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Assessment Methods for Problematic Eating Behaviors in Children and Adolescents With Autism Spectrum Disorder

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Autism spectrum disorder (ASD) can be associated with eating problems. However, currently, there is a lack of established guidelines for assessing and addressing eating behaviors in individuals with ASD. This gap in research exists due to the challenges associated with using traditional assessment methods, which may lead to discrepancies in responses and unintentional potential biases from caregivers. In this review, we provided a comprehensive overview of various eating behaviors commonly observed in individuals with ASD. These behaviors include 1) food neophobia, 2) selective eating, 3) binge eating, 4) food avoidance, 5) chewing and swallowing problems, 6) pica, 7) rumination, 8) rituals, and 9) problematic behaviors. Furthermore, we provide a perspective of utilizing digital tools: 1) augmentative and alternative communication; 2) ecological momentary assessment; and 3) video analysis, behavioral analysis, and facial expression analysis. This review explores existing assessment methods and suggests novel assessment aiding together.

Keywords: Eating disorder; Autism spectrum disorder; Deep learning; Telemedicine.

INTRODUCTION

Autism spectrum disorder (ASD) is a heterogeneous neurodevelopmental disability [1]. Children diagnosed with ASD exhibit a wide range of characteristics, including varying levels of challenges in social interaction, social communication, and inflexibility, as well as varying degrees of co-occurring mental conditions [2]. With varying symptoms and severity, individuals with ASD are required to be diagnosed and treated based on their distinctions. For instance, Grzadzinski et al. [3] stated that the Diagnostic and Statistical Manual of Mental Disorder, Fifth Edition does not include all symptoms assessing ASD due to its considerable heterogeneity. As it should classify the specific sub-criteria within ASD symptoms, we also propose subcategorizing problematic behaviors to include eating-related issues and specify the details of each of the eating behaviors. This allows for more specific criteria for assessing ASD besides the assessment of the Diagnostic and

Statistical Manual of Mental Disorder, Fifth Edition, and other symptoms and deficits should also need to be researched in a similar approach. The association between ASD and food-related difficulties has been established from the early stages of ASD studies [4]. It has been found that a significant proportion of children (approximately 44% to 89%) diagnosed with ASD experience challenges related to feeding [2,5,6]. Despite the prevalence of problematic eating behaviors among individuals with ASD, extensive research on how these individuals should be treated depending on their distinctive eating behaviors has not been undertaken. Therefore, the objective of this review is to explore new assessments to complement the existing assessment approaches. The following introduction will dive into the development and diagnosis of food-related issues among patients with ASD.

Assessment of problematic eating among patients with ASD: research participation competency

Several studies explored the association between eating disorder (ED) and ASD, who could successfully complete questionnaires and participate in research. For example, one study

explored the relation between ED and neurodevelopmental disorders, such as attention-deficit/hyperactivity disorder and ASD [7]. In obese children, two questionnaires were used: the Eating Disorder Examination Questionnaire (EDE-Q) and the Eating Disorder Inventory for Children (EDI-C) [7]. The research implies that patients with ASD are exposed to a higher risk of having problematic eating patterns, yet no specific diagnosis method is outlined. It also suggests that young people with high-functioning ASD can be assessed using ED criteria, as they demonstrated competency in completing participation in the research.

Assessment of problematic eating among patients with severe ASD: challenges in research participation

Regarding severe ASD symptoms, the use of questionnaire forms in a clinical setting has substantial limitations. One study excluded individuals with ASD with verbal deficits or intellectual disabilities (ID). Dell'Osso et al. [8] explored an association between ED and ASD. Notably, in the screening phase, they excluded individuals with verbal disorder or ID who were not able to perform self-reports [8]. Furthermore, there was a case report of a man in his adolescence who had ASD and ED [9]. The patients with ASD showed binge eating episodes and vomiting symptoms that caused substantial weight loss; the patient's symptoms were reported by caregivers due to a deficiency of linguistic ability [9]. This provides an overarching question of how individuals with severe ASD should assess their eating-related behaviors. Given the increasing number of patients who experience severe symptoms, it is important to accelerate the development of assessments for them. While there is existing research on people with higher-functioning ASD, severe ASD has not yet been extensively considered. Given the symptoms of ASD, understanding and completing the questionnaire alone can be challenging, resulting in reliance on a caregiver to complete the questionnaire and report symptoms. At the same time, it is crucial to note that caregivers' reports have a high chance of bias, potentially leading to reduced sensitivity and specificity. The key point here is that some individuals with ASD were able to successfully participate in the study without any communication issues. People with severe ASD who are not capable enough to give their accurate opinions or express themselves may experience difficulty in answering each question in the clinical assessment questionnaires.

