Sentence Reading Comprehension by Means of Training in Segment-Unit Reading for Japanese Children with Intellectual Disabilities

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Abstract Children with intellectual disabilities (ID) often have difficulty in sentence reading and comprehension. Previous studies have shown that training in segment-unit reading (SUR) facilitates the acquisition of sentence reading comprehension skills for Japanese students with ID. However, it remains unknown whether SUR training is also effective for individuals unable to read sentences and can generalize to untrained sentences. In this study, we examined the improvement and generalization of sentence reading accuracy and comprehension for two children with ID through SUR training with listening comprehensible sentences. During training, the segments were sequentially presented in their correct spatial

locations, and participants read them aloud. After the training, participants' reading accuracy and comprehension improved for both trained and untrained sentences. The results suggest that presenting the components of stimuli sequentially in their correct spatial locations is key to facilitating the development of sentence reading accuracy and comprehension for individuals with ID.

Keywords Segment-unit reading training · Intellectual disabilities · Reading accuracy · Reading comprehension

The utility of the work for Clinicians and/or researchers of behavior analysis

- Segment-unit reading training (SUR) was effective in improving and generalizing reading accuracy and comprehension for children with intellectual disabilities (ID).
- Repeated reading of shorter units of sentence stimuli helped children with ID read and comprehend.
- Listening-comprehensible sentences helped children with ID improve their reading skills.
- Presenting the components of stimuli sequentially in their correct spatial locations is key to develop reading comprehension skills.
- SUR training can improve individuals' reading skills from word level to sentence level.

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Introduction

Acquisition and Development of Reading Skills in Individuals with Intellectual Disabilities

Children with intellectual disabilities (ID) often have difficulty in acquiring early literacy skills (e.g., Katims, 2001). Although the reading skills of this population vary from inability to read to word reading capability (e.g., Ratz & Lenhard, 2013), most individuals with ID are able to read and comprehend words as their age increases (Jones, Long, & Finlay, 2006; Lemons, Zigmond, Kloof, Hill, Mrachko, Paterra et al., 2013). Several skills have been shown to be strongly related to the development of word reading skills in children with ID: phonological awareness (Allor, Mathes, Roberts, Cheatham, & Champlin, 2010), letter-sound knowledge (Dessemontet & de Chambrier, 2015), picture naming (Soltani & Roslan, 2013), and temporal processing (van Wingerden, Segersa, van Balkom, & Verhoeven, 2016).

Allor et al. (2010) provided daily training in early literacy skills, including phonological awareness and comprehension, for 34 children with ID as the treatment group, with 25 other children with ID as the control group. Their results showed

that the children with ID in the treatment group significantly improved their word segmentation and word reading fluency compared to the control group. Omori and Yamamoto (2013) demonstrated that Japanese children with ID were able to acquire reading skills for Hiragana words (Japanese phonograms) by means of a sequential stimulus pairing (SSP) training procedure. During SSP training, letters from the word were presented one by one, each in its correct spatial location within the word. After observing the presented stimuli during the training, all participants learned to read and comprehend Hiragana words accurately. However, these studies (Allor et al., 2010; Omori & Yamamoto, 2013) primarily focused on skills in word reading and comprehension, and improved phonological awareness did not result in better reading comprehension for longer passages (Allor et al., 2010). Thus, it is necessary to develop an effective training method for sentence reading comprehension in children with ID.

Listening Comprehension and Visual-Spatial Attention in Developing Reading Comprehension Skills

Despite their achievements in word reading and comprehension (Jones et al., 2006; Lemons et al., 2013), most individuals with ID struggle to read and comprehend sentences (Fajardo, Ávila, Ferrer, Tavares, Gómez, & Hernández, 2014). Recently, van Wingerden et al. (2016) evaluated the development of sentence reading comprehension skills in typically developing (TD) children and children with ID. Their results showed that only the group of children with ID needed to develop their listening comprehension and temporal processing of serial, phonemic, and word information (van Wingerden et al., 2016) skills in order to improve their reading comprehension. When reading skills are mature, listening comprehension skills can be a predictor of future improvement in reading comprehension for children with ID (Roch, Florit & Levorato, 2010; van Wingerden et al., 2016). This evidence suggests that reading comprehension for individuals with ID can be facilitated by training with sentences that are easy for them to understand by listening (listening comprehensible sentences).

