanisms, in addition to purely visual information, were employed to recognize changes in scene when viewer repositioning is involved.

As viewers reposition themselves, the physical movement of doing so generates additional input in the form of vestibular, and proprioceptive information, providing reinforcement through afferent signals. Simultaneously, the planned action of movement to a secondary viewing position may bolster the efference copy that is predictive of the action. This increase in information may improve the relationship between efference copy and sensory feedback, aiding an individual in detecting changes when actively changing viewpoints.

1.4 Summary

This experiment was performed to further investigate the influence of efference copy in real world settings, particularly detecting changes in scene. A similar method and apparatus to one used in the Simons and Wang (1998) experiment on perceiving real-world viewpoint changes was developed. Several modifications were performed to focus on the contributions of these signals. A comparison of task between groups of high and low schizotypal individuals was designed to create conditions for evaluating the effect of efference copy alignment to afferent signal, in performing spatial updating tasks. We hypothesize that: if a misalignment between efference copy and sensory feedback is substantial enough, it could influence accuracy in detecting changes

in spatial updating tasks, particularly when body-based information is used. Individuals with a presumable dysfunction of efference copy (High schizotypal traits) are expected to perform less accurately in these tasks due to impairment.

It would be expected that both groups of participants (High and Low) could perform similarly in conditions in which the view of the scene stays the same (rotated condition). This scenario serves as a control condition because the differences in scene layout could be solved by purely visual means and would not necessarily be influenced by misalignment of efference copy. However, if the relationship (alignment) between the process of efference copy and sensory feedback functions as the underlying mechanism that produces an accurate response, we would expect to see lower accuracy in high schizotypal individuals, especially in tasks that rely on body-based information.

Alternatively, if efference copy misalignment to sensory feedback is not critical to detecting changes in scene during spatial updating, both high and low schizotypal participants are expected to report similar accuracy in recognizing display changes in both same view and different view conditions.

CHAPTER II

METHOD

2.1 Participants

Participants were undergraduate students at Cleveland State University and recruited through the SONA psychology research participation system. All were asked to sign consent forms per IRB regulations previous to participating in the experiment. A total of 25 participants were tested, 18 female, 7 male ranging from age 18-23. One female participant claimed to have nystagmus, a condition that involves dysfunction of eye movement control (symptoms of which were observed). It was not known if this would affect results, however as a precaution this participant's data were excluded. The results reported in this study were from the remaining 24.

2.2 Materials

The structure of the apparatus used was a 48" tabletop painted black, resting on four furniture sliders. To facilitate rotation a dowel handle was

inserted into the vertical table edge. Nine black 1.5 inch "hook" side Velcro strips were attached to the tabletop in randomly chosen positions, numbered 1-9. Five familiar objects (piggy bank, ball, scrub brush, cylinder, tissue box) were used. All items had black 1.5 inch "loop" side Velcro strips attached to the bottom. Three chairs, placed at specified locations, one marked with an "X" as the starting point, one marked with the number 1 on it and the other marked with a number 2 were used as viewpoints. The outer walls of the room were draped in a black, continuous curtain. A circular portion of the room was curtained to conceal the tabletop. A single torch lamp was used for illumination. All equipment placement and measurements were written in fluorescent marker on the black carpeting of the room. A small hand held black light was used to navigate through the procedure of the experiment. A computer was available to access the on-line adapted PAS.

2.3 Procedure

Each individual participated in 40 total trials, 20 from position one and 20 from position two. The tabletop was stationed on the floor, inside the circular curtain, used to occlude the participant's view of the tabletop and items. The starting position of the handle on the table was directly across (180°) from the center start position (chair marked "X"). Two chairs were placed in predetermined viewing points (designated as 1 and 2). These viewpoints were positioned 47°, respectively to the left and right of a predetermined center point (chair marked with "X"). Participants began each viewing from the center position (chair marked with "X") as depicted in Figure 2.

Figure 2. Photo of viewpoints.

