Effect of a Precursor-Based Intervention
with Multiple-Schedules on Self-Injurious Behavior:
A Case Study[*]

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〈요 약〉

Function-based intervention is an established, evidence-based treatment to address severe problem behaviors. However, ethical and safety concerns arise in relation to identifying the function of the problem behavior. This study examined the effectiveness of the precursor-based functional communication training (FCT) with schedule thinning to decrease severe self-injurious behavior (SIB) in a 15-year-old boy with developmental disabilities. A sequential analysis using Yule's Q was conducted to quantify the sequential association between the precursor and the SIB, followed by a functional analysis (FA) to identify the function of the precursor. Based on the results of the FA, FCT and reinforcement schedule thinning were implemented for the precursor. The outcomes suggest that precursor-based treatment with enhanced feasibility and practicability would be a viable treatment approach for severe SIB.

<Keywords> precursor behavior, self-injurious behavior, functional communication training, reinforcement schedule thinning, precursor-based intervention

Ⅰ. Introduction

Self-injurious behavior (SIB) is often observed in individuals with developmental disabilities. As SIB can cause serious injury to the individual and occur with comorbid problem behaviors that are harmful to others (MacLean, Tervo, Hoch, Tervo, & Symons, 2010), it is important to develop and implement effective interventions. Although function-based behavioral interventions including functional communication training (FCT) have been the most effective among various treatments in managing serious problem behaviors (Min & Kim, 2019; Park & Kim, 2017; Greer, Fisher, Saini, Owen, & Jones, 2016), there are several practical and safety issues to consider when implementing behavioral interventions to address SIB. Function-based behavioral interventions entail a functional analysis (FA) to identify the function of SIB, during which the behavior is likely to be evoked and thus may cause significant harm to the individual and other people including caregivers and therapists (Fritz, Iwata, Hammond, & Bloom, 2013).

One alternative to directly dealing with SIB is to identify and treat its precursor in a response-class hierarchy manner (Apamo-Gannon, 2016; Slaton, Hanley, & Raftery, 2017; Warner et al., 2020). A precursor-based intervention is a safer approach to treat SIB by analyzing and changing the contingencies of its precursors, thereby preventing more severe and dangerous behaviors (i.e., SIB) from occurring. Some precursor-based treatments from previous studies (Langdon et al., 2008; Najdowski, Wallace, Ellsworth, MacAleese, & Cleveland, 2008; Slaton, et al., 2017) implemented FCT to decrease the precursor and consequently SIB. In these studies, alternative functional communication responses (FCR) produced the same consequence as precursors and manipulated contingencies of precursors, resulting in a significant reduction of both the precursor and SIB.

Some limitations should be considered to determine whether precursor-based treatments can be practically used by caregivers in their daily settings. The FCT is designed to provide reinforcers on a fixed ratio 1 (FR1) schedule. However, in daily settings, it is difficult for caregivers or teachers to consistently reinforce every instance of FCR (Fisher, Kuhn, & Thompson, 1998). Therefore, it is uncertain whether FCR can be successfully applied in daily settings. If every instance of the alternative communication response is not reinforced, the resurgence of the target problem behavior is highly likely to occur.

To increase the practicability of the FCT treatment, one possible modification is to incorporate a reinforcement schedule thinning method. Fisher et al. (1998) and Fisher et al. (2000) proposed a

mult FCT as a schedule thinning method to address the difficulty of providing reinforcer for every FCR instance and enhance individuals' tolerance when the reinforcement of FCR is unavailable or delayed. ―Mult FCT is defined as the FCT with a compound schedule in which each component (i.e., SD, SΔ) is associated with a specific reinforcement schedule and a visual or auditory signal. With the use of visual or auditory signals, participants can be taught to distinguish when the reinforcement of communication is available (i.e., SD condition) from when it is unavailable (i.e., SΔ condition). For signaled, compound schedules, the duration of the SΔ condition was increasingly lengthened as sessions continued(Greer et al., 2016). Through the review of a large-cohort investigation that used the signaled schedule thinning approach, Greer et al. (2016) demonstrated that the mult FCT resulted in a significant reduction of serious problem behaviors and prevented the resurgence of problem behavior. Thus, further research is required to confirm the effectiveness of the precursor-based treatment using FCT with multiple schedules (i.e., mult FCT). This provides insights into how caregivers can feasibly deliver reinforcers in daily settings when using a precursor-based FCT.

