

Reading Fluency Deficits in Schizophrenia: Evidence from Return-Sweep Saccades

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Introduction

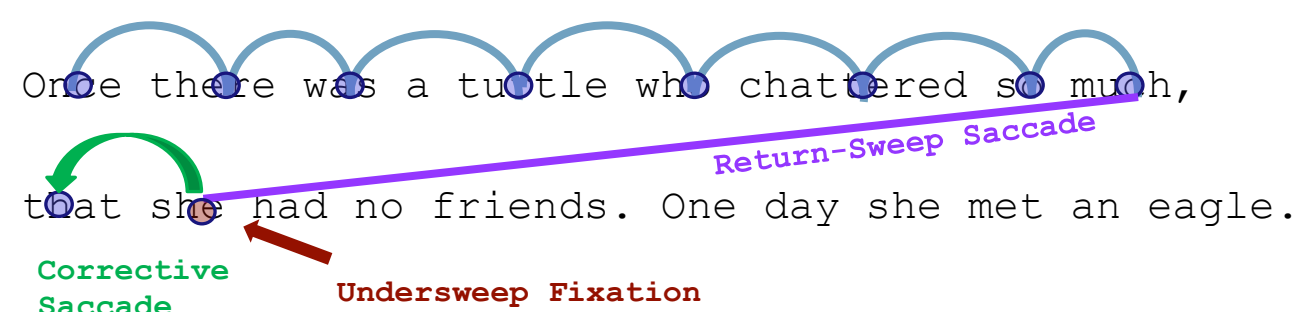
Individuals with Schizophrenia (Sz) show dramatic reading fluency deficits (see Vanova et al., 2020 for review)

2-Hit Deficit Model (Dias et al., 2021) → Deficits in both lower-level (e.g., oculomotor, parafoveal) and higher-level (e.g., lexical, semantic) processes contribute to reading dysfunction in Sz (see Whitford et al., 2018 for review)

Examining return-sweep saccades allows us to disentangle the involvement of lower- and higher-level processing deficits

- Readers often undershoot return-sweep saccades resulting in an undersweep fixation, and corrective saccades are needed to fixate at the line-initial word target (Slattery & Parker, 2019)
- Return-sweep targeting errors likely reflect lower-level oculomotor errors (e.g., Parker et al., 2019)

Intra-Line Saccades

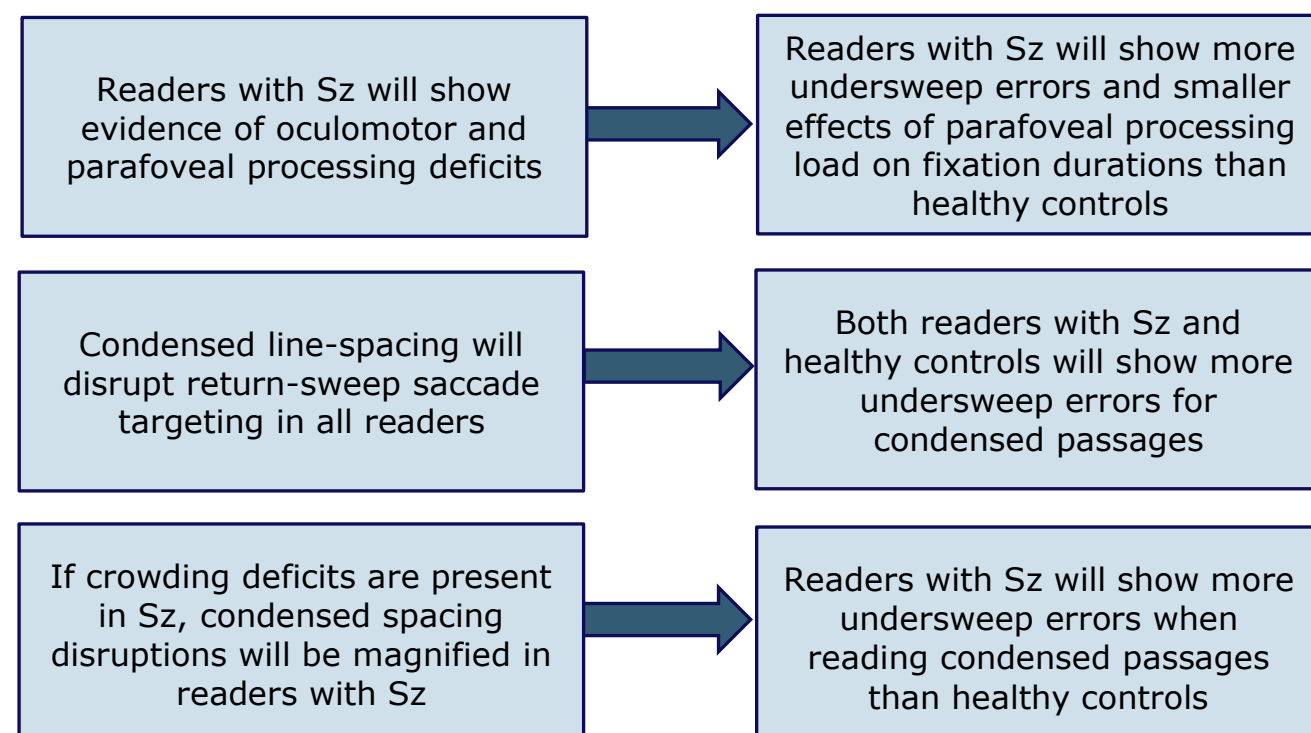


To assess lower-level oculomotor function during connected-text reading in Sz, we analyzed an existing dataset (Dias et al., 2021) in which participants read multi-line passages while their eye-movements were recorded