The overhead lights were turned off and the torch lamp was on. The position of the lamp was 12-15' behind the center start position, creating enough illumination for the participant to identify the items on the tabletop

Once seated in the starting position, the participants were informed they would be viewing a scene with five items on a tabletop. They were told that one of the items would be moved to a new location on the table and that they would be asked to identify the item that was moved. They were also informed that in addition to the item moving, that the tabletop could be rotated and they would be informed at the beginning of each trial if it would be a rotation condition or not with the words "This will be a rotation condition" or "This will not be a rotation condition" each time. The scene on the tabletop was revealed to the participant for 3s as depicted in Figure 3.

Figure 3. Photo of view from start point.

The scene was created with the five items (tissue box, ball, piggy bank, brush, cylinder) attached to five randomly chosen Velcro positions within the nine predetermined Velcro locations. The arrangement of items on the tabletop for each of the trials was randomized, creating forty unique tableaus. At the conclusion of 3s, the experimenter closed the curtain, directing the participant to move to either position one or position two. The participant got up from the chair and walked to the designated viewpoint, and then sat down in the chair at that viewpoint.

While the participant was moving to the designated viewpoint, the experimenter went behind the curtain to move one of the five items to a new location. Throughout the forty trials each item was moved 8 times, based on a randomized schedule.

13
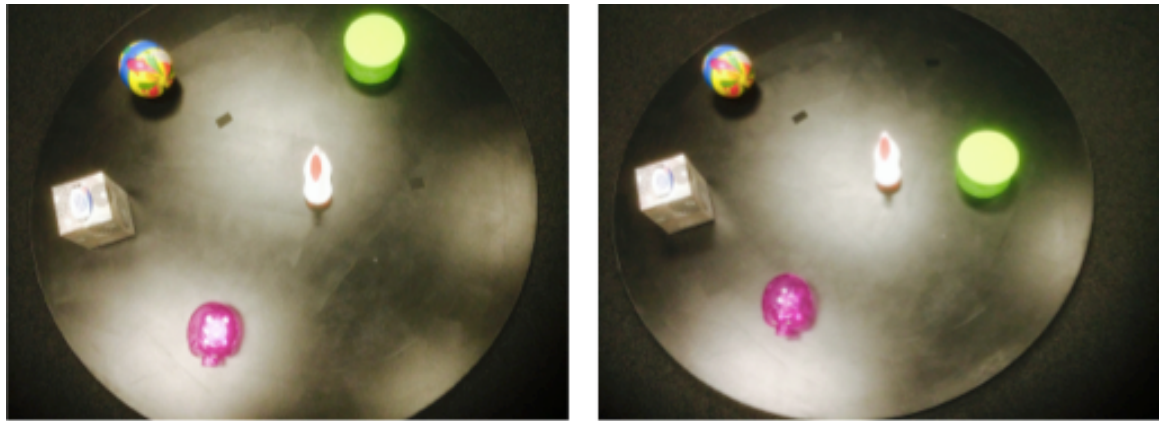
Figure 4. Scene comparison photos, photo on right shows the cylinder was moved to a new location.

This item change is depicted in Figure 4. Note that the cylinder was the item designated to move during occlusion and on viewing from new position (1 or 2), the correct answer to "which item has moved?" would be "cylinder".

One half of the views from each viewpoint (10 of viewpoint one and 10 of viewpoint two) were designated as rotation, the tabletop rotated 47° opposite the direction that the participant moved. Rotation was achieved by moving the handle on the table from its starting position (180° from chair "X") to a point marked on the floor in fluorescent paint (only visible by black-light), 47° to either the right or left in relationship to participant movement.

