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RESEARCH ARTICLE

Mand Modality Preference Assessments among High- and Low-Tech Options for Individuals with Intellectual and Developmental Disabilities: A Systematic Review

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Abstract

The extant literature demonstrates that individuals with intellectual and developmental disabilities (IDD) exhibit preferences among communication modalities when multiple modalities are available and produce reinforcement on identical reinforcement schedules. High- and low-tech communication options, such as voice output devices and picture cards, are commonly recommended for individuals with limited vocal communication skills. In this study, we conducted a systematic literature review of research studies that implemented mand modality preference assessments (MMPAs) that included both a high- and low-tech communication option with individuals with IDD. We identified 27 studies meeting our inclusion criteria and summarized the participant demographics, MMPA design and procedural variations, and MMPA outcomes. The results suggested that high-tech communication options were generally more preferred over low-tech options. However, there was a high degree of variability in how the studies were conducted and conclusions were reached. We discuss some of the current research gaps and the implications for clinical practice.

Keywords Mand modality assessment · Preference · Communication preference · Concurrent schedules · Functional communication training · Augmentative and alternative communication

Behavior analysts have long been concerned with increasing the communication of individuals with disabilities and have had a particular interest in increasing appropriate communicative responding for reinforcers (i.e., manding; Reynolds & Risley, 1968). Appropriate manding is a response targeted in common behavioral treatments, including functional communication training (FCT) and mand training. FCT is one of the most researched and successful function-based treatments to reduce challenging behavior exhibited by individuals with intellectual and developmental disabilities (IDD; Carr & Durand, 1985; Tiger et al., 2008). FCT involves teaching an individual an appropriate mand (i.e., a functional communication response; FCR) that results in the reinforcer functionally related to the challenging behavior while simultaneously placing the challenging behavior on extinction. For individuals with IDD who do not exhibit challenging behavior, mand training uses a similar approach to FCT in that an individual is taught a socially acceptable communication response to obtain reinforcers, which are often based on the results of stimulus preference assessments (Sundberg & Partington, 1998). Considerable research has demonstrated the effectiveness of FCT (Ghaemmaghami et al., 2021) and mand training (DeSouza et al., 2017).

Selecting an appropriate mand modality is among the most important steps in FCT and mand training (Houck et al., 2022). Although vocal communication (i.e., spoken language) may be a mand option for some individuals with disabilities, augmentative and alternative communication (AAC), which includes any form of communication except for vocal communication (American Speech-Language-Hearing Association, 2021), must be considered for minimally vocal or nonspeaking individuals. Common forms of AAC include manual sign language, low-tech AAC, and

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high-tech AAC. Low-tech AAC includes nonelectronic/battery powered instruments, such as picture cards, picture exchange communication systems (PECS), and communication boards. High-tech AAC includes electronic devices with speech output, such as microswitches and speech generating devices (SGDs).

Studies have shown that the mand modality selected may affect the outcomes of FCT in several ways. Individuals exposed to multiple mand modalities during training may acquire proficiency (i.e., the ability to use an option independently) with a particular option faster than other options or only reach proficiency with a single option (e.g., Couper et al., 2014). Likewise, Ringdahl et al. (2009) demonstrated that mand proficiency before FCT correlated with intervention success. Several studies have suggested that generalization (McLay et al., 2015; Randall et al., 2021) and maintenance (Achmadi et al., 2014; Couper et al., 2014; van der Meer et al., 2012b) of manding may be greater for one modality than another. In a study related to this, Ringdahl et al. (2018) showed that the persistence of a mand under extinction conditions might be greater for one modality than another, which in the case of individuals who also exhibit challenging behavior may reduce the likelihood of resurgence of challenging behavior. Studies comparing multiple mand modalities have shown that, in some cases, one modality produces a greater reduction of the challenging behavior than another (Ringdahl et al., 2009), and the resurgence of challenging behavior may be greater with one modality than another when both are unavailable or placed on extinction (e.g., Randall et al., 2021; Ringdahl et al., 2018). Although there does not appear to be a consensus as to which mand modality reliably produces the best overall outcomes, the fact that differential effects have been observed when more than one modality has been used illustrates the importance of the mand modality selection process.

Authors of FCT and mand training studies usually omit information regarding the selection process or the specific reason(s) for choosing a particular mand modality (Houck et al., 2022), but exceptions exist. For example, Valentino et al. (2019) demonstrated that prerequisite skills, such as motor and vocal imitation, as well as matching two- and three-dimensional stimuli, could be used to identify an "optimal" mand modality for mand training with young children with disabilities. It is more common for studies to describe and empirically demonstrate the benefits of using one modality over another. For example, Bailey et al. (2002), Horner and Day (1991), and Richman et al. (2001) showed that mand modality options requiring less response effort (e.g., touching a picture card) or offering greater discriminability for use (e.g., pictures) were better options for individuals with limited physical abilities or discrimination skills and produced better treatment outcomes. Studies have also demonstrated better treatment outcomes when the mand modality chosen was based on an individual's baseline proficiency (e.g., Ringdahl et al., 2009), speed of acquisition (e.g., Adami et al., 2017; Valentino et al., 2019), or previous experience with a particular modality (e.g., Winborn et al., 2002). Other studies have elected to use a mand option based on its portability (e.g., manual sign) or ease of recognition by a conversation partner (e.g., picture card or device; Durand, 1999). However, practitioners and AAC users will likely find benefits and drawbacks to any mand modality option. For example, the manual sign option offers high portability because it requires no additional equipment (e.g., picture cards or a device), but it can be difficult to acquire proficiency due to the necessary finger and hand manipulations required to produce many signs (Achmadi et al., 2014; Couper et al., 2014), and it has produced less robust treatment effects during FCT than other modalities (e.g., Heath et al., 2015). Moreover, the manual sign is more likely to have a limited audience who understand and can respond to the manual signs (Tiger et al., 2008).