Importance of assessment of eating behaviors: ASD medication adverse effects aspects

The importance of acknowledging problematic eating behaviors among ASD is crucial as food-related issues are prevalent. One of the reasons for this issue may stem from the ad-

verse effects of psychiatric medication. Methylphenidate is beneficial for hyperactivity and attention deficits; however, according to parental reports, reduced appetite was reported as an adverse effect [10]. Clozapine is used for disruptive behaviors among ASD; however, several studies found that it is associated with gastrointestinal issues, such as constipation [11]. Other antipsychotics used in ASD treatment, such as olanzapine and risperidone, were also associated with constipation [11]. Several studies have reported weight gain as a medicinal adverse effect among patients with ASD. Individuals taking antipsychotics, such as risperidone, may experience weight gain due to a rapid increase in appetite [12]. Risperidone, an effective medication for individuals with ASD, intervenes in problematic behaviors, such as aggression and self-injury [13]. As medication is imperative for patients with ASD to safely interact with others and maintain a good quality of life, its role is essential. However, substantial weight gain as an adverse drug effect remains a concern. Weight gain leads to consequences, such as a higher likelihood of isolation or bullying in social settings [14,15]. Additionally, there is a high chance of developing type 2 diabetes mellitus [16,17]. Despite the severe side effect of weight gain due to medication in managing ASD symptoms, a study found that discontinuing medication causes a rapid return of the problematic behaviors [13]. This highlights the challenge of discontinuing the medication despite the side effects of weight gain.

Importance of assessment of eating behaviors: treatment aspect

The significance of exploring each eating behavior in ASD can lead to the development of better treatments. To address these problematic eating behaviors, the widely used intervention for ASD behavioral issues is applied behavior analysis (ABA) [18], considered applicable to most aforementioned behaviors. Concerning food-related behaviors in ASD treatment, Roane et al. [18] suggested that functional behavioral assessment in ABA is effective in intervening in atypical eating behaviors in ASD. However, treatment intervention may vary when targeting specific behaviors. A case report found that using glucagon-like peptide-1 agonists not only positively impacts weight loss but also relieves repetitive thoughts or behaviors and impulsive behaviors [19]. This indicates that behavioral problems during food intake can potentially be intervened by glucagon-like peptide-1 agonists. When individuals show reluctance to eat, cyproheptadine may be useful as it is known to be an effective medication for treating anorexia nervosa by enhancing appetite [20]. In this context, we suggest developing tailored interventions and medication together for each food-related behavior to achieve high efficiency.

Aim and scope of the review

In consideration of the overall context, this review aims to provide existing questionnaires and introduce digital assessment tools to aid in making more precise assessments for problematic eating behaviors in patients with ASD (Fig. 1).

QUESTIONNAIRE FOR PROBLEMATIC EATING BEHAVIOR FOR ASD

There are various aspects of problematic eating behaviors for ASD in the Aut-Eat Questionnaire (AEQ) [21]. The problematic eating behavior section in the AEQ questionnaire examines six domains: eating sameness and rituals, overeating, chewing and swallowing problems, food selectivity, problem behaviors during mealtime, and food avoidance [21]. We utilize the questionnaires to broaden and specify additional behaviors within the following categories: food neophobia, selective eating, binge eating, food avoidance, chewing and swallowing problems, pica, rumination, ritual, and problematic behavior (Table 1).