This "rotation" created a condition where the items in the scene were perceived to be in the same positions, with the exception of the item that had been moved (similar to Figure 4). The remaining views (10 in viewpoint one and 10 in viewpoint two) were "non-rotation" conditions. The table remained aligned with the center point mark while the participant moved to the

designated viewpoint creating a new perspective on the positions of the items, as well as detecting the item that was moved. The order of rotation and non-rotation views, were randomly assigned throughout the 40 trials. Figure 5 is a diagram of the layout of the experiment.
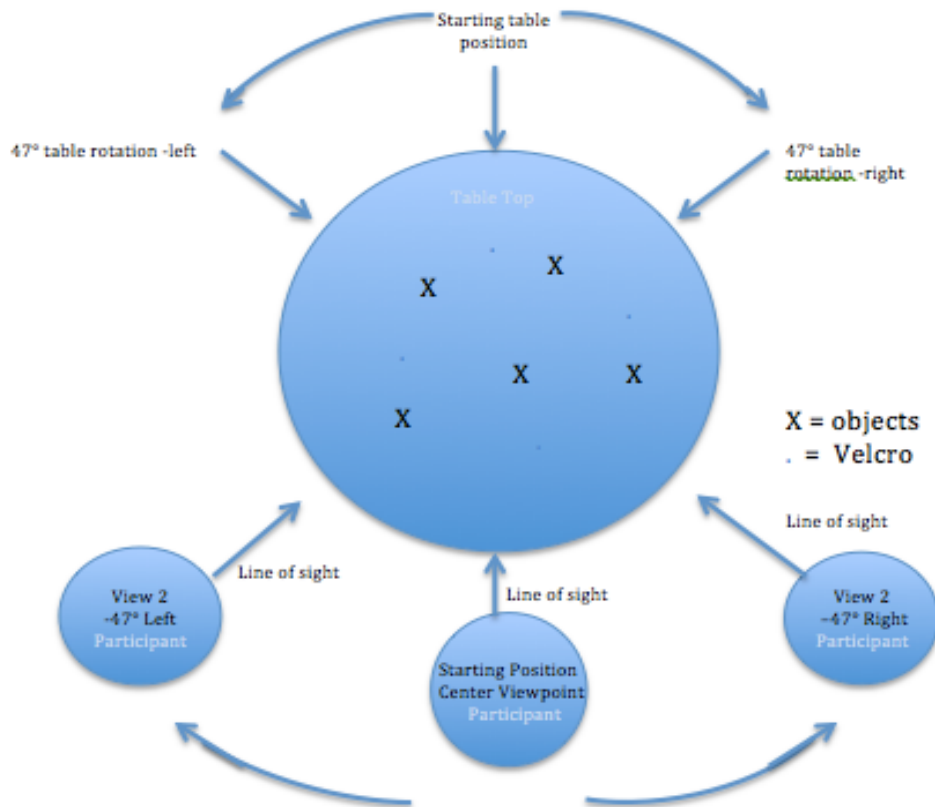

Figure 5. Schematic diagram of experimental setup and manipulations.

Answers were recorded as either correct or not. When all of the trials were completed the participant was asked to take an on-line PAS questionnaire. Once this was completed they were finished with their participation in the experiment.

2.4 Measurement

The dependent variable is the accuracy score for change detection.

Two independent variables included table rotation described as rotation (R) and no-rotation (NR), and the level of schizotypal trait, determined as high (H) or low (L) through PAS testing. The H group had PAS scores ranging between 7-20 and the L group had PAS scores ranging between 0-5.

A 2X2 mixed ANOVA was conducted. Table rotation was the within subjects variable, in two levels, rotation and non-rotation. Level of schizotypal traits was the between subjects variable with two levels, high and low. The main-effects of independent variables, high and low schizotypal groups and viewing condition (rotation and non-rotation) on the dependent variable (accuracy score) were reviewed for significance. Interaction between high and low groups and viewing condition were also assessed for significance.

CHAPTER III

RESULTS

PAS scores were calculated for 24 participants (M = 7.1, SD = 6.03). Participants were divided into high and low groups by using the median PAS score of 6. The high group consisted of 10 participants with scores ranging from 7-20 (M = 13.1, SD = 4.5), the low group consisted of 14 participants with scores ranging from 0-5 (M = 2.9, SD = 1.7). It was reasonable to have the division between the groups at the PAS score of 6, given the normative data in which the mean PAS score was approximately 6.7 (see section 1.2 above).

