Title

Student Name, Major; Mentor Name, Department

Literature Review

Words and letters are part of our normal visual scene. A child, on average, is exposed to over 500,000 words during a typical school year. By adulthood, we are expert readers, having been exposed to millions of words. Often, the presence of words can control the accuracy and reaction times in many tasks. For example, in the Stroop effect, the meaning of the word interferes with the identification of the color of the word (e.g., RED, MacLeod, 1991). Another demonstration of efficient word recognition is the "word superiority effect," which is the quicker (Starrfelt, et al, 2013) and more accurate (Fine, 2001) identification of letters in real words than in non-words. Reading requires the integration of letter information into appropriate word units, and improves as the separation of letters decreases. However within clusters of letters, individual letter identification improves as the separation between letters increases. This is visual crowding, when neighboring elements increase the difficulty of identifying a target element (Levi, 2008; Pelli, 2008; Whitney, 2009). It has been suggested that crowding is the consequence of over-integration of features by the visual system, when features of a target object and those of nearby objects fall within the same integration area (Pelli Palomares and Majaj, 2004). For instance in Fig. 1, perceiving the top right "A" on the left is easier than on the right side of the fixation point in the center. The effects of crowding are stronger in peripheral vision than in the central visual field (Pelli, et al, 2004). Crowding is quantified by its magnitude (i.e., the relative decrease in letter identification accuracy between single and crowded letters), and by its spatial extent (i.e., the maximum distance between target and flank letters where the letter identification accuracy is still "crowded"). Visual crowding has been connected to reading speed (He, et al, 2013). Words can be also be crowded by other words (Yu, Akau, & Chung, 2012). Moreover, some aspects of developmental dyslexia have been attributed to the inappropriate integration of letter features that occurs in crowding (e.g., Martelli, et al, 2009).

Although crowding has been linked with reading, direct investigation of how the characteristics of crowding might change within the context of words is lacking in the literature. For example, while it seems that the magnitude of the crowding effect does vary within words and non-words, it is not yet clear whether the spatial extent of crowding is the same in words and non-words. Moreover, while the crowding effect has been reported to be stronger in children than in adults (Seong Taek, et al, 2010), very little is known about how higher-level integration, such as word formation, would affect crowding in typically-developing children.

Research Statement

This study will investigate the effect of word recognition on visual crowding within a developmental perspective. It has three main objectives: (1) To replicate and extend the word superiority effect in the crowding paradigm in adults (Fine, 2001), (2) To study visual crowding and word recognition in typically-developing children, and (3) To correlate the extent and magnitude of the crowding phenomenon with standardized measures of reading fluency and comprehension. We hope to test the possibility that letter recognition within the context of words and non-words would be related to reading abilities in children and in adults.

Fig. 1. Demonstration of crowding at texture formation due to averaging. If you fixate on the central cross, the letters on the left are identifiable as "A"s, whereas the letters on the right appear jumbled. The explanation for this phenomenon is that the average of four "A"s is an "A" but the average of "A"s and "B"s is a non-legal letter.

Project Goals and Training Objectives

- Continue research procedure and ethics training, specifically for working with children
- Continue practice in implementing standardized tests, and continue training in Matlab programming and finalize experimental design
- Recruit 15-20 adults (aged 18-25 years) and 15-20 typically-developing children (aged 7-9 years).
- Collect data in Matlab and analyze data using SPSS to test for significant results.

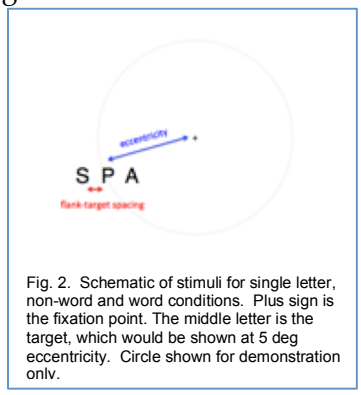

Fig. 2. Schematic of stimuli for single letter, non-word and word conditions. Plus sign is the fixation point. The middle letter is the target, which would be shown at 5 deg eccentricity. Circle shown for demonstration onlv.

Project Significance

Reading is one of the most crucial skills that can be learned during the developmental process. A better understanding of the links between crowding and reading, particularly in development, could lead to new tools in examining deficits in reading fluency. In turn, it could lead to future studies in perceptual learning with hopes to design training protocols to improve reading. Having a developmental approach allows insight

into how variability in reading skills and could provide clues into how the integration required in reading is related to the over-integration in the crowding phenomenon. This would be particularly helpful for individuals who have to learn to read with peripheral vision, such as those with strabismus (Sharma, et al, 2000) or macular degeneration (Chung, 2014).