Food neophobia

Food neophobia refers to the behavior of avoiding novel foods [22]. Martins et al. [23] used the Food Neophobia Scale (FNS) [24] to explore eating behaviors between children with and without ASD, although the FNS scale was not developed
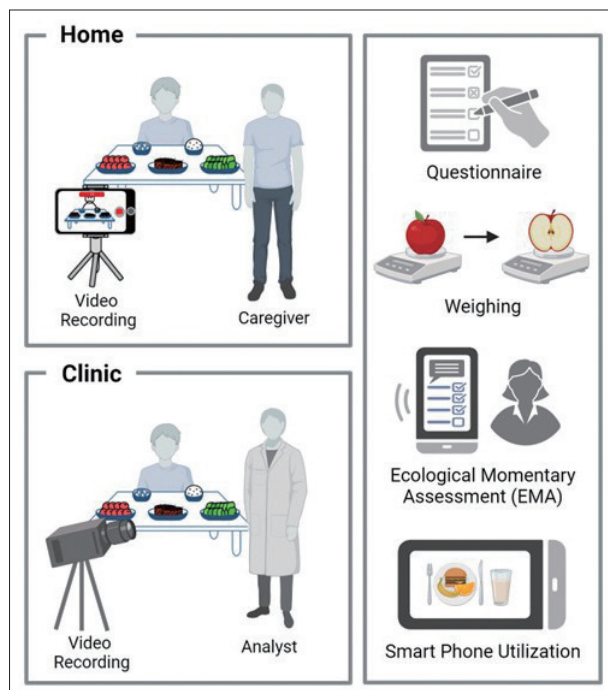

Fig. 1. Overview of assessment in atypical eating behaviors in individuals who need special assistance. This figure was created using BioRender (https://www.biorender.com/).

exclusively for the child age group [24]. Another study by Kral et al. [22], used the Child Food Neophobia Scale for ASD, employing different versions—the original version [25] and a modified version [26].

In a separate study, a modified version of the Child Food Neophobia Scale was used, consisting of only six questions rated on a 4-point Likert scale [22]. These questions primarily focused on whether children trust new foods, their feeling toward new foods, and their willingness to eat new foods [22].

Selective eating (food fussiness)

The terms "food selectivity" and "picky eating" require clarification, since some individuals perceive them to be highly similar. Picky eating occurs when people have a limited choice of what they eat [24,27-29]. Conversely, "food selectivity" indicates a situation where people insist on having specific types of foods with particular textures or colors [28]. Matheson et al. [30] found that children with ASD consume a higher quantity of high-calorie foods, such as sweetened beverages and snacks rather than vegetables and fruits [30-32]. This suggests that food selectivity regarding these items may cause severe health problems. The AEQ can be used for the assessment of selective eating. It is designed for the use of caregivers and includes general information about individuals, containing 44 items with a 6-point Likert scale response [33]. Seiverling et al. [5] used the Food Preference Inventory (FPI) to determine what caregivers and patients have eaten. This helped identify issue and plan strategies to address problematic behavior.

Binge eating (overeating)

Nickel et al. [34] found that 4.7% of their research participants with ED, including binge eating disorder, were also diagnosed with ASD. While studies on the diagnosis of ED and ASD have been extensive, exploration of binge eating symptoms among patients with ASD remains limited. One available research study on binge eating within patients with ASD involved a case study of an individual who took antipsychotics, and this study observed the individual's symptoms and weight loss over time [19]. Compulsive behavior can contribute to binge eating or loss of control of pace during eating [21,35]. Additionally, maintaining routine and repetitive behavioral patterns have been linked to selective eating [33]. The AEQ is a tool that can be used to assess binge eating behavior. Moreover, overeating symptoms among individuals with autism can be used in ASDs-comorbid for children (ASD-CC) [36]. Worley and Matson [37] utilized this assessment in their research [36,37].

Food avoidance

Food avoidance refers to an inability or refusal to eat cer-

Table 1. Types of autism spectrum disorder's problematic eating behavior with its assessment's tools (questionnaire and suggested digital tools)

ASD problematic eating behaviors	Questionnaires	Digital tools
Food neophobia	• Food Neophobia Scale (FNS) • Child Food Neophobia Scale	• Augmentative and Alternative Communication (AAC)
Selective eating	• Aut-Eat Questionnaire (AEQ) • Food Preference Inventory (FPI)	• Ecological Momentary Assessment (EMA)
Binge eating	• Aut-Eat Questionnaire (AEQ) • Autism Spectrum Disorders-Comorbid for Children (ASD-CC)	• Video analysis
Food avoidance	• Aut-Eat Questionnaire (AEQ) • Screening Tool of Feeding Problems (STEP)	
Chewing and swallowing problem	• Screening Tool of Feeding Problems (STEP) • Aut-Eat Questionnaire (AEQ)	
Pica	• Swedish Eating Assessment for Autism Spectrum Disorders (SWEAA)	
Rumination	N/A	
Ritual	• Aut-Eat Questionnaire (AEQ)	
Problematic behavior	• Aut-Eat Questionnaire (AEQ)	