The current study examined a way to treat severe SIB safely by addressing the precursor and evaluated the effectiveness and feasibility of a precursor-based FCT on multiple schedules. Specifically, the current study extended Langdon et al.'s (2008) study in two aspects: (a) obtaining a statistic (i.e., Yule's Q) as a reliable index to identify the precursor-SIB sequential association, and (b) using mult FCT to make a precursor-based FCT more practical and efficient.

Ⅱ. Method

1. Participant and Settings

The participant was a 15-year-old boy diagnosed with autism spectrum disorder (ASD) and intellectual disability. According to K-CARS, his severity level of ASD was mild to moderate, and his communication ability was restricted to two- or three-word utterances. The participant often showed severe SIB (e.g., hand biting and head banging) and at times showed aggressive behavior towards the person who tries to stop the SIB. The participant was referred to an intensive problem behavior intervention program in a children's hospital due to his serious SIB. The assessments were

conducted in a therapy room (3 m x 6 m) that contained padding on the walls and floors. Mult FCT sessions were conducted in a padded break room (6 m x 6 m) that included a treadmill, a cycling machine, and a trampoline. The treatment team consists of one supervisor, one main therapist, and two assistant therapists. The supervisor oversaw the treatment carried out by the main therapist and one therapist. The other therapist recorded the data.

2. Response Definitions and Measurement

Both the precursor and the SIB were first identified during the caregiver interview and direct observation. The precursor of the SIB included frowning, intermittent whimpering, and shouting. The SIB included hands biting and head banging. During five direct observation sessions, the occurrences of both the precursor and the SIB were recorded in 10-s intervals for sequential analysis to examine the association between the precursor and the SIB. For each session, the total occurrences of each behavior (i.e., the precursor and SIB) were converted into rates to establish the baseline for examining the effect of the mult FCT on the precursor and SIB. During the FA sessions, the rates of the precursor and the SIB were recorded using a laptop computer. Frequency data of the vocal FCR ("I want a break"), the alternative response to the precursor, was collected during direct observation sessions as well as FCT sessions. The percentage of correct vocal FCR was calculated during the mult FCT. Correct vocal FCR was defined as independently generating the FCR within a 20 second interval from the onset of the transition from the period of unavailable to available reinforcement. Prompted vocal FCR was defined as the FCR emitted with a therapist's help 20 seconds after the transition. At this point, since the participant had already mastered the FCR from the FCT sessions, the participant had a high likelihood of independently presenting FCR within 5 seconds. Nonetheless, if the participant does not present FCR, to prevent the therapist from waiting indefinitely, prompt for the FCR was given 20 seconds after the transition. The vocal FCR was trained to show only during SD period through Mult FCT, not SΔ period. Thus, an error of vocal FCR was regarded as the participant emitting the FCR during the interval in which reinforcement was unavailable (SΔ period). No error response in SΔ period suggests that the participant is able to discriminate the stimuli indicating reinforcement availability. The percentage of correct vocal FCR was calculated by dividing the number of correct FCR by the sum of correct, prompted, and error FCR in each session and then multiplying the result by 100.

3. Interobserver agreement

Interobserver agreement (IOA) was obtained by three independent, trained observers. Reliability was assessed during at least 20% of sessions. IOA averaged 94,2% for the precursor, 96.5% for the SIB, and 99.6% for the FCR.

4. Fidelity

The procedural fidelity was also collected using the procedural checklists, and the result was 97.5%.