For written sentence stimuli, visual-spatial attention such as eye movements toward each word (Rayner, 2009) could be a possible problem in temporal processing. Usually, skilled readers are able to visually identify the meaning of a word in a sentence to comprehend the written sentence (Rayner, Fischer, & Pollatsek, 1998). In an eye-tracking study of passage reading (Omori & Yamamoto, 2011), TD children were observed to focus on whole words or segments, whereas students with ID focused on one letter at a time. A great number (or length) of stimuli also interferes with visual-spatial attention and word integration during reading comprehension (Fajardo et al., 2014; Perovic, 2006). Perovic (2006) showed that a single sentence was even long enough to understand the

meaning by reading for children with ID. Fajardo et al. (2014) reported that children with ID showed poorer performance on reading comprehension tests as the sentences became longer. These results suggest that children with ID are not as skillful as TD children at visually identifying or abstracting words from whole sentences; this in turn may make it more difficult for them to improve their reading comprehension skills.

Repeated Reading Training with Whole Sentences

Repeated reading training has often been used to improve sentence reading accuracy, fluency (e.g., Ambruster, Lehr, & Osborn, 2003), and comprehension (Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003). In typical repeated reading training sessions, individuals are required to repeatedly read whole sentences, which are also used in the testing phase. This training method is widely used in Japanese school settings and is generally effective for TD children. However, as the length of the sentences increases, children with ID have performed more poorly on reading comprehension tests (Fajardo et al., 2014). Other research has confirmed that they find it challenging to read long sentences or passages repeatedly (e.g., Sheridan, Reichle, & Reingold, 2016). Thus, it may be inappropriate for children with ID to receive repeated reading training with whole sentence units. Because these children are better at reading and segmenting words (Allor et al., 2010; Jones et al., 2006; Lemons et al., 2013; Ratz & Lenhard, 2013) than at reading sentences (Fajardo et al., 2014), a more successful strategy for their repeated reading training may be to present each word or segment in the sentence sequentially, one at a time.

Training with Shorter Texts or Segments

Potocki, Megnan, and Ecalle (2015) found that reading intervention using shorter texts was more effective than training in phonological awareness in improving passage reading comprehension for poor French readers without ID. In a Japanese study, Nakagawa, Omori, Sugawara, and Yamamoto (2013) compared two types of repeated reading training for one student with autism spectrum disorder and ID: whole sentence-unit training versus segment-unit reading (SUR) training, which required the participant to read words or segments presented in their correct locations in the sentence. After the student read each segment, it disappeared, and the next segment was presented at the next location; this repeated until the last segment was correctly read. The participant's reading accuracy and performance on a reading comprehension quiz improved more after SUR training than after sentence-unit training. These results suggest that presenting sentences in segments should make it possible for children with ID to integrate the meanings of the words and thus to read and comprehend the sentences (Perfetti, Landi, & Oakhill, 2005).

However, the participant in the study of Nakagawa et al. (2013) was already able to read sentences 79% accurately before the intervention. Therefore, it is still unknown whether SUR training is effective for participants with ID having poor reading skills. What is more, no previous study has yet investigated whether training effects can be generalized to untrained sentences.

Objective

In this study, we examined whether the reading accuracy and reading comprehension of two children with ID would improve under segment-unit reading training. In previous studies of segment-unit reading training (e.g., Nakagawa et al., 2013), participants were instructed to read each segment of the sentence presented sequentially in its correct location, followed by a whole sentence stimulus and the corresponding picture stimulus. In the present study, a segment refers to a component of a Japanese sentence consisting of one meaningful word and one particle. A particle does not have a semantic referent to a real object but has a syntactic meaning in the sentence.

We first examined whether reading accuracy for the trained set would improve along with accuracy for an untrained sentence set through generalization. We also examined whether listening comprehensible sentences would help participants improve their sentence reading comprehension skills. We prepared sentences that participants could not comprehend when the written sentence stimuli were presented but were able to comprehend when their corresponding spoken sound stimuli were presented. We hypothesized that participants would improve their sentence reading comprehension skills through segment-unit reading training using listening comprehensible sentences.