Another important consideration when choosing a mand modality is the individual's preference. There are several potential benefits to incorporating an individual's preferred mand modality during FCT and mand training. Studies have shown that preference for mand modality may be associated with more rapid acquisition (Couper et al., 2014; van der Meer et al., 2012a, b, c) and better maintenance of positive outcomes for the preferred modality relative to a less preferred modality (van der Meer et al., 2012b, c). In addition, Ringdahl et al. (2018) found that using high-preferred modalities resulted in greater persistence in manding relative to low-preferred modalities when each modality contacted extinction. Apart from more positive outcomes, consideration of an individual's preference for mand modality has been identified as a way to promote individual autonomy by allowing people to determine the methods that they prefer to use when communicating with others (van der Meer et al., 2011; Sigafoos et al., 2005).

Preference for mand modality is typically determined by response allocation (i.e., frequency or percentage of opportunities each modality is selected) during a mand modality preference assessment (MMPA). MMPAs may be conducted using a concurrent operants arrangement whereby each mand option is available and, when used, provides direct reinforcement (e.g., Ringdahl et al., 2016; Winborn-Kemmerer et al., 2009) or a concurrent chains arrangement whereby a modality is selected (sometimes using pictures representing the mand options), resulting in the opportunity to mand using the selected mand option (e.g., Achmadi et al., 2014). Although vocal communication is rarely included in

MMPAs, various AAC options such as manual signs, low-tech communication aids (e.g., picture cards), and high-tech communication aids (e.g., SGDs) are frequently evaluated in groups of two or three modalities.

Several reviews of AAC usage among individuals with IDD have been conducted, but only a few have described preference data from MMPAs (Aydin & Diken, 2020; Carnett et al., 2021; Lorah et al., 2022; van der Meer et al., 2011). Among those that have, high-tech AAC has generally been more preferred over low-tech AAC overall, but the difference between them has varied considerably across reviews. For example, Carnett et al. (2021) reported that 52% of participants in the studies they reviewed preferred high-tech AAC options, whereas Lorah et al. (2022) reported that 84% of participants in the studies they reviewed similarly preferred high-tech AAC options. This discrepancy may be partly due to the limited number of studies and participants in each review. To date, reviews including MMPA outcome data have been composed of a small range of studies (between 7 and 14 studies, ranging from 12 to 42 participants), mainly due to restrictions on the populations studied (e.g., ASD only; Aydin & Diken, 2020; Lorah et al., 2022), the dates of study inclusion (e.g., last 5 years; Carnett et al., 2021), or because the review was conducted more than 10 years ago (e.g., van der Meer et al., 2011). Moreover, within these reviews, little attention has been paid to participants' magnitude of preference (i.e., the degree to which one mand modality was selected) and the methodological and procedural variations used to conduct the MMPAs. Thus, a more inclusive review focused solely on preference for AAC that includes information on the magnitude of preference and procedural variations of MMPAs seems warranted.

In light of some of the restrictions and knowledge gaps of previous literature reviews on MMPAs, in the current study, we conducted a systematic literature review using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Page et al., 2021) guidelines to synthesize a more inclusive research literature base on MMPAs that included high- and low-tech AAC options for individuals with developmental disabilities. As part of this review, we sought to answer three broad questions:

1. What were the outcomes of the MMPAs, relative to high- and low-tech communication modalities, with particular attention paid to the magnitude of preference (i.e., the percentage of selections of a modality during MMPA trials)?
2. What are the characteristics of the participants included in studies using MMPAs?
3. What procedural and methodological variations were used to conduct MMPAs?

Method

Search Strategy

A doctoral student in psychology and a faculty psychologist conducted primary and reliability searches of electronic databases, respectively. We used the PRISMA (Page et al., 2021) guidelines for the systematic literature review. We identified studies using PsycInfo and ERIC (via EBSCO), Scopus, and PubMed that included any of the multiple variations related to two main concepts: (1) preference and (2) communication. Appendix 1 details the exact terms and parameters used in the search strategy.