ASD, autism spectrum disorder; N/A, not available

tain foods, potentially leading to inadequate meeting nutrition levels [21,38]. Children with ASD who exhibit food avoidance can be assessed using the AEQ. In addition, Kral et al. [22] identified that unusual oral sensitivity contribute to individuals with ASD avoiding specific types of foods. Dunn examined children's sensitivity using the 125-item Sensory Profile Caregiver Questionnaire, aiding those requiring special assistance in completing the questionnaire [39]. This questionnaire comprises nine factors measuring various areas, including the oral sensory sensitivity subscale, relevant to problematic eating behavior in individuals with ASD [22]. Furthermore, food avoidance might also be related to self-injury and aggression during food intake. This can be measured by the Screening Tool of Feeding Problems (STEP) [40], which is already used for adults with ID, but it is not yet validated for use in patients with ASD, representing a limitation in our review [5].

Chewing and swallowing problems

Chewing and swallowing problems are commonly observed among individuals with ASD and can have negative impacts, such as a high risk of choking and malnutrition [21,41-43]. One of the swallowing issues in people with ASD could be aspiration, defined as the passage of a substance, such as a liquid or foreign body, from the mouth or upper gastrointestinal tract into the lungs [44]. Individuals who repeatedly ruminate or vomit food into their airways are at risk of aspiration, choking, and pneumonia [45]. The STEP [40] assesses aspiration, food selectivity, feeding skills, food refusal, and rumination [5,40]. Chewing and swallowing information can

be referred to as a subscale of aspiration in the questionnaire [5]. A possible limitation of the questionnaire is that it is intended for adult use, and not for children [5]. However, the STEP [40] is highly useful because it focuses not only on ASD but also on ID. This is particularly relevant because individuals with the comorbidity of ASD and ID may face greater difficulty completing the questionnaire compared to those with ASD alone. For children with ASD to assess their problematic eating behavior, the AEQ can be utilized for assessment [21].

Pica

Pica is characterized by consuming or chewing of non-edible materials, such as soil or bottle caps [46]. This behavior is more likely to be exhibited by individuals with ASD and ID, and its comorbidity implies a severe impact [21,47,48]. Kern et al. [49] investigated interventions utilizing reinforcement for individuals with developmental disability, including autism or severe mental retardation, which effectively reduced pica symptoms involving the consumption of nonedible material. Nisticò et al. [50] investigated high-functioning ASD with atypical eating that included pica symptoms using the Swedish Eating Assessment for ASDs (SWEAA). It consists of eight subscale and two single items: 1) Perception, 2) Motor control, 3) Purchase of food, 4) Eating behavior, 5) Mealtime surroundings, 6) Social situation at mealtime, 7) Other behavior associated with disturbed eating, 8) Hunger/satiety, 9) Simultaneous capacity, and 10) Pica [51]. This review highlights the importance of Pica. We suggest that the SWEAA is a useful tool to assess pica behavior in patients with ASD.

Rumination

Rumination is an eating problem that can be observed in children and adolescents with ASD, characterized by the repeated regurgitation and swallowing of recently consumed food [52]. Rumination can lead to stomach acid reflux and tooth erosion [53]. In severe cases, eating becomes painful and can even lead to food refusal [46]. While adolescents and adults with normal intelligence experiencing rumination episodes can be treated with reassurance, explanations, and behavioral intervention [54], these treatments might not be as effective for children with ASD [46]. Tailored treatment for severe ASD is needed to develop effective strategies. To the best of our knowledge, no study has developed or used specific assessment tools to evaluate rumination in patients with ASD.