Methods

Participants

We recruited the participants from a mainstream elementary school. Two children with intellectual disabilities (ID) participated in this study; both are identified by assumed names. One child, YUMA, was also diagnosed with autism spectrum disorder (ASD) by a pediatric doctor, using DSM-IV-TR (American Psychiatric Association, 2000) criteria. Informed consent was obtained from both children and their parents. We were unable to assess our participants with the Wechsler Intelligence Scale for Students—Fourth Edition (WISC-IV; Japanese edition; Wechsler, 2010) or other standardized test batteries, so we assessed them with the Kyoto Scales of Psychological Development (KSPD; Ikuzawa, Matsushita, & Nakase, 2002) and measured their developmental quotients (DQ) and mental age (MA). To represent their listening

comprehension skills, their verbal ages (VA) were measured by means of the Picture Vocabulary Test-Revised (PVT-R; Ueno, Nagoshi, & Konuki, 2008).

RUI was a first grade boy with a chronological age of 6 years and 10 months. His full-scale DQ was 60, with 53 on cognition and adaptation (C-A) subscales and 67 on language and sociability (L-S). His MA was 3 years and 10 months. His VA measured by PVT-R was 4 years and 6 months. He was able to read all Hiragana letters and most words fluently. However, it was difficult for him to read two or more words in succession, and he was unable to read sentences without a delay of 1 s or more between segments. In addition, he often started reading a vertically written sentence from the top left word, although reading initially from the top right is required.

YUMA was a third grade boy with a chronological age of 8 years and 3 months. His full-scale DQ was 49, with a C-A DQ of 58 and a L-S DQ of 47. His MA was 4 years and 1 month, and his VA was 7 years and 1 month. Unlike RUI, YUMA was sometimes able to read two words in succession, but he was unable to read three words in a sequence accurately and fluently. He also struggled to read sentences without a delay of 1 s or more between segments.

Apparatus and Stimuli

The experimental procedures were conducted in a lab room at Keio University. A desk and a chair were used in all experimental phases, and a laptop computer (Panasonic, Let's note CF-S10, Windows 7) was used to present stimuli. Stimulus sentences and segments for the training phase were generated using Microsoft PowerPoint 2007. We prepared 12 sentence stimuli, with each sentence stimulus consisting of one sentence presented on two lines. All sentence stimuli were written in Hiragana letters containing 5.50 (SD = 0.52) segments and 24.08 (SD = 1.00) letters on average.

Table 1 shows the three types of experimental stimuli: sentence stimuli, spoken sound stimuli, and picture stimuli. These stimuli were assigned to two stimulus sets, set 1 and set 2. We indicated the segments by inserting spaces between segments. Sentences in stimulus set 1 had a mean of 5.33 (SD = 0.52) segments and 23.83 (SD = 0.96) letters and those in stimulus set 2 had 5.67 (SD = 0.52) segments and 24.33 (SD = 1.03) letters. RUI was trained with stimulus set 1 and YUMA was trained with stimulus set 2. An untrained stimulus set was used for the generalization test.

Experimental Design

A multiple baseline design across participants was used (Kazdin, 2011).