5. Social Validity

Social validity was evaluated by the caregiver of the participant. The social validity evaluation consisted of four items: 1) the importance of the intervention outcome, 2) the acceptability of intervention procedures, 3) ease of implementation of intervention procedures, 4) the applicability of intervention procedures in a general environment. These four items were based on the study of Gresham and Lopez(1996) that evaluated social validity with respect to the importance of intervention goal, the appropriateness of intervention procedures, and the significance of the intervention outcome. Each item was evaluated on a 5-point scale ranging from not at all (1 point) to very much (5 points). According to the evaluation results, the average score was 4.0. To speak specifically, the intervention outcomes helped improve the participant's quality of life. The precursor-based intervention to reduce the SIB was a safe and appropriate intervention method. The intervention method was implemented with no difficulty. However, the caregiver commented that the implementation had some limitations depending on settings and situations.

6. Procedures

1) Descriptive analysis
The caregiver was interviewed about the possible precursors and the problem behaviors of the participant. Based on the interview information, direct observation was conducted across five sessions,

with each lasting 5 minutes (25 minutes in total), to identify when and where the participant was likely to engage in the SIB. According to the caregiver's report, the SIB was likely to occur when the participant was asked to complete an unfavorable task. To observe in such a situation, the participant was observed while the caregiver requested him to complete the task that he did not prefer (e.g., walk, sit down, stand up), and the potential precursor and the SIB were recorded. If the participant displayed the SIB, his caregiver allowed him to take a break. The assessment of the severity of the SIB showed the highest level (score of 4 on a 4-point Likert scale) of injury risk behavior. Since further assessment of SIB was highly risky, initiating the precursor FA and precursor-based treatment was more appropriate than directly intervening in the SIB.

2) Sequential analysis of precursor-SIB relation

Yule's Q is used to determine whether a sequential relation exists between two events (refer to Yoder and Feurer [2000] for details). As McComas et al. (2009) pointed out, Yule's Q, a statistical index, can provide a more viable measure of the sequential relation compared to other indices such as the simple and the transitional probabilities. In the context of this study, Yule's Q provides an estimate of the probability that the SIB (i.e., biting and headbanging) follows a precursor (i.e., whimpering, frowning, and shouting). To calculate Yule's Q, the SIB and precursor data obtained from direct observation were used.

3) Functional analysis of precursor behavior

Prior to the FA of the precursor, preferred items were identified using paired stimulus preference assessments (Fisher et al., 1992). The FA of the behavior was implemented using a pairwise test-control design (1-10 sessions) in which a demand condition (test) and a play condition (control) were alternated in a randomized order; all conditions lasted 5 minutes. During the demand condition, the caregiver provided an instruction to do a non-preferred task (e.g., walking, sitting down, standing up) and gave a break for 20 seconds, contingent on the precursor. During the play condition, preferred items (e.g., YouTube videos) were provided, and attention (e.g., praise for playing appropriately) from the caregiver was delivered at least once every 30 seconds while all demands were withheld. Following the pairwise FA, an additional brief FA (11 – 15 sessions) was conducted using five conditions (i.e., ignore, attention, toy play, tangible, and escape) to confirm the results of the pairwise FA. All conditions of the brief FA lasted 5 minutes and were conducted

similarly to the procedures described by Iwata et al. (1982/1994).

4) Experimental design

This study consists of baseline phase, FCT phase, and mult-FCT phase. At the baseline phase, the level of SIB before the treatment was determined from direct observation of the participant with the caregiver. Then FCT was implemented to teach FCR as an alternative for the precursor. After mastering the independent FCR, mult-FCT was initiated. Considering safety concerns and parental disapproval, the study did not have any reversal sessions to observe the treatment effect on SIB.

5) Intervention procedure

(1) Baseline

Baseline data of the mult FCT used the data of the five initial observation sessions to compare the levels of the precursor and the SIB before and after treatment.