Inclusion and Exclusion Criteria

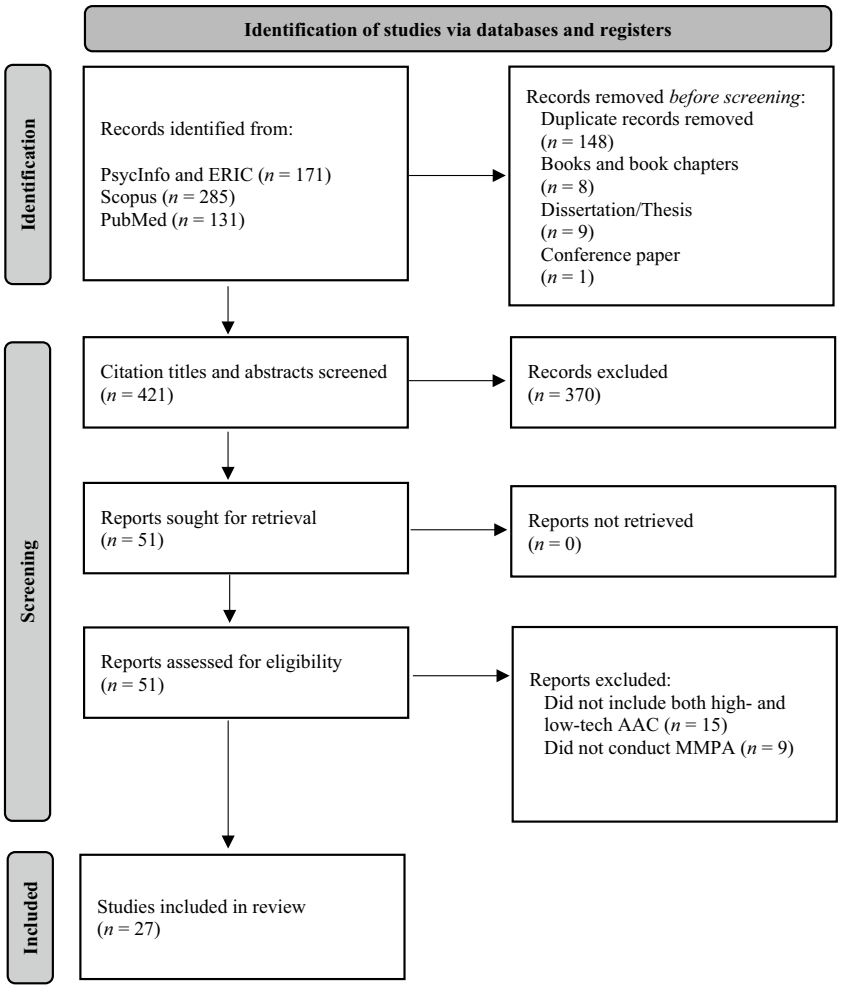
Inclusion and exclusion criteria were determined a priori. Criteria for inclusion were that the study (1) was an empirical study published in an English language peer-reviewed publication; (2) included an MMPA composed of at least one high-tech and one low-tech AAC option; (3) reported the results of the preference assessment in text or figures; and (4) included participants with developmental disabilities. Studies using FCT or mand training procedures were included and not delineated for the purpose of this review. There were no limitations on publication year. Reviews and unpublished dissertations were excluded.

We focused on high- and low-tech AAC options because vocal communication is infrequently included in MMPAs, and manual sign is rarely preferred over other AAC options (see Aydin & Diken, 2020). However, we did not exclude any studies in this review that included vocal or manual signs, as long as the study also included both high- and low-tech AAC options.

Study Selection

Figure 1 displays the PRISMA flow diagram. The database search was conducted in February of 2023 and yielded 587 citations. After screening for duplicates, books, book chapters, dissertations/theses, and conference papers, 421 unique citations were assessed for eligibility. Title and abstract screening for inclusion and exclusion criteria resulted in 51 articles for full-text assessment of eligibility. Twenty-four additional articles were excluded after full-text assessment, resulting in 27 studies that met full inclusion criteria. Interrater agreement (IRA) was

Fig. 1 PRISMA flow diagram



calculated using a point-by-point agreement approach and was 100% for the initial search, 97.4% for the title and abstract screening, and 100% for articles meeting full inclusion (i.e., the final list of studies eligible).

Data Extraction and Interrater Agreement

Data on participant demographics (e.g., age, race, gender, level of cognitive functioning), MMPA procedures (e.g., timing, assessment type, mand options included), and MMPA outcomes (i.e., percentage of selections of each mand option across MMPA trials) were extracted from each study by the same individuals who conducted the primary and reliability searches. For articles that did not provide specific outcome data on the MMPA in table or text but included a graphical display of data, WebPlotDigitizer (Version 4.5; Drevon et al., 2017) was used to extract the data. WebPlotDigitizer is a computer software program that digitally converts graphed data points into graphed values. To examine the distribution of all participants' MMPA outcomes by magnitude of preference (i.e., the percentage of selections made for their most preferred modalities), we calculated the percentage of participants whose magnitude of preference for their most preferred modality fell between a range of magnitudes, beginning with 51% to 59% of MMPA trials, up to those who selected a modality for 100% of trials. Operational definitions for all variables evaluated in this review are included in Appendix Tables 3, 4 and 5. Reliability data were collected for 20% of all data extracted across all variables, and IRA was calculated using three metrics percent agreement, Cohen's Kappa, and Intraclass correlation, using IBM SPSS Statistics (Version 28). Percent agreement was calculated for all variables, resulting in a mean of 96% (range: 79%–100%). Cohen's Kappa was calculated for all variables with nominal data, resulting in a mean coefficient of 0.93 (range: 0.46–1.00). Intraclass correlation coefficients (ICC) were calculated for variables measured with interval or ratio data, resulting in a mean coefficient of 0.97 (range: 0.87–1.00). IRA, including percent agreement and either Kappa or ICC for each variable, is provided in Appendix Tables 6, 7 and 8.

Results

Participant Characteristics

Across the 27 studies included in this review, there were 97 total participants. However, among those participants were nine individuals whose MMPAs did not include both high- and low-tech AAC options and four individuals that did not receive an MMPA at all. Thus, 84 total participants across 27 studies were included in this review. Demographic data for the 84 participants are shown in Table 1. The majority of subjects were male (82%), diagnosed with autism spectrum disorder (75%), and under the age of 10 years (69%). Participant race/ethnicity was only reported for 5 of the 27 studies (19%), and language spoken in the home was only reported in four studies (15%). The second most common diagnosis was intellectual disability (ID), at just under half of all participants (42%; 35 of 84); however, this number is likely an underestimate as 11 studies (41%), totaling 49 participants (58%), did not provide information on cognitive level for the participants or indicate whether participants had ID. Eighty-one percent of the studies included information on participants' AAC history; among those that did, more than half (58%) of the participants did not have any prior history with high- or low-tech AAC. A much higher percentage of participants with prior AAC training had previous training with low-tech AAC (22 participants or 26% overall and 19 participants or 23% with low-tech only) relative to high-tech AAC (4 participants or 5% overall and 1 participant or 1% with high-tech only). More than half of all participants (48 participants or 57%) were reported to be nonvocal, but no information on vocal communication was provided for three studies (11%), including 13 participants (15%). Sixteen studies (59%) included information on participants' challenging behavior, mainly consisting of tantrums (13 participants or 15%), aggression (nine participants or 11%), and self-injury (eight participants or 10%). Once again, these outcomes likely underestimate the actual proportion of participants exhibiting challenging behavior because 41% of the identified studies (including 53 participants) did not report whether participants exhibited challenging behavior. No study explicitly stated that a participant did not exhibit challenging behavior.