Table 1 Experimental stimuli

Set 1			Set 2		
No.	Sentence stimuli Spoken sound stimuli (Translation)	Picture stimuli	No.	Sentence stimuli Spoken sound stimuli (Translation)	Picture stimuli
1-1	ちちのひに、おとうさんに ぶれぜんとを わたしました。 //Chichino hini otousanni purezentowo agemashita// (I gave my father a present on Father's Day.)		2-1	こうえんの すなばで、やまをつくって あそびました。 //Kouen no sunaba de yama wo tsukutte asobimashita// (I made a mountain in the sandbox in the park.)
1-2	ちちのひに、おとうさんに にがえを あげました。 //Chichino hini otousanni nigaeowo agemashita// (I gave my father a portrait on Father's Day.)		2-2	うみで すなを あつめて、やまをつくって あそびました。 //Umi de suna wo atsumete yama wo tsukutte asobimashita// (Collecting sand on the beach, I pretended to make a mountain.)
1-3	ぼくは、うさぎの こやをきれいに そうじしました。 //Bokuwa usagino koyawo kireini souji shimasita// (I cleaned the rabbit hutch thoroughly)		2-3	ぼくは、おんがくの じかにに うたを うたいました。 //Boku wa ongaku no jikan ni uta wo utaimashita// (I sang a song in music class)
1-4	ぼくは、がっこうの ぶーをきれいに そうじしました。 //Boku wa gakko no puru wo kirei ni souji shimasita// (I cleaned the school pool thoroughly)		2-4	ぼくは、おんがくの じかにに たてぶえを ふきました。 //Boku wa, ongaku no jikan ni tatebue wo fukimashita// (I play the recorder in music class)
1-5	ぼくは、おみこしの うしろを もって かつぎました。 //Bokuwa omikoshino ushirode motte katsugimashita// (I carried the back part of the portable shrine)		2-5	ぼくは、ひなんくんれんの ときに せいれつを しました。 //Boku wa hinan kunren no toki seiretsu wo shimasita// (I lined up for the evacuation drill)
1-6	ぼくは、おみこしの うしろで うちわを あおぎました。 //Bokuwa omikoshino ushirode uchiwawo aogimashita// (I used a big fan behind the portable shrine)		2-6	ぼくは、ひなんくんれんで つくえの したに はいりました。 //Boku wa hinan kunren de tsukue no shita ni hairimashita// (I got under the desk during the evacuation drill)

RUI was trained with stimulus set 1 and YUMA was trained with stimulus set 2

Dependent Variables

The dependent variables were the percentages of accurately read sentences in a set, percentages of correct responses on listening comprehension tests, and percentages of correct responses on reading comprehension tests. To evaluate the accurately read sentences in a set, we scored a correct response if the participant was able to produce the spoken sound corresponding to the visually presented sentence stimulus without making any reading errors and without a delay of 1 s or more between segments. Examples of reading errors included repeating the initial sound in a word, skipping the word, reading with a non-corresponding sound, and dysfluent reading. Even if the participant made only one reading error in a sentence, we marked the sentence as incorrect. We divided the number of accurately read sentences in a set by six to obtain the percentage of accurately read sentences in a set.

On the listening comprehension test, the participant listened to one of six spoken sound stimuli in a stimulus set which was read by the experimenter. The participant was instructed to point to the corresponding picture stimulus from among six choices. After the six spoken sound stimuli in one stimulus set were presented, the six spoken sound stimuli in the other stimulus set were one-by-one presented twice. We scored a correct response if the participant was able to choose the picture stimulus that corresponded to what the experimenter read. On the reading comprehension test, we presented one of the six sentence stimuli in a stimulus set on the computer. The participant was instructed to point to the corresponding picture stimulus from among six choices. After the six stimuli

in one stimulus set were presented, the six stimuli in the other stimulus set were one-by-one presented twice. We did not require the participant to read these sentences aloud. We scored a correct response if the participant was able to choose the picture stimulus that represented the meaning of the presented sentence stimulus.

Reliability

Two observers, including the first author, independently evaluated whether participants responded correctly on all reading tests and comprehension tests. We calculated block-by-block inter-observer agreement (IOA) to determine inter-rater reliability. We divided the number of agreements by the total number of agreements and disagreements and then multiplied by 100. IOA was 100% for both participants' responses, indicating perfect agreement. We also calculated kappa (Cohen, 1968) to measure inter-rater reliability and obtained a value of 1.00 for all responses in both participants.

Procedure

A testing session included pre-assessment, sentence reading baseline, segment-unit reading training and immediate probe, post-training reading probe for trained sentences, reading probe for generalization, and post assessment.

Figure 1 shows the trained and tested relations in the evaluation section: pre- and post-assessment and baseline (Fig. 1a; top left), training and immediate probe (Fig. 1b; top right), post-training and reading probe (Fig. 1c; bottom left), and

Fig. 1 Trained and tested relations of evaluation phase. Pre- and post-assessment and baseline (a, top left); training and immediate probe (b, top right); post-training reading probe (c, bottom left); and generalization (d, bottom right).

generalization (Fig. 1d; bottom right). In Fig. 1, black dotted lines in all panels represent the tested relations, such as listening comprehension, reading comprehension, and reading probes. The black solid line in Fig. 1b represents the trained relation between sentence stimuli and picture stimuli, and the gray line indicates the time sequence in which sentence stimuli were presented in SUR training.