(2) Precursor-based intervention: Multiple schedule FCT

Prior to the mult FCT, the participant was taught how to emit the vocal FCR ("I want a break") as an alternative behavior to the precursor. Each session consisted of 10 trials. While a demand (e.g., walk, sit down, stand up) was presented to the participant, the vocal FCR was independently generated using the progressive-prompt delay (i.e., 0, 2, and 5 seconds). During the FCT sessions, participant was reinforced whenever he presented a vocal FCR, whereas both the precursor and the SIB were not reinforced (i.e., no break). When the percentage of independent FCR was 80% or higher during two consecutive sessions, the given prompt was systematically faded to the next time delay interval (e.g., 0-2 seconds, 2-5 seconds) until the training sessions ended.

After the participant met the mastery criterion of independent FCR ("I want a break"), the mult FCT began. The mult FCT procedure consisted of a reinforcement available period (SD) and a reinforcement unavailable period (SΔ). The colors of the poster boards served as the stimuli to discriminate between the two components: green for SD and red for SΔ. The presentation of each color (i.e., green or red) marked the start of the specific component (i.e., SD or SΔ). Within the 15-minute duration of each treatment session, SD and SΔ components were alternately implemented. The therapist started the SD component with the presentation of the green poster, and the participant needed to independently request a break. When the participant requested a break, the

therapist immediately provided a break until the SD interval terminated. There were no programmed consequences for the precursor and the SIB. After the first break, the therapist switched over to the SΔ component with the presentation of the red poster and provided instructions (e.g., "It's time to walk."). In this component, the occurrence of FCR, precursor, or SIB was not reinforced.

The duration of the SΔ component was gradually increased (i.e., 40, 50, 60, 70… 230 seconds) when the level of the precursor was below the criterion of at least 90% reduction of the baseline level for two consecutive sessions. The SD interval was also adjusted to increase by at least 25% of the SΔ interval as the SΔ interval increased. The precursor recurred when the SΔ interval lengthened, suggesting that the value of the reinforcement should be strengthened. The supplementary reinforcer (i.e., edible reinforcer) was introduced in the second 180/45 schedule (Session #68) of the mult FCT procedure.
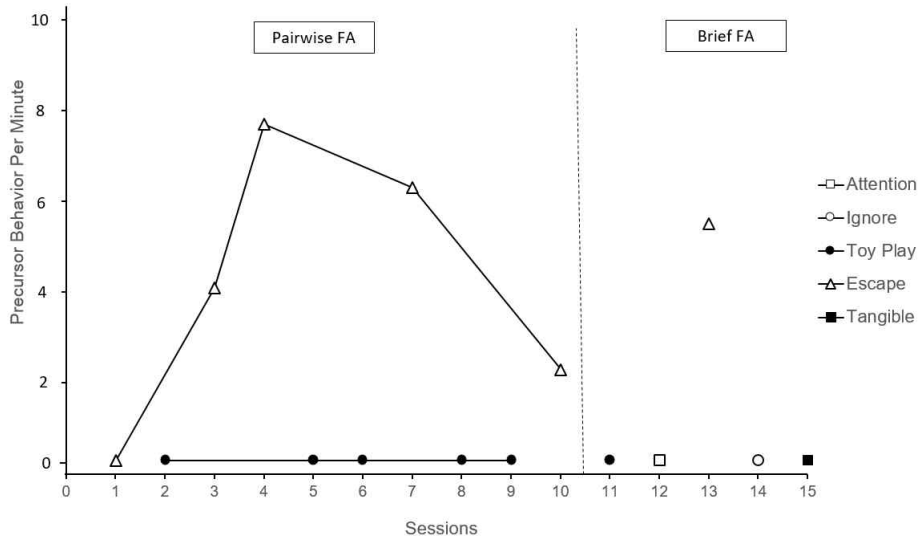
Ⅲ. Results

1. Sequential Analysis of Precursor-SIB Relation: Yule's Q

The calculated Yule's Q value was 0.97, indicating a strong and positive sequential association between the precursor and the SIB. The result demonstrated a high likelihood of the SIB following the precursor.

2. Functional Analysis of Precursor Behavior

<Figure 1> displays the FA results of the precursor. The occurrence rate of the precursor in the demand condition averaged four times per minute (range, 0.0 – 7.4) which was higher than those in the control condition (i.e., play condition). The result of the additional brief FA replicated the outcomes from the prior pair-wised FA, demonstrating that the function of the precursor was to escape.

