Chapter 1: Introduction

Title of Study

{The eye looks but the brain sees}
Designing an interactive learning experience on Visual Perceptual Problems for Pre-school children

The Problem

The purpose of the study is to examine current methods used to train visual perceptual skills in pre-school children (aged 4-6), so as to avoid *Visual Processing Disorder*. The aim of the project is to develop an interactive learning experience by (a) merging two-dimensional designs (typography, page layout and graphic visualisation techniques) with fun-engaging tactile elements, and (b) bringing narrative into the series of visual perceptual exercises developed as a result of (a).

Visual Processing Disorder otherwise known as Visual Perceptual Disorder, refers to perceptual problems such as visual discrimination, visual memory, visual sequential memory, visual spatial relationships, visual figure-ground, visual form constancy and visual closure (Jenkinson, Hyde and Ahmad, 2008).

Research Question:
Can graphic design enhance the learning experience of visual perceptual skills for pre-school children?

- How can visual perceptual exercises be made more interactive and fun?
- What kinds of narrative can make visual perceptual exercises more exciting and engaging?

Keywords:
Visual perception, Graphic Design, Interactivity, Narratives, Pre-school children (age 4-6)

Context

Occupational Therapy is the field of expertise that directly deals with Children Learning Disabilities such as Visual Processing Disorder. It seeks to enhance a person's participation in daily activities by designing environments to help improve performance or by restorative activities to improve mental and physical health (Law, 2014). Besides, *Behavioural Optometry* holds the belief that vision can be acquired with training and focuses on preventing visionary problems while enhancing human's visual performance {Hickman, 2005). Furthermore, *Art Therapy* is also employed to help children with language, emotional and neurological challenges in better communication (Notbohm, 2008).

As more research became invested in dealing with children's learning disabilities, games and activities, both 2-dimensional and 3-dimensional, were designed over the years and are now made available to parents and teachers as educational resources through publishing companies such as Ann Arbor and Bright Minds.

Upon observations however, these is a lack of combined 2-dimensional and 3-dimensional experiences that could potentially enhance the interest in learning. Workbooks are lacking interactive elements and hands-on experience that could stimulate more playful learning, which better creates meaning and understanding in children with emotional problems and developmental delays (Singer, 2006).

My project aims to make learning interactive, interesting and encouraging for these children who are slower in educational progress. It is also intended for the improvement and improvisation of existing strategies, employing knowledge in graphic design and playful approaches, in hope that learning can become even more fun, innovative and productive.

Methods

The following steps outline the methodology employed in the research. The first three steps (A, B and C) will be performed concurrently prior to the last step (D).

A: Review the implications, teaching strategies and activities present in dealing with visual perceptual problems in the field of Occupational Therapy and Behavioural Optometry Therapy

B: Study existing activities (2-D and 3-D) and identify fun and productive activities that has room for improvement and improvisation

C: Examine narratives and existing graphic styles that appeals to pre-school children through popular storybooks

D: Develop a series of activity books, improvised and improved with the use of graphic design and interactivity

Outcomes

The study deals with the limitations of existing learning activities for *Visual Processing Disorders* in engaging fun and innovative learning. It demonstrates how graphic design, in the form of typography, page layout and graphic visualisation, and further interactivity of the activities, can enhance the learning interest and experience in these children. It creates relevance of Visual Communication in bridging the art and science of learning, especially in the area of learning visually.

Limitations

Due to time constraints, the study will only address selected problems with regards to visual discrimination, visual memory, visual sequential memory, visual spatial relationships, visual figure-ground, visual form constancy and visual closure. Also, solutions will be based on present effective models for greater success rate and preliminary testing to be performed on the audience may not be complete.