Pre-assessment

In the pre-assessment (Fig. 1a), we conducted a listening comprehension test with spoken sound stimuli and a reading comprehension test with sentence stimuli. During the listening comprehension test, the experimenter read 12 prepared spoken sound stimuli one by one. The participant was instructed to choose the picture stimulus that represented the meaning of what the experimenter read by pointing at one of six choices. After the listening comprehension test was completed, the reading comprehension test began. The child read 12 sentence stimuli and for each was required to choose the corresponding picture stimulus from six choices by pointing. For both tests, all stimuli were presented or read twice, with each test consisting of 24 trials. No feedback was given during pre-

assessment. After completing the reading comprehension test, the participants began the baseline phase.

Baseline

During the baseline (Fig. 1a), participants were instructed to read aloud two blocks of 12 sentences, with sentences presented one by one on the computer. Each block presented the six sentences of the trained set twice in a random order. Participants were required to read the whole sentence stimulus without making reading errors. If the participant could not read a word or segment accurately or correctly twice, the experimenter only pointed to the first letter of the targeted word or segment by using a finger and no vocal feedback was given during baseline. Neither participant was able to read the sentences accurately and fluently, and neither showed any improvement after several blocks (two blocks for RUI and four blocks for YUMA). We then started training with segment-unit reading.

Segment-Unit Reading Training and Immediate Probe

During segment-unit reading training, we used only one of the two stimulus sets.

Figure 2 shows the sequence of segment-unit reading training. When a two-line sentence was being trained (for example, *ぼくは、うさぎの こやを きれいに そうじ しました*//*bokuwa usagino koyawo kireini souji shimasita*/I cleaned the rabbit hutch thoroughly), the first segment, *ぼくは、*, was presented on the upper right side of the computer display, and the participant was instructed to read it. After the participant was able to read the segment accurately, the experimenter clicked the computer mouse and the second segment, *うさぎの*, appeared on the middle right. The third segment, *こやを*, was presented on the bottom right; the fourth, *きれいに*, on the top left; the fifth, *そうじ*, on the middle left; and the last segment, *しました*, on the bottom left. During training, we did not present the next segment until the participant was able to read the presented segment accurately. If the participant was unable to read the segment twice, we provided a vocal prompt of the presented segment. Immediately after the participant had read the sentence in segments, all segments were presented together as a whole sentence. The participant was instructed to read the whole sentence aloud, in an immediate probe trial. After reading the whole sentence, the participant was instructed to observe the corresponding picture stimulus, which was presented for 2 s and followed by presentation of a black screen for 2 s. The new segments of the next sentence were then presented. Six sentence stimuli were presented twice each for a total of 12 trials, presented in random order. Within 1 cycle of segment-unit reading training and immediate probe, the participant had to read all sentences accurately and fluently for two consecutive training blocks to meet the mastery criterion. If the participant failed to meet the criterion, we trained him on the same stimulus set again.

Post-training Reading Probe for Trained Sentences

After meeting the mastery criterion, the participant read all the sentences in a trained set as the post-training reading probe. Participants read the same sentences used in the training phase and were not given prompts or correction. Six sentences were presented twice, for 12 trials. The post-training reading probe lasted until the participant was able to read all sentences accurately and fluently for two blocks in succession. If accuracy on either of the blocks in the post-training reading probe was below 100%, the participant was given a third block of reading probes. The post-training reading probe ended when accuracy on the third block reached 100%. If reading accuracy for sentences in a set in the two of three blocks were less than 100%, the participant began the training again.

Reading Probe for Generalization

After finishing the reading probe for the trained sentences, the participant was instructed to read the six sentences in the other stimulus set that was used in the baseline phase. For the generalization probe, sentence stimuli were presented one by one on the computer and participants were required to read each sentence aloud. No prompts were given even though the participant made reading errors. Six sentences were presented twice in each of two blocks. The termination criterion was identical to that of the post-training reading probe for trained sentences.

Fig. 2 A trial of segment-unit reading training and immediate probe

Post-assessment

In the post-assessment, we conducted only a reading comprehension test, which was identical to those in the pre-assessment.