Rituals

Individuals with ASD commonly follow their own specific repetitive routine, extending to mealtime, where they might demand foods served on plates of a particular color [21,38,55,56]. Eating rituals or repetitive patterns of behavior, including adherence to food types and mealtime rules, are also thought to contribute to food selectivity [38,42,57]. Children with ASD engage in more "ritualistic eating behaviors" when consuming food compared to that in typically developing children. These ritualistic behaviors are patterns that require more specific tools or presentation to consume food. Additionally, children with ASD tend to reject a wide variety of foods due to their routine requirement for specific serving styles or textures of foods [58]. Furthermore, a study comparing the AEQ between ASD and typical developing control groups showed increased ritualistic behavior during meals with age in the ASD group [33]. Ritualistic eating behaviors can be assessed by using the AEQ.

Problem behaviors during mealtime (such as aggression and motor impairment)

Patients with ASD may exhibit aggressive or compulsive behaviors [19]. These behavioral pattern might manifest as signs of aggression and tantrums, potentially interfering with the dining experience within a family setting [21,59]. Aggressions were assessed by using the AEQ [21]. ABA and other psychological treatments have proven most effective for managing these aggressive symptoms [60]. Motor impairment could be a contributing factor during mealtime disturbance, as it is a symptom of ASD. ASD with motor impairment may involve motor skill delays or atypical movement patterns [61-64]. Specifically, fine motor skills, including the use of knives and forks, present challenges [49,65]. Moreover, feeding issues during mealtime among individuals with ASD may be influenced by characteristics, such as limitations in impairment or communication, as explained by Seiverling et al. [5]. Problematic behaviors during mealtime can be assessed using the AEQ.

DIGITAL ANALYSIS TOOLS FOR PROBLEMATIC EATING BEHAVIORS IN PATIENTS WITH ASD

Research findings indicating a potential co-occurrence of symptoms between ED and ASD emphasize the need to develop assessment tools specifically designed for individuals with severe ASD. These individuals may have limited communication abilities that make it challenging for them to complete questionnaire-based assessments. In such cases, alternative methods can be employed to assess problematic eating. When addressing individuals with ASD, the use of digital tools can lead to more accurate assessments by eliminating potential caregiver bias and reducing the need for a third-party involvement. These methods include using digital tools, such as augmentative and alternative communication (AAC),
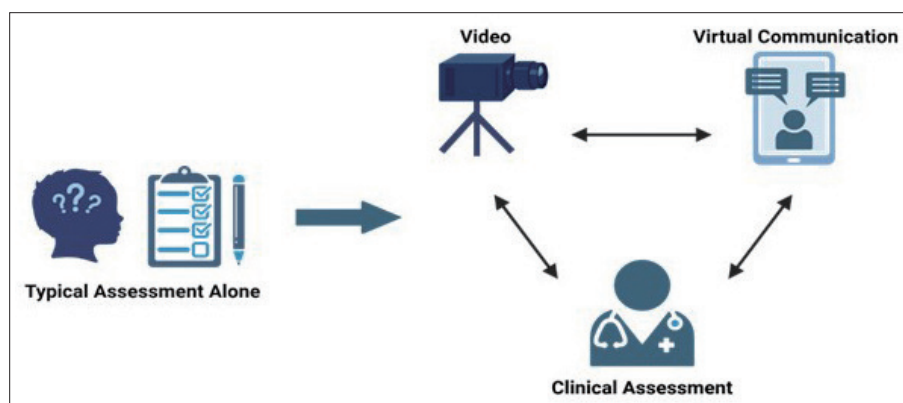

Fig. 2. Overview of utilizing digital tools in assessments. This figure was created using BioRender (https://www.biorender.com/).

ecological momentary assessment (EMA), and video analysis (Fig. 2).

AAC

AAC is a system that helps individuals with limited verbal communication skills, beneficial for those requiring special communication assistance, such as individuals with nonverbal ASD and even those with verbal ASD [66,67]. In recent research, authors designed and demonstrated a collaborative AAC application that supports multiple caregivers to actively participate in AAC-aided communication and record the behaviors of patients with ASD in a home setting [68]. This not only provides an opportunity for individuals to collect more behavioral information in their home environment for a more accurate assessment, but also means that caregivers and patients have the convenience of remotely access healthcare professionals without in-person hospital visits.