Definition of Terms

Visual Discrimination:	The capacity to indicate the similarities and differences in relation to shape, colour, size and other forms of detail.
Visual Memory:	The capacity to store and recollect visual information in order to make relations to the past and present
Visual Spatial Relationship:	The interpretation of objects in space in relation to distance, size and orientation
Visual Figure-ground:	The skill to differentiate objects from its distractive background
Visual Form Constancy:	The capacity to relate shapes of similar form despite differences in size, position, direction, orientation and distance
Visual Closure:	The capacity to imagine a complete object despite some missing details
Typography:	The design of letters, its arrangement and appearance
Graphic Visualisation:	Techniques involving the organisation and projection of information into better communicated visual diagrams
Page Layout:	The composition and interaction of information on a page
Interactivity:	A characteristic of activities that stimulates response to stimuli and that encourages fun and playfulness

Chapter 2: State of Art Review

The following review provides some insights on the importance of vision in children's life and education. It states the assumption of visual acuity providing sufficient needs for good visual performance and turns around to validate the need for visual perceptual skills to further boost the functional potential of vision. The discussions also include the assessment of suitable target audience and present methods employed to treat this problem, concluding with other forms of knowledge related to visual perception and potentially beneficial for the training of visual perception.

The Role of Vision:

Vision is the dominant sense that guides us around in the world. It allows us to receive information from our environment and accounts for our daily experience. Moreover, studies show the importance of vision as guiding movement in a newborn's development (Getman 1985). However present in this society, are some misconceptions that if one has perfect vision, "the ultimate interpretations of that clarity would automatically follow, and nothing more than that could be achieve"(Getman 1985).

This belief is in fact an outdated concept that needs to be addressed. For maximized visual performance, one is required to enhance his visual interpretations and skills. This is proven by the use of glasses, in which visual acuity is corrected to allow clarity in sight . Yet, the varying visual performance of individuals with corrected eyesight displayed the insufficiency of just visual acuity (Getman 1985). This issue could be better clarified by the notion of Visual Processing, in which the eye looks but the brain sees. The definitions adopted from Oxford American Dictionary explained the differences between 'looking' and 'seeing'. 'Look' is defined as "[directing] one's gaze toward someone or something or in a specified direction" while 'see' refers to "[perceiving] with the eyes, [to] discern or deduce mentally after reflection or from information". This illustrates the two-step procedure in vision processing, otherwise known as visual perception, which requires the brain to interpret all visual stimuli received from the eyes.

Visual Perception Defined:

There is more to Visual Perception that needs to be known. Visual perception is described as the process of identifying, internalizing and coordinating visual stimuli received through the eyes, allowing consciousness and understanding of our surroundings (Priyadarshi, Goswami et al. 2012). This appreciation of information then enables us to construct meanings about our lives. (Williams, Northstone et al. 2011) provided some examples that are labeled under visual perceptual abilities, that is, "visual attention (the ability to highlight specific features or places within the visual field); visual search (the ability to move the eyes within a scene to detect relevant targets); perceptual grouping (the ability to combine components of a scene into a meaningful whole)" etc. Also, (Brown, Rodger et al. 2003) adopts Gardner's definitions of the various visual perceptual sub-skills to make clear the factors being evaluated in a Test of Visual Perceptual Skills. These sub-skills are namely (1) visual discrimination, (2) visual memory, (3) visual-spatial relationships, (4) visual form constancy, (5) visual sequential memory, (6) visual figure-ground and (7) visual closure."

The Importance of Visual Perception:

Having known what Visual Perceptual is, it is also important to highlight its significance and effects. Visual processing affects reading, spelling, mathematics and visual-motor integration, thus disrupting daily activities such as work, play and learning (Brown, Rodger et al. 2003). (Priyadarshi, Goswami et al. 2012) in investigating the correlation between reading and perceptual skills, cites (Gardner 1985) in dividing perception into "discrimination (judgments to define subtle differences), processing (ability to sequence meaningful language), memory (immediate recall), and /or comprehension (interpretation)". They evaluated the correlation between visual auditory perceptual skills and reading abilities. 160 typically developing children aged 6 to 13 years old were recruited from a Hindi and an English school. 20 students from each grade were assessed on their reading skills and perceptual abilities. Reading was evaluated based the Early Reading Skills by Rae & Potter (1973), auditory perceptual abilities evaluated in 3 subsections (auditory identification level, auditory recall level and auditory discrimination, and visual perceptual abilities evaluated in 2 levels (level 1: the ability to discriminate differences in forms, size, shape and orientation; level 2: ability to discriminate alphabets). Data collected

shows that perceptual learning is simultaneous with reading abilities and in terms of visual perception, visual discrimination and visual memory are two core skills related to early reading skills. It is inferred that a perceptual problem may hamper the progress in learning how to read when the children are young at lower primary levels. However, the interrelations between these 2 skills gets more complex at upper levels and perceptual deficits may be compensated by other reading related skills.