Results

Reading Performance

Figure 3 shows the percentages of accurately read sentences in a set for the two participants. RUI (top panel) was unable to read any sentences accurately during the baseline phase. He often read the first letter of the segment repeatedly, skipped segments, and was unable to read sentences fluently, producing delays between segments. However, his reading performance gradually improved after the segment-unit reading training, and he required five blocks to meet the mastery criterion. In both trained and untrained sentence probes, he was able to read all sentences accurately and fluently.

YUMA (bottom panel) could read some of the two-line sentences correctly in the baseline phase. However, he often

struggled to read sentences, producing skipping errors and reading with non-corresponding sounds and delay between segments. After four blocks of training, his reading performance improved. In the reading probe for the trained sentences, his reading performance declined to 67% in the first block. However, his percentages of accurately read sentences in a set recovered to 100% in the following two blocks. In the reading probe for generalization, his reading performance improved, and he scored 100% in two of the three blocks, although he could read only three of the six untrained sentences in the first block of this phase.

Listening and Reading Comprehension Tests

Table 2 shows that in the pre-assessment, both participants were able to choose accurately the corresponding picture stimuli in the listening comprehension test, 91.7% for RUI and 100% for YUMA. On the other hand, their performance on the reading comprehension test declined to 8.3% correct for RUI and 25.0% for YUMA. After the segment-unit reading training, both students' performance on the reading comprehension tests improved to 100%.

Discussion

Improvement of Reading Accuracy Through Segment-Unit Reading Training

In this study, we first examined whether two children with ID could improve their reading accuracy on a trained sentence set and then generalize to an untrained set by means of the segment-unit reading (SUR) training procedure. Neither participant was able to improve his reading accuracy through whole sentence-unit reading training, in which they read sentences repeatedly. As soon as the SUR training was conducted, reading accuracy improved for both participants. During probe sessions, after SUR training was removed, both children still showed adequate reading accuracy. The results are consistent with previous research (Nakagawa et al., 2013) in which children with ID improved their reading accuracy through SUR training only. A novel finding of the present study was that training effects generalized to the untrained sentence set by producing accuracy on the reading probe. Allor et al. (2010) reported that children with ID were able to acquire word segmentation skills via training focused on phonological awareness. Just as words can be divided into phonemes, sentences are made up of segments or words. By presenting each segment sequentially, we discovered that children with difficulties in sentence reading were able to acquire accurate reading skills, in the same way that previous research has shown that phonics, or learning to identify shorter

Fig. 3 Percentages of accurately read sentences in stimulus sets. *Filled shapes* indicate sentences in the trained set and *open shapes* those in the untrained set. RUI was trained with stimulus set 1 and evaluated the generalization by stimulus set 2. YUMA was trained and evaluated vice versa

Table 2 Results of listening and reading comprehension tests

Participants	Stimulus set	Listening comprehension test	Reading comprehension test	
		Pre-assessment	Pre-assessment	Post-assessment
RUI	Trained set	83%	0%	100%
	Untrained set	100%	17%	100%
YUMA	Trained set	100%	33%	100%
	Untrained set	100%	17%	100%

Note. We did not conduct a listening comprehension test in the post-assessment because both participants scored nearly 100% in the pre-assessment

component of words, facilitates the acquisition of word reading skills (Allor et al., 2010).

Why Present Shorter Units of Stimuli Sequentially?

Reading long sentences repeatedly during the baseline phase did not affect the reading accuracy of children with ID. However, both participants immediately improved after SUR training, which presented one segment at a time in a sequence. They rarely made errors during the training phase because they already had a repertoire of words they could read accurately (Ratz & Lenhard, 2013), and their reading levels were equivalent to that of first graders (Jones et al., 2006; Lemons et al., 2013). If we had presented both the first and second segments together on a same slide, the training would have been a forward chaining procedure. Prior to intervention, our participants were rarely able to read two or more words in succession. If we had presented two or more segment stimuli on a slide, participants would likely have made a greater number of reading errors during training. By presenting one segment at one time in SUR training, we decreased the potential for reading errors in children with ID. Therefore, presenting each segment stimulus one by one increased sentence reading accuracy for individuals with ID.