Research Questions

1. What is the source of reading deficits in Sz? (higher-level or lower-level processing?)
2. How does line spacing (which impacts visual crowding) impact return-sweep behaviors?

Predictions



Sample Stimuli

Figure 1. Sample passages in each line spacing condition.

Condensed
All over the world farmers face many difficult problems. Fruits, vegetables, and other plants are frequently attacked by insects and diseases that can wipe out an entire crop. Farmers attempt to control these pests by using chemicals, but these poisons can make our food unsafe to eat. They can also harm insects and birds. At any season of the year, weather may also destroy crops. Extreme heat or cold, too much rain or too little, hail or high winds—all can seriously decrease crop yields. Unlike pests, severe weather conditions are usually impossible to predict or control.

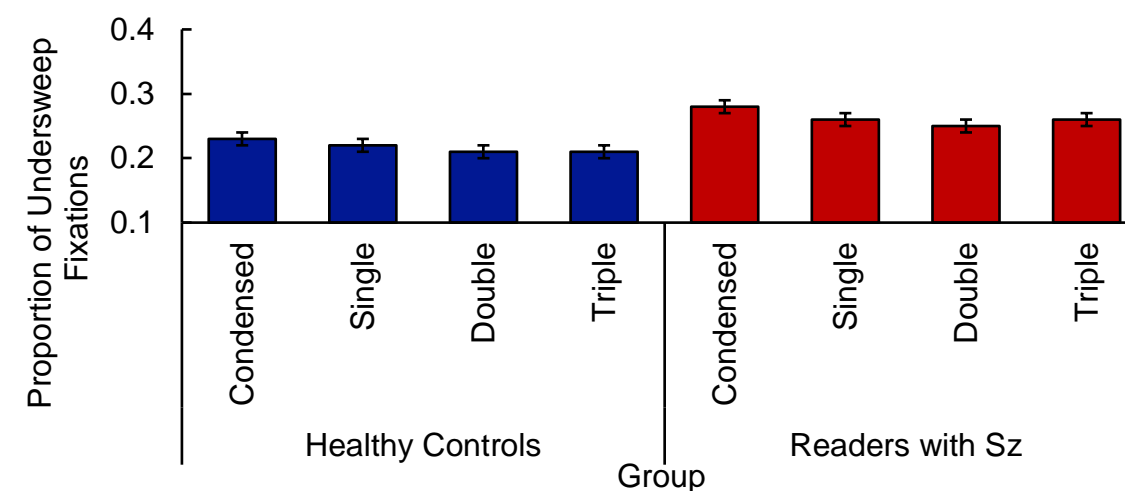
Single-Spaced
Many American farm workers have been aided by the efforts of a shy patient man named Cesar Chavez. As a youth, Cesar traveled from one farm to another picking crops as they ripened. Since his family had no permanent home, Cesar had attended thirty-seven different schools by the time he reached the seventh grade. As he grew older, he became increasingly concerned about the poverty and suffering of the farm workers. He began speaking to groups of workers about their need for safer housing and better health care. He convinced the grape pickers in California to join together and strike for better pay and working conditions. A strong believer in nonviolence, he led many peaceful protest marches and organized the first successful farm workers' union in the United States.

Double-Spaced
On an empty lot near the park many people were hard at work. Several boys were cleaning off the lot. They picked up old boards, trash, and dry branches that covered the ground. Others cut the tall weeds and carried them away. Then all the girls raked the ground smooth. At last a group of parents arrived. They put up some swings and a seesaw, and placed an old wooden boat besides a tree. Then they built a strong fence all around the lot. Now the children had a safe playground that everyone in the neighborhood had helped to make.

Triple-Spaced
One bright summer day a young boy and his grandmother walked to a nearby pond to fish. The boy's grandmother showed him how to put worms on the hook so they would not come off. For a long while they sat quietly waiting for the fish to bite. Suddenly the boy got a good bite. As he tried to land the fish, he became so excited that he dropped the pole into the water. The fish quickly swam away with it, and soon the pole disappeared. The boy looked wide-eyed at his grandmother. They both had a good laugh.