Project Design and Methodology

Participants will be recruited from the participant pool at the University of South Carolina, and children will be recruited from the surrounding community. The proposed task is based from a pilot study in adults, which showed a correlation between reading abilities and visual crowding. Stimuli will be presented using MATLAB software on a MacMini attached to a 21- inch ELO monitor. In mixed conditions, 3-letter words, or 3-letter non-words will be presented for 100 ms on an imaginary circle with a radius of 5 deg. For the 3-letter arrays, the spacing will vary from 1, 1.5, 2, 2.5 and 3 deg. The letters will be 1 deg in width. Each block will have 80 trials, blocked by 5 letter spacing. There will be a control condition, in which only one letter is shown. Participants will be asked to identify the central letter by typing the letter and pressing the return key. Accuracy and reaction times will be noted. The difference in accuracy will be used to index the word superiority effect. The extent of crowding is the spacing at which the flankers no longer have an effect on letter identification. The magnitude of crowding is the difference in accuracy between the flanked and single letter condition. The three letter words will be chosen using a permutation of 20 different letters (e.g. opt, top, pot, tpo). Participants will also be given the GORT-V (Gray Oral Reading Test) to measure reading fluency and comprehension. After completing all trials, participants will be asked about their reading habits. Results will be analyzed using the Statistical Package for the Social Science software (SPSS). To determine whether there are differences between children and adults in the crowding magnitude, a 2 (participant group) x 2 (word/non-word condition) x 5 (spacing) mixed measures ANOVA will be conducted. To determine whether the spatial extent of crowding differs between children and adults, spatial extent will be measured for every participant and it will be evaluated using a 2 (participant group) x 2 (word/non-word condition) ANOVA. Interactions between participant group and condition would indicate differences in implicit word formation between children and adults. Pearson correlation analyses will be conducted on crowding magnitude, spatial extent, reading fluency and reading comprehension scores derived from GORT-V.

Project Timeline

Literature Review:		September YEAR – ongoing
Design Experiment/Beta Testing:		September – November YEAR
Data Collection:	Adult Recruitment:	November - March YEAR
	Children Recruitment:	January – June YEAR
Data Analysis:		March – June YEAR
Conferences:	Discover USC Conference:	April YEAR
	Vision Sciences Society Conference:	May YEAR
Manuscript Writing:	Preparation:	May- July YEAR
	Submission to Journal of Vision:	August YEAR

Anticipated Results and Dissemination

The proposed study stems from a developmental perspective in investigating crowding and how it relates to reading abilities. Our findings could help us to better understand how a persons reading fluency might correlate with their ability to identify crowded words or letters, which could potentially form new reading rehabilitation strategies for children with amblyopia, dyslexia, and other disabilities. We expect that the magnitude of crowding would be smaller in words than in non-words because of the word superiority effect. In addition, we expect that the magnitude of crowding would be larger in children than in adults, but it is not clear whether the spatial extent would vary with age. If the extent does vary with age, it would suggest drastic change in cortical connectivity (Levi, Klein & Aitsebaomo, 1985) from childhood to adulthood. We plan to present our findings at Discover USC and the Vision Sciences Society Conference. We also plan to submit our paper from this line of research to peer reviewed journals such as Journal of Vision.

Personal Statement

After USC, I plan to attend graduate school in Clinical Psychology. Due to my work as Executive Director of an on campus event that benefits St. Jude Children's Research Hospital, I have been able to visit the actual hospital in Memphis. The work that they do at St. Jude has thus inspired me to create a new ultimate goal of eventually being able to work as a pediatric clinical psychologist at St. Jude. I thought that the Child Perception and Attention Lab (CPandA Lab) would be a great opportunity to get my foot in the door to begin working with children while also advancing my knowledge on many different topics and research techniques in psychology. The Magellan Scholar grant would allow me to continue working in the CPandA lab, and to commit more time to my research in order to begin testing children on my experiment.

References

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For instructions on completing this form: http://www.sc.edu/our/doc/BUDGETInstructionsforWORD.pdf

Magellan Scholar BUDGET FORM

Student's Name: _____

Student salary	Hours Estimated number of hours student will work	Rate Enter the hourly wage	Subtotal
Research hours during semesters when enrolled in classes	140	10	$1,400.00
Research hours during semesters when NOT enrolled in classes	80	10	$800.00
Fringe: Student salary * student fringe rate[1] (what is fringe? See budget instructions or guidebook)			
Enrolled in classes	$8.00	0.65%	$0.05
Not enrolled in classes	$8.00	8.31%	$0.66
Materials/Supplies		Enter sub-total from below:	$470.00
Travel		Enter sub-total from below:	
		TOTAL:	$2,670.72
		Amount requested for Scholar award:	$2,670.72

Double-click on table to enter data

Budget Justification/Description

Student Salary: Indicate estimated number of student research hours per week and hourly rate separated by semesters when student is enrolled in classes or not enrolled in classes (generally fall or spring vs summer semesters).

1. **Not in Class (summer): 10 hrs/wk x 8 weeks = 80 hours**
2. **In class (Spring Semester): 10 hrs/wk x 14 weeks = 140 hours**

Materials/Supplies: Indicate items, quantity, and estimated price. *Be sure to include taxes on all purchases.*

1. Participants/Subjects: 20 Children at $15.00 per = $300
2. SPSS software: $60
3. Endnote = $110

Travel: Indicate location, purpose of travel, estimate itemized costs (transportation, lodging, registration, etc).