〈Figure 1〉 Functional analysis of precursor behavior

3. Precursor-Based Intervention: Multiple Schedule FCT

<Figure 2> presents the results of the mult FCT treatment with a supplementary, edible reinforcer. At baseline, the occurrence rate of the precursor averaged five times per minute and the occurrence rate of the SIB averaged 2.1 times per minute. Excluding a few initial sessions, the precursor generally occurred below the criterion of at least 90% reduction of the baseline level for 40 sessions (40/40 to 170/42) after the treatment was introduced. During Sessions #96 to #107, the rates of correct FCR fluctuated, resulting in the temporary display of the precursor; however, as the sessions with the SΔ interval of 230 seconds progressed, the percentage of correct FCR became stable again, and the precursor decreased. In contrast, the SIB exhibited an incidence near zero after the mult FCT.

In the case of the target vocal FCR, even though the participant mastered the FCR during the FCT sessions, the rates of correct FCR exhibited a high level of variability until the level stabilized (28 sessions). With a few exceptions, the correct FCR reached a stable level of 100% starting from the SΔ component of 120 seconds. The stable level suggested that the participant was able to discriminate stimuli that signaled the availability of the reinforcement.
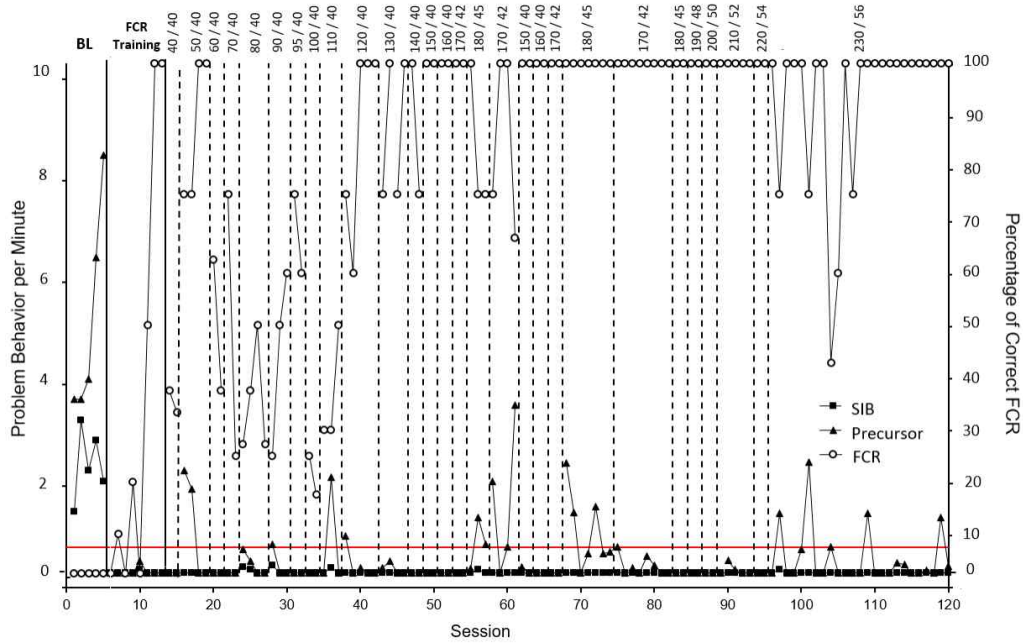
⟨Figure 2⟩ Percentages of correct FCR and the rates of precursor and SIB

Ⅳ. Discussion

The current study provided evidence on the effectiveness of using a precursor-based mult FCT to reduce SIB, suggesting that the precursor-based treatment can potentially be a useful alternative approach to reduce severe SIB. Based on the result, discussion and suggestions are as follows.