MMPA Procedures

MMPA procedures varied substantially across the reviewed studies along several dimensions, including the functional context (i.e., type of reinforcer the mand functions for), specific schedule type, the timing of the assessment, manner of data collection and reporting, and the number of mand options within the MMPAs. Among 15 studies (55%) that reported

Table 1 Characteristics of participants included in the systematic literature review

Participant Characteristics	$N = 84$
Age in years, mean ± *SD* (range)	9.9 ± 10.3* (2–68 years)
Gender, males—*N* (%)	69 (82%)
Race or Ethnicity—*N* (%)	
White/Caucasian	5 (6%)
International (including Vietnamese, Chinese, Malay)	4 (5%)
Native Hawaiian/Pacific Islander	3 (4%)
Hispanic	3 (4%)
Black/African-American	1 (1%)
Asian/Asian-American	— (0%)
Not reported or undetermined	68 (81%)
Primary language spoken at home (Child and/or Family)	
English	7 (8%)
Dutch	4 (5%)
Mandarin	2 (2%)
Malay	1 (1%)
Maltese	1 (1%)
Spanish	1 (1%)
Not reported	69 (82%)
Diagnosis	
Autism spectrum disorder	63 (75%)
Intellectual disability (ID)	35 (42%)
Down syndrome	4 (5%)
Seizure disorder	4 (5%)
Other (e.g., neurologic disorder, speech and language impairment, Rett syndrome, Angelman syndrome)	15 (18%)
Cognitive ability (level)	
Severe/Profound ID	11 (13%)
Moderate ID	3 (4%)
Mild ID	— (0%)
ID—not specified	21 (25%)
Not ID or not reported	49 (58%)
AAC communication history	
Previous training with low-tech only (e.g., PECS)	19 (23%)
Previous training with low- and high-tech	3 (4%)
Previous training with high-tech only	1 (1%)
No history of AAC training	49 (58%)
Not reported	11 (13%)
Vocal communication skills	
Nonvocal	48 (57%)
Vocal (including echolalia)	23 (27%)
Not reported	13 (15%)
Challenging behaviors—*N* (%)	
Tantrum	13 (15%)
Aggression	9 (11%)
Self-injury	8 (10%)
Property destruction	5 (6%)

Table 1 (continued)

Participant Characteristics	$N = 84$
Disruptive behavior	2 (2%)
Elopement	2 (2%)
No challenging behavior or none reported	53 (63%)

*Beck et al., 2008, did not include the ages for two participants

the presence of challenging behavior among participants, 6 studies (40%) reported using a functional behavioral assessment (FBA; e.g., functional analysis, descriptive assessment, indirect assessment) to inform the functional context for the MMPA procedures. Overall, less than one quarter (6 studies or 22%) of studies used an FBA. This number may seem low, but given that most studies either did not report on participants' challenging behavior or included participants with no challenging behavior, it may be that an FBA was not warranted for many participants. Except for the 6 studies that conducted an FBA, only 2 of the remaining 21 studies (10%) provided an explicit rationale for why they chose the functional context. Of the studies that conducted an FBA, half of the participants displayed a tangible function (four participants or 50%), followed by escape (two participants or 25%) and attention (two participants or 25%). Only one participant was reported to have challenging behavior maintained by multiple functions, and the MMPA was conducted across both functions. Only studies that employed an FBA used a context other than tangible for the MMPA. Among the studies that conducted the MMPA within a tangible context, an equal number (10 studies or 42%) included a combination of toys and edibles and toys only, whereas a small number used edibles only (four studies or 16%). Tangibles and/or edibles were most often identified via preference assessment (21 studies or 84%).

The schedule type for MMPAs was similar across all studies, but the specific procedures varied. All studies reported using a concurrent schedule arrangement, with 63% employing a concurrent operants arrangement and the remaining 37% using a concurrent chains arrangement. For studies utilizing a concurrent operants arrangement, a selection response indicating preference was recorded when a participant used one of the available communication options to mand (e.g., touch a card, activate a device). The selection response for studies using a concurrent chains schedule varied, with four studies (40%) recording preference when a participant touched one of the communication options, two studies (20%) recording preference when a participant reached toward a communication option, and one study (10%; Stasolla et al., 2014) recording preference when a participant gazed at a single option for at least 3 s. Two studies (20%) indicated a concurrent chains schedule was used but did not specify how a response selection was recorded. Fifteen studies (55%) reported controlling for placement bias across trials or sessions, 2 studies reported that they did not control for placement bias, and 10 studies (37%) did not report any information on placement or control for placement bias.

Data collection for MMPAs was based on a fixed session duration or a fixed number of trials. Seven studies (26%) used a fixed session duration of either 5 or 10 min, whereby the number of selection opportunities depended upon how quickly a selection was made and the programmed reinforcement magnitude (e.g., 60 s). Thus, fewer than five opportunities were likely for a 5-min session with a 60-s reinforcement interval. This approach reported a preference for a particular modality as a percentage of opportunities selected or responses per minute selected. For 20 studies (74%), sessions (or "probes") consisted of a fixed number of trials, ranging from 1 to 10, with each selection resulting in a specific duration of reinforcement (e.g., 60 s). In the fixed trial approach, preference for a particular modality was reported as a percentage of trials selected.