(Getman 1985) in his commentary, indicated the dominance of visual activities in both work and play, requiring visual skills in both classroom projects and personal hobbies. (Williams, Northstone et al. 2011) in their study, explores visual perceptual abilities in normal children. Information was collected from 4512 subjects in an ongoing birth cohort study. In a survey, mothers of normal children aged 13 years old were asked to recall for visual perceptual problems when their children were younger. These data was evaluated with the children's present grades in their school's reading and mathematics examinations to observe it there is any correlations between visual perceptual inabilities with future learning capabilities in reading and mathematics. From the results gathered, it was found that children with difficulties interpreting cluttered scenes when they were younger had more difficulties in reading and mathematics, while children with difficulties in guidance of movement performed poorer for mathematics. There was no connection made between facial recognition with reading. Notably, the functions of dorsal stream and ventral stream (visual processing networks) are responsible for better concentration, visual-motor integration and word recognition, attributes that affect the quality of reading and doing mathematics. Therefore, it has been deduced that poorer performance in reading and mathematics could be a result of lower visual perceptual abilities. The research presented the availability of simple strategies to deal with visual perceptual problems, and encouraged future readers to look into producing appropriate and affordable assessment tools.

Williams and her team's thesis ties in with that of (Pieters, Desoete et al. 2012), which investigated the connection between Mathematical Learning Disabilities (MLD) with visual perception, motor skills and visual-motor integration. Results show that visual perception was associated with procedural calculation (pattern/ formula-related calculations), motor skills was associated to number fact retrieval (fine motor coordination/ aiming, catching, balance), while visual-motor integration was associated to both procedural calculation and number fact retrieval. Hence it has been deduced that some, but not all children with MLD perform poorer in areas of visual perception, visual-motor integration and especially in motor skills. In other parts of the article, they referred to Piaget's observation that the slightest act of sorting and counting requires an accurate mental concept of numbers to differentiate between 6 and 9 for example. It is also highlighted that children tend to avoid tasks which they perform badly, pointing to a possibility of visual perceptual skills and learning being further delayed if not addressed.

(Yu 2012) having a different interpretation of Visual Interpretation, describes visual perception as a process of internalizing and organizing information. By studying children's interaction and understanding of picture books, the author investigates the way children acquire and constructs meaning and the relevance of culture and mental models in this process of meaning-construction. Using the two books Kitten's First Full Moon and the Red Book, the author answers to the questions (1) what levels of visual perception do three-to-five year old children demonstrate in interpreting images of picture books, (2) what are the factors in visual perception that contribute to three-to-five year old children's understanding and interpretation of images in a picture book, (c) what factors influence levels of visual perception. Notably, before picture books can be used as learning resources to help children "develop experience, concepts, knowledge and [understand] symbols in representing their views", the children needs appropriate visual perceptual skills that gives them accuracy and precision in the process of identification and differentiation, ensuring that meaning made through visual associations are drawn sensibly and relevantly.

Target Audience:

The above review provided relevance to visual perceptual skills. Yet, it is necessary to specify a suitable age group in which interventions have a higher chance of success. We observe that most studies on visual perception target preschool children to evaluate effectively (Yu 2012, Chen, Lin et al. 2013). Though (Priyadarshi, Goswami et al. 2012) targeted a wider age group of 6 to 13 years old, it is highlighted that while perceptual development is homogenous with reading abilities, it is a skill best acquired at lower primary levels of 6 to 9 years old. (Williams, Northstone et al. 2011) pointed out in his study results that children aged 13

years old with difficulties in reading and mathematics had more trouble in visual perceptual skills such as interpreting cluttered scenes when they were younger. Thus, it shows that visual perceptual skills are best acquired at an age younger than 13 years old, and that there is a measurable statistics that show better visual perceptual skills contributing to better reading and mathematics at a later stage in learning.