Overall performance score for combined groups in each rotation condition was calculated. Total mean score for rotation condition was .72, total mean score for non-rotation condition was .82. Significance was found in the main effect between rotation conditions ($F(1,22)$ = 11.60, p = .003, η_p^2 = .345). The mean accuracy score for the low group was .79; the mean accuracy score for the high group was .75. These results were not significantly different ($F(1,22)$ = .781, p = .386, η_p^2 = .034).

Mean accuracy score for rotation condition in the low schizotypal group was .75 and the high group was .69. The mean accuracy score for non-rotation in the low schizotypal group was .83 and the high group was .82. Interaction between these variables was not significant ($F(1,22) = .835$, $p = .371$, $\eta_p^2 = .037$). See Figure 6.
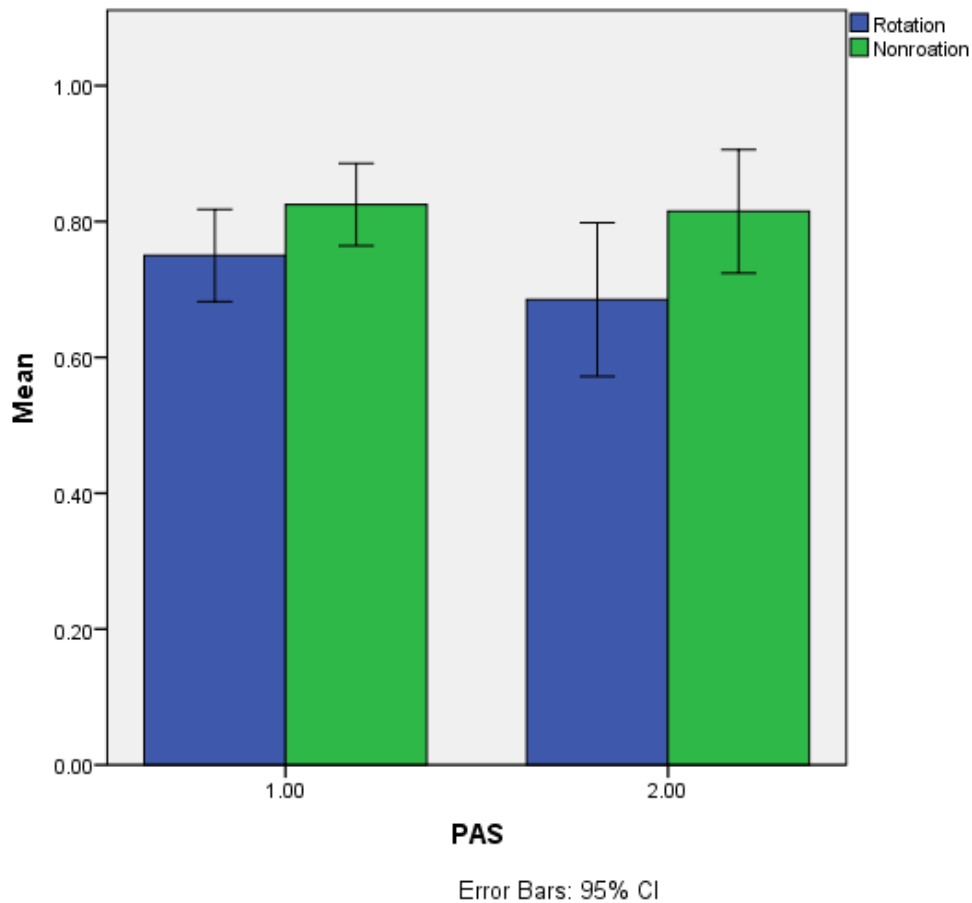
Figure 6. Means of accuracy scores for High and Low groups. Vertical axis shows the mean accuracy score in percentage of correct answers. Horizontal axis shows the two PAS groups (1=low, 2=High), it also indicates performance in each

condition for each group. Blue represents the rotation or "same view" trials

performance, and green represents the no rotation or "different view" trials.