First, the treatment was generated based on the assumption that a precursor shares its operation function with the SIB. In this study, the SIB did not occur during the FA of the precursor behavior in which the precursor was reinforced. This demonstrates that the function of precursor is same as that of the SIB. Therefore, changes to the contingencies of the precursor would also result in changes to those of the SIB. When a functionally equivalent behavior (i.e., FCR) was taught as a replacement of the precursor, the precursor significantly decreased, and the SIB did not occur. This finding replicated previous studies (Dracobly & Smith, 2012; Langdon et al., 2008) in that when the operant function of the precursor was determined and then reinforced, severe problem behaviors considerably decreased.

To date, many researchers have identified problems associated with FA of severe problem behavior (Dracobly & Smith, 2012; Langdon et al., 2008; Najdowski et al., 2008). Specifically, the FA procedures require evoking and reinforcing the target behavior. Consequently, increase in severe problem behavior was more likely to occur during the FA condition than the natural environment (Kahng et al., 2015). The FA process poses a safety concern when the topographies of the assessed behavior are harmful to the individual and/or others. However, the risks can be mitigated when the focus of FA is on the precursor rather than the severe problem behavior (Heath & Smith, 2019). In this regard, this study demonstrated the possibility of using precursor behavior to implement a safe and function-based intervention for serious problem behaviors.

Second, to examine the effects of a precursor-based treatment, it is critical to verify a strong sequential relation between the precursor and the SIB. This study obtained a reliable estimate of the sequential association through Yule's Q. Yule's Q, a transformed odds ratio, can provide a more viable measure of the sequential relation between two events, compared to other indices such as the simple and the transitional probabilities(McComas et al., 2009). It specifies the direction (i.e., positive, negative, zero) and strength (i.e., -1 to 1) of the sequential relation between the events and controls for chance association by considering the events' base rates (Lloyd et al., 2013). For instance, when intervals in which events of interest did not occur are included in the transitional probabilities' calculation, the strength of the contingency index is altered in that longer observation sessions would produce differences of transitional probability. The chance of association is also increased when the events of interest occurred at a high frequency during observation. The value yielded from Yule's Q calculation of the probabilities between the precursor and SIB was .97, demonstrating a strong sequential association between the two behaviors. The finding from Yule's Q provided strong supporting evidence that a sequential relation between the behaviors of interest is less likely due to a chance association. On the other hand, previous studies either did not conduct a sequential analysis(e.g., Najdowski et al., 2008) or applied a descriptive analysis(e.g., Dracobly & Smith, 2012; Langdon et al., 2008) in which chance association could be interpreted as significant association. This study further provided supporting evidence for the possibility of reducing SIB by identifying and manipulating its precursor in a natural environment with the use of Yule's Q.

Third, procedurally, the low incidence of SIB could be due to reinforcement being implemented contingent on FCR across the FCT and the SD condition of the mult FCT, while the precursor and the SIB were placed on extinction. Specifically, the FCR was differentially reinforced in the presence

of a stimulus, resulting in the stimulus acquired evocative and abative effect on the FCR and SIB, respectively. In addition, the practicability of the FCT was increased by adding multiple schedule thinning. By thinning the FCT reinforcement schedules to naturally occurring schedules in the natural environment, the method can be more practical and appropriate in addressing problem behaviors in the applied settings (Greer et al., 2016). Furthermore, the mult FCT signaled the availability or unavailability of reinforcement, and FCR occurred more often in the SD condition than in the S△ condition. Low to zero occurrences of SIB and precursors occurred across both the SD and S△ conditions. This simulates the natural environment where caregivers may present reinforcement at intermittent periods and apply mult FCT with greater ease.