Past and Present Approaches:

Fortunately, there is a prevalence of materials available to deal with visual perceptual problems. As described in the articles by (Chen, Lin et al. 2013) and (Williams, Northstone et al. 2011), these skills can be enhanced through practice (Kramer & Hinojosa 2010). Exercises such as Ann Arbor Perceptual Series and teaching materials like Visual Thinking Cards (Seymour 1983) are available in the market.

The most prominent and debatable approach to date is vision training. The American Academy of Pediatrics published this journal (Pediatrics 2009) to address the issue of reading, dyslexia and the validity in the use of vision therapy to improve reading abilities. Reading difficulties impedes children's learning and can affect them emotionally and psychologically. Besides highlighting the characteristics of dyslexia, the article rejects vision therapy as a method to improve reading, as visual processes were disregarded as causes of reading difficulties. (Getman 1985) however, says otherwise. It claims that optometric vision training has benefited "thousands of children who have been victims of visual problems", rectifying their impeded school performance and boosting their intellectual potential. Special lenses and prisms in vision training work by altering visual signals, and in that train the user to "discriminate and interpret" the differences against the normal visual environment when tools were not used. Even though vision training does not impact directly on reading, it is improved in the absence of visual stress as eradicated by vision therapy. Besides, he compares the activity of wine-tasting to that of visual perception, urging that visual sensibility just as the sensitivity to differentiate the subtle contrast in taste in wine-tasting is key to the full appreciation of images. What you do not see, you do not know, just like what is often quoted, "He who does not read is no better informed than he who cannot read." An image is not appreciated if one does not realize its hidden beauty in the details. Besides, the available assessment tools such as Test of Visual Perceptual Skills (TVPS) were evaluated and mixed reactions has been derived. Some such as (Brown, Rodger et al. 2003) condemned the lack of factor analysis, which disregarded the common features of the seven visual perceptual sub-skills, hence leaving the test user too much freedom in interpreting the results, while others (Chen, Lin et al. 2013) favored and supported, claiming its advantage in "good internal consistency and good criterion-related validity".

Given that there is so much to resolve, visual communicators and designers could play a role in communicating and providing for the need of these visual skills for greater visual authenticity, such that the audience can grow to become more perceptive, appreciative and responsive to their environment. From the above discussion, it points out a possibility that approaches such as vision therapy may not be well communicated to the consumers concerned and that qualitative data such as user experience may be required to account for the effectiveness of a design.

Other inspirations:

Various studies have showered inspirations in my design direction and goals. Since it is suggested that there may be larger implications of visual perceptual skills on other areas that are not purely visual (Pieters, Desoete et al. 2012), the design research on visual perception could reverse its direction in studying on mathematical puzzles, of which it affects. The channel of mathematics could kindle relevant ideas for visual perceptual training and offer avenues for both language and skills to be mastered at the same time. It is ultimately beneficial to draw observations from studying the actual domain of puzzles commonly encountered by children. This form of integration could apply to converging exercises for visual perceptual sub-skills as well. The overlapping characteristics of these visual perceptual sub-skills has provided problems in assessments when evaluated separately (Brown, Rodger et al. 2003), revealing the multiplicity and non-mutual exclusive nature of activities. Hence, it would make sense to integrate these exercises for visual perceptual skills to be collectively acquired, and for a more cohesive learning experience to be achieved.

In addition, (Chen, Lin et al. 2013) in their study, investigated the effects of multimedia and group therapy in visual perceptual training for preschool children with developmental delay. Using a pretest-posttest double-

blind approach, 64 children aged 4 to 6 years old were divided into 4 groups: multimedia visual perceptual group training, multimedia visual perceptual individual training, paper visual perceptual group training and a control group. The first 3 groups went through 40-minute visual training each week for a duration of 14 weeks before they were re-evaluated with The Test of Visual Perceptual Skills (3rd edition), an assessment tool for visual perceptual skills. Data collected displayed significant improvements for the first 3 groups that accomplished the 14-week training, with the highest success observed in the multimedia group training, followed by the multimedia individual training. Besides showing that the multimedia medium and group sessions are more beneficial, the authors also cited Visser and Keller (1990) in their three strategies in achieving learner's attention, that is by sensory attraction, problem exploration and maintenance by changes. The experiments had employed animated feedback, highlights and colorful frames to draw the children's attention.