Results – Proportion of Undersweep Fixations

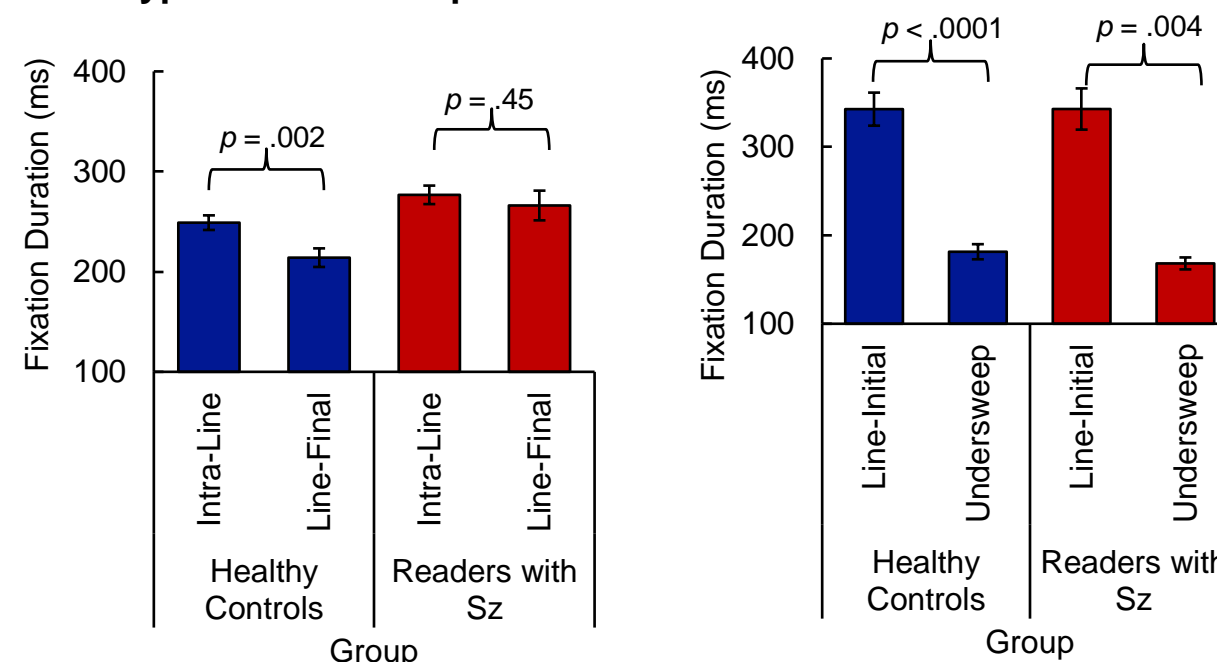
Figure 2. Average proportion of undersweep fixations as a function of group and line spacing. Error bars represent standard error of the mean.



- Effect of Group (Sz > HC), $\chi^2(1) = 7.21, p = .01$
- Effect of Line Spacing Condition (Condensed > Double & Triple; Single > Double), $\chi^2(3) = 15.43, p = .001$
- No Group x Line Spacing Condition Interaction, $\chi^2(3) = 0.60, p = .90$

Results – Fixation Durations

Figure 3. Average fixation duration (ms) as a function of group and fixation type. Error bars represent standard error of the mean.



- No Effect of Group, $F(1, 54) = 3.17, p = .08$
- Effect of Fixation Type, $F(3, 44,493) = 792.71, p < .0001$
- Group x Fixation Type Interaction, $F(3, 44,492) = 37.00, p < .0001$

Methods

Participants

- 26 individuals diagnosed with Sz, and 26 healthy controls
- Groups matched on age, parental SES, and handedness

Materials & Apparatus

- 8 single paragraph passages taken from GORT-4 (grade levels 5-8)
- Eye movements were recorded using a Remote EyeLink 1000 (SR Research)

Procedure

- Participants silently read each passage on a computer screen and clicked mouse button when finished

Conclusions

Consistent with the 2-hit deficit model (Dias et al., 2021), readers with Sz showed evidence of lower-level, oculomotor processing deficits during connected-text reading

- The proportion of return-sweep saccade targeting errors (i.e., undersweep fixations) was higher in readers with Sz compared to healthy controls

Readers with Sz show reduced sensitivity to parafoveal information (replicating Whitford et al., 2013), because Sz did not benefit from decreased parafoveal processing load

- Readers with Sz do not benefit from decreased parafoveal processing demands at the end of a line prior to return-sweep implementation, as evidenced by similar line-final and intra-line fixation durations (for a related discussion, see Parker et al., 2019)
- Both groups showed the typical pattern for fixations that do not benefit from parafoveal pre-processing (i.e., shorter undersweep compared to line final fixations; see e.g., Slattery & Parker, 2019)

Consistent with prior work (Roinishvili et al., 2015), readers with Sz did not show differential sensitivity to visual crowding compared with healthy controls

- For both groups, the probability of making an undersweep fixation was higher for condensed passages compared to double- and triple-spaced passages in all readers, supporting previous work demonstrating the detrimental effects of reduced spacing on saccade targeting during intra-line reading (e.g., Slattery & Rayner, 2013)

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