However, the outcomes of this study should be interpreted cautiously. Considering both the safety concerns and primary aim of this study, an FA of the SIB was not conducted. While the results from using Yule's Q method may have demonstrated a stronger relationship between the precursor and the SIB compared to other analytical methods, the relationship can still only be assumed as they share the same operant function, and the SIB was indirectly affected by altering the contingencies of the precursor. Thus, other explanations might also be tenable. For example, as the baseline data were collected in a different room from the treatment room, other variables such as room size or types of equipment available may have affected the results. That may have altered the stimuli that evoked or maintained the SIB. Additionally, there were no reversal sessions to observe the treatment effect on SIB when the treatment is "turned-off or -on" due to safety concern and parental disapproval. According to the parent's reports, in the absence of interventions at home, the occurrence of precursor and SIB at home increased. This parental report indirectly implies that the target behavior would re-occur at the level of the baseline if the reversal to baseline had been implemented. However, without such a component, there is a limitation in demonstrating the functional relation between the treatment and SIB.

Future research should replicate the procedures with multiple participants and use an experimental design that follows baseline logic. In addition, findings reported in this study support that the precursor-based procedures are useful and efficient in a clinical setting. However, the generality of the current treatment across settings would also be critical. If caregivers are able to implement the treatment in home settings, the same effect may be observed under the natural environment. More research is needed to evaluate if caregivers are able to learn how to conduct the treatment for their children at home.

Despite the limitations, the result aligns with those of previous studies (Dracobly & Smith, 2012; Langdon et al., 2008; Najdowski et al., 2008), supporting that by reinforcing the FCR, the precursor drastically decreased and the participant no longer engaged in the severe problem behavior. Extending upon the prior studies, this study demonstrates that a precursor-based treatment with the use of the mult FCT can be more effective in addressing SIB. Unlike some previous studies in which precursors were reinforced to prevent the onset of problem behaviors as they were not harmful, the precursor-based intervention used in this study aimed to decrease both the precursor and SIB. Given that precursors are often socially inappropriate or harmful (Lalli et al., 1995), the outcome of this study suggests that a precursor-based treatment can be a feasible and practical treatment option for severe problem behaviors, enabling individuals with severe behavioral problems to acquire an alternative, appropriate behavior. In addition, only the independent FCR occurring within the allotted time frame was reinforced, which led the precursor and problem behaviors to be extinguished more successfully, compared to prior research where FCR was prompted contingent on the occurrence of the precursor (e.g., Langdon et al., 2008; Najdowski et al., 2008). Because the precursor was used as a signal to prompt the FCR, and then followed by reinforcement, the precursor and FCR may become a chained event, resulting in the reinforcement of the precursor. Lastly, in the present study, mult FCT was conducted with $S^{\triangle}$ intervals extended over three minutes so that the participant was able to discriminate when the FCR was applicable.

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요 약

전조 행동 기반 다중 스케쥴 기능적 의사소통 중재가
심각한 자해 행동에 미치는 영향: 사례 연구

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기능 기반 중재는 문제 행동을 중재하는데 있어 효과적인 것으로 증명된 근거 기반 중재법이다. 그러나 문제 행동의 기능을 알아내는 것과 관련하여 안전 및 윤리적 문제가 발생할 수 있다. 이 연구는 이러한 문제점을 보완하기 위해 사용될 수 있는 전조행동 기반 다중 스케쥴 기능적 의사소통 훈련(FCT)의 효과를 연구하였다. 연구대상은 심각한 자해행동을 보이는 자폐 스펙트럼 장애를 가진 15세 고등학생이다. 시간 순차적 연관성을 나타내는 통계지표의 하나인 Yule's Q를 사용하여 자해행동에 대한 전조행동을 확인한 후, 전조행동의 기능을 알아내기 위해 기능 분석(FA)을 실시하였다. FA 결과를 바탕으로 전조행동에 대해 FCT 및 강화 스케쥴 약화 중재를 시행하였다. 중재 결과, 기능적 의사소통 반응이 증가함에 따라 성공적으로 전조행동의 감소와 함께 자해행동도 감소하였다. 이러한 결과는 문제행동을 다루는데 있어 강조되고 있는 주 접근인 근거중심, 기능기반 중재가 안전 등의 문제를 야기할 수 있는 심각한 문제행동중재에 있어서도 가능하도록 현실적 대안을 제시한다.

주제어 : 다중스케쥴 기능적 의사소통, 전조행동기반 치료중재, 자해행동

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