Other studies such as Exploring Visual Perception and Children's Interpretation of Picture Books (Yu 2012) for instance, brings to light the role of visual narrative in children's learning. Visual narrative could be factored in as part of the design approach to enable more fun-engagement and interaction in children's learning of visual perceptual skills. Valued characteristics of picture books derived from the research, namely "total effect of words and pictures, childlike qualities, communication of visual message, story/ meaning related to illustrations, and model of narrative language", can be taken into consideration in the design process. The article of Visual size perception and haptic calibration during development (Gori, Giuliana et al. 2012) investigates the effects of touch on sight to gauge the impact of haptic calibration of participant's visual size perception. The results suggest that "in young children, touch calibrates visual size perception and vision calibrates haptic orientation perception", explaining the observations of some children's books having tactile elements, as it is now justified that it plays a role on visual perception. It sheds light on how interactivity can be productive in my project, in that the present designs were observed to have yet factored in tactile qualities to aid in visual size perception.

Conclusion:

The above discussions seek to establish the significance of visual perception and present available methodologies and approaches employed in the assessments and training of visual perception. It serves as a platform to inform and inspire the designer in formulating appropriate ways to answer to the research question of whether graphic design makes the learning experience on Visual Processing Disorder more interactive for Pre-school children.

Chapter 3: Methodology

Methodology

Upon discussing the significance of visual perceptual skills in the previous chapter, my project aims to study present visual perceptual exercises and infuse them with narrative and interactivity, so as to enhance the exercises with further fun-engaging quality. My research question of how graphic design can enhance the learning experience of visual perceptual skills for pre-school children, will be addressed by focusing on 3 aspects: visual perceptual skills, interactivity and narrative. The methodology will be divided into 2 phases. The first concentrates on information gathering through coding, memos and visual research. The second phase looks into design and execution process that requires memos, material research and visual research.

Research question:

Can graphic design enhance the learning experience of visual perceptual skills for pre-school children?

- How can visual perceptual exercises be made more interactive and fun?
- What kinds of narrative can make visual perceptual exercises more exciting and engaging?

- Phase 1 -

Methodology of Study

- **Coding**
  Coding refers to the labeling or assigning of general keywords to data. Such organization of data facilitates the process of classifying, identifying and retrieving data.

- **Memo**
  Memos are personal notes, opinions or ideas about research progress and on the research subject itself. There are 2 types of memo (Esterberg, 2002) ; procedural memos monitors and keep research progress up to date, while analytic memos involves analyzing and interpreting the data itself.
- **Visual Research**
  Visual research in this context, refers to researcher found visual data. Visual data are collected from secondary sources to be analyzed in the approach of photo-analysis and content analysis.

Instrumentation

- **Review**
  Information gathered will be organized, compiled and evaluated according to their relevance, feasibility and practicality. Scales and criteria will be drawn up for rating and further evaluation.
- **Observation**
  Insights will be noted down from non-participatory observations on children activities.
- **Mapping**
  Mind-maps will be used to connect ideas from various platforms. Information charts/diagrams will be employed for summarizing, categorizing and drawing associations between ideas.

Data Collection Methods

1. Visual perceptual exercises in puzzle books, electronic games, card games and board games will be gathered as secondary resources for study.
2. Popular narratives will be compiled from existing library recommendations, journals and articles.
3. Interactive and interesting elements will be collected from innovation and lifestyle magazines, DIY websites, product design-related/ material science books, journals and articles.
4. Observations will be conducted at the main sites of children activities: libraries, pre-school classrooms playgrounds, science/discovery ceter. Data will be collected via video recording and field notes.

Data Analysis

1. **Visual Perceptual Exercises**

- Upon compilation, visual perceptual exercises will be coded with the visual perceptual sub-skills they ascribe to, the nature of operation, the composition, the interactivity elements and level of difficulty.
- Following coding, these exercises will be categorized into visual mood boards where visual research, in the form of content analysis will be carried out, along with annotations of analytic memos.

2. **Narrative**

- Well-liked stories will be coded descriptively and in patterns based on the genres, the plot and codes of values. Visual research in the form of content analysis will be carried out for aspects such as illustration style, reading difficulty, number of words per page.
- Memos will be jot down to interpret and rate accordingly the "total effect of words and pictures, childlike qualities, communication of visual message, story/meaning related to illustrations, and model of narrative language"(Yu 2012).
- Subsequently, data will be organized into visual mood boards for review and brainstorming later.