The number and timing of MMPA administrations varied, with most studies (16 studies or 59%) conducting the MMPA only once, most often after a training or acquisition phase. Ten studies (37%) conducted at least one MMPA before intervention/training, and seven (26%) conducted at least one MMPA in a maintenance/follow-up phase. One study (McLay et al., 2015) conducted MMPAs during six phases (baseline, intervention, postintervention, generalization, follow-up, and long-term follow-up).

Although MMPAs were conducted at various time points, all studies included a training phase that allowed participants to develop or demonstrate proficiency with the mand options compared to the MMPAs. Many definitions for proficiency were used, with most studies requiring participants to use a mand option independently and with accuracy 80% or more of the time across multiple sessions. Of the studies reporting data on proficiency, 92% of participants (68 out of 74) developed proficiency with both the high- and low-tech options.

More than half of the studies (16 studies or 60%) used only two mand options (i.e., one high-tech and one low-tech option) during the MMPA, and the remaining (11 studies or 40%) included three or more options, with the third option usually being a manual sign. Although all studies used a similar form of a low-tech option (i.e., picture card, PECS card, or PECS book), the most common high-tech option was Proloquo2Go, which was used by more than half (44 participants or 52%) of the participants. BIGMack switches (12 participants or 14%) and GoTalk devices (10 participants or 12%) were also more common than other high-tech options. Studies varied on the number of items or activities a participant could mand for with the high- or low-tech option during MMPA trials. For example, Ganz et al. (2013) included both a high-tech (i.e., iPad with PECS Phase III application) and low-tech (i.e., PECS communication book) modality and each modality was set up so that

participants could mand for one of four different stimuli that were depicted as pictures or icons on the communication modalities. Just under half of all studies (13 studies or 48%) included only one general mand (e.g., "more" or "toys") on each communication modality. However, nearly as many studies (12 studies or 44%) included three or more mand options for each modality, which were often associated with the specific tangibles/edibles that were available.

In addition to measures of individual preference, some studies included other social validity measures, such as caregiver or teacher preference for mand options. Several studies noted that teacher or parent familiarity or the cost of AAC influenced their decisions on what options to include in the study. However, only four studies (15%), with a total of 11 participants (13%), asked either caregivers (three studies and 5 participants) or teachers (one study and 6 participants) for their preference for mand modality.

Outcomes of MMPAs

As noted previously, studies conducted MMPAs at various points throughout each study. This distribution of MMPAs and the differences in MMPA session duration/number of trials contributed to a substantial range in the total number of MMPA trials conducted across participants, ranging from 1 to 200. Fourteen participants (17%) received more than 100 total MMPA trials, and 10 participants (12%) received fewer than 10 total trials. More often, participants received between 20 and 49 trials (33 participants or 39%) or between 50 and 99 trials (22 participants or 26%).

The wide range of trials calls into question the systematic nature of defining what constitutes a preferred modality. Only 22% of studies ($n = 6$) provided guidelines regarding how the authors determined preference. For those studies that provided this information, a determination of preference was often based upon reaching a specific percentage of trials where a mand option was chosen—either 70% or 75% (four studies or 15%; e.g., Ganz et al., 2013)—or selecting one option more than another for five consecutive sessions (two studies or 7%; e.g., Ringdahl et al., 2016). In some studies, an explicit definition of preference was not offered; however, a mand option was identified as "preferred" or "slightly preferred" even when it was selected in slightly more than 50% of MMPA trials (Ganz et al., 2013; Falcomata et al., 2010; Sigafoos et al., 2009; van der Meer et al., 2012a).

Given that preference may be defined in several ways, it may be beneficial to view outcomes based on different thresholds (i.e., percentage of selections that would indicate preference), timing (i.e., the point at which MMPAs were conducted), and in strict high- versus low-tech comparisons (i.e., eliminating choices for vocal or manual sign options). Regarding thresholds, we evaluated both a simple majority threshold (i.e., choosing one option on 51% or more opportunities) and a 70% threshold. In terms of MMPA timing, we considered the total number of selections from all MMPAs within a given study and those from MMPAs conducted after acquisition (or during training for those that did not have a postacquisition phase). This latter measure was used to exclude baseline MMPA data, which was collected before a participant had been trained on the mand modalities, and generalization and long-term follow-up MMPA data, which were conducted at variable intervals following acquisition across studies. We also analyzed MMPA selections between low- and high-tech options after acquisition but excluded other selection options, including vocal mand and manual sign, and trials where no selection was made.

Table 2 summarizes the MMPA outcomes for all studies included in the review and shows the distribution of participants' selections of their most preferred modality by magnitude. In the studies that included vocal and manual sign options, neither were ever the most preferred communication option; however, for 4% of participants ($n = 3$), manual sign was chosen more than a low-tech option overall but less than a high-tech option and still well below the 51% threshold. When total selections for all MMPAs within each study were considered (i.e., including all phases and options), 74% of participants ($n = 62$) selected a high-tech option more often than a low-tech or other option. When the threshold for preference was increased to 70% or greater, most participants still selected a high-tech option more often, but the overall percentage dropped to 55% ($n = 46$). Four participants (5%) selected neither a high- nor a low-tech modality for more than 50% of total MMPA trials and one of those participants selected high- and low-tech options equally (i.e., 50% each). Similar outcomes were observed during the Intervention/Post-Acquisition Phase. More participants preferred high-tech options than low tech-options, regardless of threshold (77% and 62% for the lower and higher thresholds, respectively). When only considering high- and low-tech options during intervention or postacquisition phases, an even greater difference in preference was demonstrated. Eighty percent of participants ($n = 67$) chose the high-tech option over the low tech-option using the lower threshold, and this number was only slightly lower (59 participants or 70%) when considering the higher threshold. Thus, the high-tech option was selected substantially more than the low-tech option regardless of the point of comparison or the threshold used.