EMA

EMA is a digital tool used to collect real-time behavior data [69] and has been used in individuals with ASD [70]. EMA can be employed as an assessment tool in conjunction with questionnaires completed by children's caregivers. Several studies utilized EMA in clinical setting. For example, Mason et al. [71] highlighted its use in assessing eating and dietary intake behaviors in children and adolescents. Similarly, Schaefer et al. [72] employed EMA in ED research, incorporating questions regarding patients' psychological status, such as shame and guilt. This method not only collects real-time nutrition logs but also records psychological data immediately, as opposed to completing questionnaires where individuals require to rely on their memory.

Video analysis

Teleconferencing allows health professionals to have more information for diagnosing disorders by observing patients' natural behaviors [73-75]. Sutantio et al. [74] demonstrated the high validity of telemedicine using a specific protocol of video recording under specified social situations to diagnose ASD in toddlers. Their findings indicate both high sensitivity and specificity, and imply the necessity of using telecare, especially for people who live remotely and face challenges in accessing medical services [74].

Our video analysis encompasses two-fold suggestions: behavioral analysis and facial expression analysis.

Deep learning has recently gained significant attention as a tool for aiding in the diagnosis of ASD. Automated eating behavior analysis using deep learning enables the examination of eating behavior patterns, such as chewing speed and frequency [76]. This video recording deep learning tool is cost-effective and can be easily measured using a smart device [76]. Similarly, one study investigated the number of chews and bites within the same eating episode [77]. Deep learning tools have been applied to study food-related behavior in both animals and humans. Recent use of a deep-learning video analysis tool, DeepLabCut, facilitates the analysis of mice and monkey behaviors in different food-related situations [78]. These advancements in deep-learning video analysis tools promise objective and comprehensive data regarding eating behavior and related mental health states. This review suggests the need for similar approaches for developing appropriate tools for humans, ensuring accurate and efficient methods for analyzing eating behaviors.

In a recent study, a mobile application was developed to capture neural, behavioral, and physical expressions of emotions and recognize emotional experiences using deep learning models based on facial expressions during eating [79]. However, producing appropriate facial expressions might be challenging as individuals with ASD often struggle with proper facial expressions and exhibit fewer facial expressions than others [80]. Considering this deficit in emotional expression, tools to assess its impairment have been developed [80]. Furthermore, Talaat [81] recently researched deep learning techniques (enhanced deep learning) to investigate emotions among ASD with the aim of helping medical practice such as early diagnosis of ASD. Future developments in facial expression assessment tools will expand the analysis of food-related emotions among individuals with ASD, contributing to a deeper understanding of ASD-related impairments.

CONCLUSION

ASD can be associated with ED and problematic eating behavior. However, assessing problematic eating behavior proves challenging, especially for patients with severe ASD. As comprehensive assessment tools tailored for individuals with ASD are still under development, this review addresses methods for assessing problematic behaviors and advocates the use of digital tools to enhance accuracy in ASD assessments. The major areas of problematic eating behaviors in patients with ASD are food neophobia, selective eating, binge eating, food avoidance, chewing and swallowing problem, pica, rumination, ritual, and problematic behaviors. These behaviors can be assessed using tools: FNS, Child Food Neophobia Scale, AEQ, FPI, 125-Item Sensory Profile Caregiver Questionnaire, the STEP, SWEAA, and ASD-CC. Novel digital tools, including AAC, EMA, and video analysis, are also utilized. Considering the symptoms and environment that people with ASD experience, digital tools play a significant role in facilitating in-depth observation for precise assessment and better inter-

vention. The use of digital tools would also help to mitigate potential bias from caregivers when it comes to completing questionnaires or describing the patients' symptoms by providing videos of patients' natural behaviors in their environments. Therefore, this review provides essential exploration of assessments and digital tools utilization to make an accurate evaluation of ASD with problematic eating behaviors.

Availability of Data and Material

Data sharing not applicable to this article as no datasets were generated or analyzed during the study.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: Miji Lee, Seolha Lee, Hyung Jin Choi. Investigation: Miji Lee, Seolha Lee. Project administration: Miji Lee, Seolha Lee, Hyung Jin Choi. Supervision: Hyung Jin Choi. Visualization: Seolha Lee, Miji Lee. Writing—original draft: Miji Lee, Seolha Lee. Writing—review & editing: all authors.

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Funding Statement

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