Generalization of Reading Comprehension Skills Using Listening Comprehensible Sentence Stimuli

We also examined whether using listening comprehensible sentences could help participants improve their sentence reading and comprehension skills. Table 2 shows that both participants were able to successfully comprehend written sentences after SUR training for both trained and untrained stimulus sets. For children with ID, skills in reading, listening comprehension, and temporal processing are necessary to develop their reading comprehension skills (e.g., Roch et al., 2010). When stimuli are presented in a temporal sequence, using nameable or comprehensible stimuli has been shown to be important in facilitating the development of word reading accuracy and comprehension for Japanese students with developmental disabilities, including ID (Omori & Yamamoto,

2013). This is because both RUI and YUMA had VA scores on the PVT-R (5 years and 4 months old on average), which were higher than their MA scores on the KSDP (3 years and 11 months old on average). Because these VA scores represent listening comprehension abilities that approach those of TD children of comparable chronological age, these participants were able to exploit listening comprehensible stimuli to improve their reading accuracy during SUR training. Although further investigation is necessary, both participants still showed 100% correct responses on the untrained sentence reading comprehension test as a result of improving their reading accuracy via SUR training and the use of listening comprehensible sentences. Comparison of the effects of using listening-comprehensible and listening-incomprehensible sentences in facilitating the improvement of sentence reading accuracy and comprehension remains a topic for future research.

Importance of Presenting Segment in Its Correct Location

Presenting each segment sequentially in its correct location helped participants visually identify words in sentences and integrate the meaning of sentences. Temporal processing skills for reading comprehension include serial processing and word integration (van Wingerden et al., 2016) and visual-spatial attention (Rayner, 2009). Previous studies have shown that children with ID have difficulty in sentence comprehension because they focus on each letter during reading (Omori & Yamamoto, 2011; Perovic, 2006). Inadequate observation during reading leads to poor reading accuracy, comprehension, and word identification within sentences (Rayner et al., 1998; Rayner, 2009).

Our sentence stimuli had similar grammatical features in common, such as stimuli 1–1 and 1–2 in Table 1. Children should be able to comprehend the meaning of a sentence stimulus if they can read and discriminate its keywords (1–1: “ぶれぜんと, present” and 1–2: “にがまえ, portrait”). However, they were unable to comprehend the sentence stimulus during the pre-assessment, which suggests that they struggled to observe the presented words and to integrate their meaning. Presenting each segment sequentially should have

decreased their difficulties in observing and integrating the meaning of words. What is more, we presented the segments one by one in their correct spatial location in the sentence. As shown in the example in Fig. 2, participants had to move their eyes from top to bottom and right to left in SUR training. Through SUR training, the children with ID learned how to read sentences accurately and how to integrate the meaning of words, improving their reading accuracy and comprehension on the untrained sentences. By contrast, they did not show improvements in the baseline phase when they read the same sentences repeatedly. These results suggest that presenting each segment in its correct spatial location in a temporal sequence was the key to facilitating sentence reading accuracy and comprehension for children with ID.

Connection of the Different Reading Levels by Presenting Stimuli Sequentially

Our findings supported our hypothesis that participants with ID would develop their sentence reading accuracy and comprehension skills through SUR training on listening comprehensible sentences. In Japanese school settings, methods for reading comprehension intervention other than repeated reading of whole sentence units are rarely used. By demonstrating the efficacy of SUR training using listening comprehensible sentences, we are able to offer a new training method for reading comprehension intervention with children struggling to read sentences.

There is abundant literature showing the development of reading skills from inability to read to word-level reading skills (e.g., Akita & Hatano, 1999). Phonological awareness has been considered key to the development of word-level reading skills (e.g., Allor et al., 2010). However, there has been no clear connection from the development of word-level to sentence-level reading skills. Our findings suggest that presenting the components of stimuli sequentially in their correct spatial location provides this connection. We believe that SUR training can improve individual reading skills from word level to sentence level. Although our participants acquired accurate reading skills and reading comprehension via SUR training, we still do not know whether participants' temporal processing skills and eye movement patterns changed. Future research should therefore include the objective evaluation of temporal processing skills and eye movement patterns by using standardized test batteries and eye tracking. The efficacy of SUR training should also be evaluated in larger populations.

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Compliance with Ethical Standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the Keio University Institutional Review Board of the Faculty of Letters and with the 1964 Helsinki Declaration and its later

amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study and from their parents.

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