3. **Interactivity**

- Interactive elements and mechanisms will be coded based on aspects such as the medium characteristics, material accessibility, the nature of operation, ease of use and user experience.
- After categorizing these data into visual mood boards, analytic memos will be noted down based on pre-constructed schemes such as Visser and Keller's (1990) strategies in achieving learner's attention, that is by sensory attraction, problem exploration and maintenance by changes (Chen, Lin et al. 2013).

4. **Children activities**

- Field notes will first be compiled with observations from video recordings after visual research in the photo-analysis approach. After interpretation and reflection, the data will be coded for patterns of movement that display certain child behavior or reactions towards different stimuli.
- Data is further classified into codes to signify general meanings and broader interpretations.

With these data generated from coding, visual research and memo annotations, larger visual mood boards and visual/word mind maps will be constructed. These mind maps and mood boards encourage more connection between seemingly separate ideas, to stimulate creativity and effective brainstorming. Data may then be grouped into smaller groups to be examined and re-think about, forming information charts and diagrams that show further associations. An important correlation would be between activity/idea and consequences/purpose (e.g. correlation between narrative construction and meaning derivation is established in sand therapy, where sand structures are built along with stories, displaying a hidden desire or emotion that is meaningful to the person). These information charts of several grouped ideas are then placed back to the general picture in the form of a map. These final steps of data analysis which are concurrent with design execution, will constantly be repeated till mature design outcomes are generated. By broadening and narrowing, zooming in and out from data, greater inspirations are gathered so that research can continue and ideas can be continuously added to the collective information system. These data will constitute ongoing procedural memos to demonstrate the research and design stages of my project.

- Phase 2 –

Methodologies for phase 2 will be conducted after major design outcomes have been produced.

Methodology of Study

- **Visual Research**
  Visual research in this context, refers to researcher-created visual data. Visual data are created to generate responses from pre-school children, that is, respondent-created data.
- **Memo**
  Memos are personal notes, opinions or ideas about the visual data outcomes. Analytic memos discuss about the effectiveness of researcher-created visual data, while procedural memos guide the process.
- **Analytic Induction**
  Analytic induction is an approach to hypothesize events that are of cause-and-effect relationships and determine its validity from the study of one or more cases.

Instrumentation

- **Review**
  Information gathered will be organized, compiled and evaluated according to their relevance, feasibility and practicality. Scales and criteria will be drawn up for rating and further evaluation.
- **Survey**
  Several questions will be prepared for both children and teachers to consolidate feedback for improvements on researcher-created designs.
- **Observation**
  Insights will be noted down from non-participatory observations of children and teachers' response to the researcher-created designs.

Data Collection Methods

1. Researcher-generated designs are presented to respondents (pre-school children) and assessed based on a criteria to be drawn up for evaluation. These aspects include level of difficulty in puzzles, level of difficulty in understanding narrative, level of interactivity, level of interest and other comments.
2. Short surveys will be conducted in the form of feedback forms. Feedback forms require children to rate the aspects discussed above. To encourage response, incentives such as designed certificates/ stickers/badges will be given to children as acknowledgement for the completion of the course. In addition to the aspects above, teachers will be asked for general opinions and views on the effectiveness of the designs and advices on how improvements can be made as well.
3. Observations will be conducted as well, when the children are responding to the designs. As video recordings are strictly banned in pre-schools, field notes will remain the main source of data collection.

Data Analysis

1. Data collected from the sessions of design trials will be compiled into information charts. Content analysis will be performed on visual perceptual exercises completed by children.
2. Content analysis will be conducted on feedback forms/surveys as well.
3. Data from observations will be compared to the analyzed data resulting from the first two steps. Analytic inductions will be carried out to identify similarities and differences in responses generated, in order to develop reasoning for certain success or failures. These explanations, along with feedback gathered from subjects, can further lead to areas that require improvements.

These analyzed data will be cross-referenced to previous literature reviews to validate certain conjectures. Inspirations gathered from the previous maps, mood boards and visual diagrams will be used to stimulate more ideas for improvement and refinement.

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