Error bars indicate 95% confidence intervals.

CHAPTER IV

DISCUSSION

This study was designed to investigate the possible influences of dysfunctional efference copy pathway and it's resulting misalignment to afferent signal on spatial updating, specifically when detection of changes in scene is required.

To create an environment in which this condition could be examined, individuals that were determined to have a possible dysfunction in efference copy processing were identified and tested. All participants participated in a change detection tasks that employed multiple spatial updating processes (moving from one viewpoint to another).

The first outcome that merits discussion is the significant difference in the cumulative accuracy score between viewing conditions, same view (M=. 72) and different view, (M=. 82) conditions. This result is in agreement with the results from Simons and Wang's (1998) experiment in which participants were

significantly more accurate in detecting changes in scene when they moved to a new viewpoint and had a new view of the scene compared to when they received the identical view of the scene. By allowing the participant to enhance their change detection through the use of body-based information, this finding indicates that non-visual mechanisms contributed to detecting the changed item. The current study attempted to explore the possibility that one of those mechanisms could be efference copy's relationship (aligned or misaligned) to afferent signal.

More importantly, both high and low groups performed similarly not only in same view trials (i.e. rotation) but also in different view trials (i.e. non-rotation). The similar performance in the rotation trials was expected because in these trials participants could have relied on visual processes that would not be impaired by misalignment of efference copy to afferent signal. However, performance in the non-rotation trials was predicted to be different between high and low schizotypal participants due to presumed misalignment between efference copy and afferent signal in high schizotypal participants. One explanation for similar performance between groups could be attributed to possible compensation in contributing mechanisms in the sensory feedback pathway and that alone is sufficient to accurately recognize changes in active display scenarios.

Another, potentially influencing factor was that there was not a large enough difference between the high and low schizotypal groups in terms of their schizotypal traits. The number of participants (24) was typical for studies of this

nature, but the distribution of PAS scores did not allow for distinct differences between groups. The highest low score was 5 and the lowest high score was 7, this lack of disparity could affect the degree of influence of dysfunctional efference copy. It is suggested that any further studies in this realm of spatial updating make concerted effort to pre-screen participants to create more distinct high and low groups to compare.

This experiment was devised to expand knowledge in defining the role of efference copy alignment to afferent signal in spatial perception, particularly in scenarios that more accurately reflect real life. It was initially inspired by previous research (Rohde & Yamamoto, 2013) in which a noticeable difference between high and low schizotypal groups in walking and imagined walking tasks had been found. Non-visual walking tasks rely heavily on body-based information for accuracy, and thus it is likely that high schizotypal individuals are more susceptible to the effects of dysfunctional efference copy in these tasks. The task for this study was less reliant on body-based information, and utilized other sensory mechanisms (i.e. visual). This made it more representative of scenarios we are faced with everyday, however it also may have made it less sensitive to individuals with efference copy that may not align with afferent signal. It is possible that, when able to draw on multiple mechanisms to solve spatial perception tasks, individuals with dysfunction in efference copy automatically divert problem solving to other functioning mechanisms that compensate for any discrepancies in efference copy. This could be a real and logical explanation for similar performance between groups.

22

It is clear that more information is needed to expand our understanding of the role of efference copy alignment to afferent signal, in spatial perception tasks. The results of this study and Rohde and Yamamoto (2013) help to provide a foundation for defining some parameters of efference copy's role in spatial perception. It is recommended that future research focuses on comparing performance of more defined high and low schizotypal groups of participants. Additionally, testing participants on tasks that rely on or isolate different mechanisms used for spatial perception will help to circumscribe the role of efference copy in human navigation.

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