Discussion

Overall, MMPA outcomes were relatively consistent across the reviewed studies. High-tech AAC options were more preferred over low-tech options regardless of how preference

Table 2 Percentage of participants' selections by magnitude of preference

	Distribution of Participants' Selections by Magnitude						By Threshold	
	51%–59%	60%–69%	70%–79%	80%–89%	90%–99%	100%	51% or more	70% or more
Overall[a, b]								
Low	5%	2%	5%	2%	1%	5%	20%	13%
High	8%	11%	10%	10%	17%	19%	74%	55%
Intervention/Post-Acquisition Phase[a, b, c]								
Low	4%	1%	4%	1%	1%	4%	16%	11%
High	11%	5%	9%	14%	18%	20%	77%	62%
Intervention/Post Acquisition Phase— Low vs. High Only[b, c]								
Low	3%	3%	5%	1%	3%	4%	18%	13%
High	4%	7%	9%	12%	22%	26%	80%	70%

This table presents the distribution of participants' selections during mand modality preference assessments (MMPAs) by the magnitude and a comparison of preference at two thresholds (i.e., 51% or more and 70% or more). In addition, MMPA selection data are presented for all MMPAs conducted across all studies (top two rows), for MMPAs conducted during the Intervention or Postacquisition Phase only (middle two rows), and during the Intervention or Postacquisition Phase for the high- and low-tech options

[a] For four participants, no option reached the 51% threshold overall during the Intervention/Postacquisition Phase

[b] One participant selected the high-tech option and the low-tech option equally

[c] Two studies (eight participants) did not conduct an Intervention or Postacquisition MMPA

was defined. This finding is consistent with previous reviews on MMPAs (Aydin & Diken, 2020; Carnett et al., 2021; Lorah et al., 2022; van der Meer et al., 2011) but across a more inclusive selection of studies that varied to a greater extent than existing reviews in terms of participants' demographics and study procedures. The reviewed studies included participants across a wide range of ages, vocal communication skills, and AAC training history. In terms of the research designs and procedures, most studies used the same concurrent operants or concurrent chains schedule arrangements to measure preference. However, they varied substantially in how they defined preference (among the few that did so), the degree to which the stability of an individual's preference was measured over time, the total number of MMPA trials conducted, and the timing of the MMPA within the assessment to treatment continuum (e.g., during baseline, training, posttraining).

Despite the important findings gleaned from these studies, there are several gaps that a synthesis of the reviewed studies could not fill. Studies included in this review generally did not report on participant characteristics sufficiently. Race and ethnicity were rarely reported, and the language(s) spoken within the participants' homes were only reported in 15% of the articles. Other important variables, such as cognitive functioning level, challenging behavior, and comorbid diagnoses, were also underreported. Research in behavior analysis has historically underreported demographic variables (Jones et al., 2020; Li, 2017), and the paucity of information in these studies present challenges to establishing the generality and social validity of the findings. The underreporting of family language is particularly relevant to studies evaluating communication preferences, as several studies have shown that children in bilingual or multilingual homes often show preferences for both instruction and expressive communication in a particular language when using AAC (Aguilar et al., 2017; Kunze et al., 2019). It is possible that the results of MMPAs may be more or less reliable depending upon whether the MMPA options use a participant's preferred language, and there may be a lower likelihood of generalization to the home setting when mand options, SGDs, in particular, use a language other than the one used in the home.

In addition to underreporting participant demographics, many studies failed to report several important procedural variables that could affect MMPA results. Among the most concerning omissions were how the contexts for manding in the MMPA were chosen (reported by 30% of studies), whether placement or positional bias (e.g., regularly choosing the option on the individual's left side) was controlled for (63% reported), and how preference was determined (19% reported). Each of these variables could undoubtedly affect the outcome for a participant and any study conclusions. For example, some children with ASD and/or ID display positional bias when asked to choose between two or more concurrently available stimuli (Bourret et al., 2012), indicating that selections may sometimes be under the control of the position of the stimulus rather than its reinforcing value. Simply alternating the placement of the mand options across trials or sessions likely would uncover position-based biases and ensure that the outcomes were valid.

In addition to the many reporting gaps described above, conclusions from this review may be limited for several reasons. First, this review only included studies that comprised both high- and low-tech AAC options. As we noted previously, high- and

low-tech modalities are more often identified as preferred than vocal and manual sign options, and no participant in any of the studies in this review that included vocal or manual sign options demonstrated a preference for the vocal or manual sign option; however, numerous studies have been conducted using MMPAs comprised of vocal and/or manual sign options but without both a high- or low-tech option. Vocal and manual sign options avoid some of the challenges associated with aided communication options, such as cost and portability, and may still be preferred by a minority of individuals with communication deficits.

Second, the general finding that high-tech AAC options tend to be more preferred than low-tech options does not tell us for whom high- or low-tech options are more likely to be preferred or elucidate individual characteristics or other factors that may predict preference for one option. Further analysis of variables that may predict preference, such as individual characteristics (e.g., motor imitation skills, cultural acceptance), proficiency across modalities, prior experience or exposure, communication partner, and the context under which the AAC would be used would be beneficial and may provide insight as to why a specific option is preferred in particular circumstances.

Third, despite research demonstrating that preference for various stimuli may change over time (MacNaul et al., 2021), little attention has been paid in the research literature to the stability of MMPA outcomes over time. Several studies in this review evaluated preference at least four weeks or more after training, and one study (Achmadi et al., 2014) evaluated preference at 18 months posttreatment; however, most studies did not evaluate preference long-term, and many only conducted a single MMPA. Future research should consider whether preference and the magnitude of preference are stable over time and across contexts and, if so, at what point preference would be considered stable.

Implications for Practice

Communication deficits are associated with several adverse social, academic, and behavioral outcomes (Curtis et al., 2018; Durkin et al., 2017), and individuals with disabilities are more likely than their nondisabled peers to exhibit communication deficits. Clinicians play a major role in helping individuals with disabilities who exhibit communication deficits develop effective communication, often through FCT and mand training. Determining the optimal mand modality is an important first step to ensuring successful communication training (Couper et al., 2014) and decreasing the likelihood of AAC abandonment (Lasker & Bedrosian, 2001). This review raises several points for clinicians to consider when determining what mand modality to use in FCT and mand training. These points fall into two broad categories: practices to pursue and practices to avoid.

Related to practices to pursue, clinicians should incorporate an MMPA when identifying the communicative response to be targeted with reinforcement. However, it would also be wise for clinicians to consider the specific procedures they use to conduct an MMPA. Despite consistent MMPA outcomes in the research literature across a wide range of procedural variations, it still seems imperative for clinicians to consider using a standardized MMPA procedure. The choice paradigm (i.e., concurrent operants or concurrent chains) that all studies in this review used seems to be an appropriate starting point. Choice is considered a highly valid measure of preference (Fisher & Mazur, 1997; Schwartz & Baer, 1991), and there is substantial research support for utilizing choice to determine preference for various leisure items/activities (e.g., Brodhead et al., 2016), foods (e.g., DeLeon & Iwata, 1996), people (e.g., Sturmey et al., 2003), academic tasks (e.g., Daly et al., 2009), social interactions (e.g., Nuernberger et al., 2012), and work tasks (St. Peter et al., 2022). Beyond using a choice paradigm, we also believe it would be beneficial for clinicians to define preference a priori and to consider both the reliability and magnitude of preference in their definition. When setting a threshold to determine a preference, clinicians should consider a higher standard, such as 70% or more selections for one mand option and repeated demonstrations (e.g., five sessions) to increase confidence in their findings. A higher threshold ensures a more evident preference and reduces the likelihood that selections are made indiscriminately. When a threshold is not initially met, it may require additional training with the mand modalities being evaluated before repeating the MMPA. Although there are still questions about the optimal timing to conduct MMPAs before committing to the preferred modality in practice (e.g., FCT or mand training), it seems clear that MMPAs are most meaningful only after similar reinforcement histories with each modality under consideration have been developed. To illustrate this point, across the reviewed studies, nearly one quarter of the participants had previous training exclusively with low-tech options. However, after exposure to training with both high- and low-tech options, nearly 90% of those participants ultimately preferred the high-tech option. As noted previously, there is little research on the stability of preference over time, across settings (e.g., school, home, community), and across contexts (e.g., to request a break from a task, attention, or a preferred snack). Thus, clinicians should consider assessment for mand modalities a continual process that does not stop following a single MMPA, regardless of the magnitude of preference a client displays.

Related to practices to avoid, clinicians should eschew the practice of selecting a mand modality based solely on their familiarity with a specific mand option or other perceived advantages, such as ease of use, portability, or the option's technological capacity. Although it is hopeful that the clinician's preference for a particular mand modality and other factors align with the client's preference, supporting the client's right to choose their communication modality may come with

several added benefits, such as faster acquisition and long-term maintenance (Couper et al., 2014; van der Meer et al., 2012b).

Likewise, clinicians should avoid selecting a high-tech AAC option as the default based only on the overall outcomes of this review. Although it may be tempting to forego MMPAs altogether and choose a high-tech option, a small number of individuals in the reviewed studies still selected low-tech options at a high magnitude, and without an MMPA, it is unclear if these individuals would be successful in utilizing a high-tech option.

Finally, although client preference for mand modality should be the preeminent measure of social validity when considering AAC options, other social validity measures may also be considered. There is value in obtaining the preference of other stakeholders, including the communication partners who are most likely to respond to the client's mands (e.g., caregivers, teachers, peers). Clinicians should be aware of why some low- and high-tech options may not be favored by other stakeholders. For example, a caregiver may find picture cards less appealing because they are easily lost and do not include voice output, which may mean that a mand is less likely to be recognized from a distance. In addition, some caregivers may find that high-tech options are less favored because they are expensive, sometimes cumbersome to maintain, and may require complex programming to tailor to the client. When differences between the client's preference and those of other stakeholders exist, especially the caregiver, we encourage the clinician to reconcile these differences with every attempt to honor the client's preference. One option for obtaining agreement between client and caregiver preference may be to provide the caregiver with outcome data from the client's MMPA before inquiring about caregiver preference. Torelli et al. (2015) provide an example of this approach. Their study included three AAC options (PECS, GoTalk, and iPad with ProLoQuo2Go) in FCT and MMPA trials for a young boy with ASD who exhibited challenging behavior. Following acquisition training and MMPAs with all three options, the therapy team presented the boy's mother with data on challenging behavior, mand independence, and client preference, all of which favored the iPad with ProloQuo2Go. As a result, the boy's mother chose the iPad with Proloquo2Go as the preferred mand option for subsequent training.

In conclusion, regardless of the specific MMPA approach taken, sufficient data exist to demonstrate that individuals receiving behavior analytic services exhibit a preference for communication modality and that preference can be and should be integrated into practice. Arguments for incorporating MMPAs based solely on supporting client autonomy may be sufficient for considering preference. However, these arguments are bolstered by growing research demonstrating the benefits of client preference for communication modality on communication acquisition, maintenance, and persistence.

Appendix 1

Search Strategy Terms and Parameters

For EBSCOhost (PsycINFO and ERIC): ("mand" OR "request*" OR "communication device" OR "speech generating device" OR "SGD" OR "voice output device" OR "voice output communication aid" OR "VOCA" OR "aided communication" OR "unaided communication" OR "communication book" OR "picture exchange" OR "picture exchange communication system" OR "augmentative communication" OR "alternative communication" OR "AAC" OR "augmentative and alternative communication" OR "communication option" OR "PEC*" OR "functional communication" OR "functional communication training" OR "FCT") AND ("preference assessment" OR "choice assessment" OR "mand modality assessment" OR "communication modality assessment" OR "modality assessment" OR "response preference" OR "concurrent schedule*" OR "concurrent operants")

For Scopus: title, abstract, and keyword ("mand" OR "request*" OR "communication device" OR "speech generating device" OR "SGD" OR "voice output device" OR "voice output communication aid" OR "VOCA" OR "aided communication" OR "unaided communication" OR "communication book" OR "picture exchange" OR "picture exchange communication system" OR "augmentative communication" OR "alternative communication" OR "AAC" OR "augmentative and alternative communication" OR "communication option" OR "PEC*" OR "functional communication" OR "functional communication training" OR "FCT") AND ("preference assessment" OR "choice assessment" OR "mand modality assessment" OR "communication modality assessment" OR "modality assessment" OR "response preference" OR "concurrent schedule*" OR "concurrent operants")

For PubMed: all terms ("mand" OR "request*" OR "communication device" OR "speech generating device" OR "SGD" OR "voice output device" OR "voice output communication aid" OR "VOCA" OR "aided communication" OR "unaided communication" OR "communication book" OR "picture exchange" OR "picture exchange communication system" OR "augmentative communication" OR "alternative communication" OR "AAC" OR "augmentative and alternative communication" OR "communication option" OR "PEC*" OR "functional communication" OR "functional communication training" OR "FCT") AND ("preference assessment" OR "choice assessment" OR "mand modality assessment" OR "communication modality assessment" OR "modality assessment" OR "response preference" OR "concurrent schedule*" OR "concurrent operants")

Appendix 2

Operational Definitions for Participant, Procedural, and Outcome Variables

Table 3 Operation definitions for participant variables

Participant variable	Definition	Data collected
Participant age	Reported age of the participant in years.	number of years
Participant gender	Reported gender of participant.	*male, female, other* (e.g., nonbinary)
Participant race	Reported race of participant based on categories define by U.S. Census Bureau or based on categories as defined by the country in which the study was conducted.	*White, Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, more than one race, International* (include country of origin)
Participant ethnicity	Reported ethnicity of participant based on the U.S. Census Bureau.	*Hispanic or not Hispanic*
Primary language Spoken at home	Reported language spoken at home by the participant and/or participant family.	any language reported
Participant diagnosis	Reported neurodevelopmental diagnosis or diagnoses of the participant. For autism spectrum disorder, variants consistent with the current diagnostic label of autism spectrum disorder include autism, autistic disorder, Asperger's disorder, pervasive developmental disorder	*autism, Down syndrome, intellectual disability, seizure disorder, other*
Participant cognitive ability	Reported level of intellectual disability.	*mild, moderate, severe, profound, not specified*
Participant AAC history	Reported history with high-tech or low-tech AAC modalities. High-tech AAC was defined as an electronic device with speech output used for communication, such as a microswitch or speech-generating device. Low-tech AAC was defined as non-electronic or battery powered instrument used for communication, such as picture cards or a communication board.	*previous training with low-tech only*; *previous training with low- and high-tech*; *previous training with high-tech only*; *no history of AAC training*
Participant vocal communication skills	Reported level of participant vocal communication.	*Nonvocal* (including as nonverbal or no speech) or *vocal* (including echolalia)
Participant challenging behavior	Reported presence of challenging behavior.	*tantrum* (e.g., crying, screaming, throwing self to floor), *aggression*, *self-injury*, *property destruction*, *disruptive behavior* (e.g., inappropriate vocalizations, refusal), *elopement*

Nominal codes are in italics

AAC augmentative and alternative communication

Table 4 Operational definitions for procedural variables

Procedural variable	Definition	Data collected
Functional behavioral assessment	The study reported conducting a functional behavioral assessment, including indirect (e.g., rating scales, interview), direct (e.g., observation without manipulation of antecedents or consequences), and experimental (e.g., functional or antecedent analysis) analyses.	*yes*, *no*
Outcome of functional behavioral assessment	Function identified by the functional behavioral assessment.	*attention*, *tangible*, *escape*, or *multiply maintained*
Study provided a rationale for the functional context	The study described how a functional context for FCT or mand training was chosen (e.g., a functional behavioral assessment was conducted, mand training was easier for edibles).	*yes, no*
Functional context for manding	The reported context for manding for each participant within the study.	*attention*, *tangible* (toys, edibles, toys and edibles), *escape, multiple functional contexts*
Determination of tangibles for manding	The reported method for determining the tangibles for manding among studies using a tangible context.	*preference assessment*, *rating scale*, *caregiver/teacher interview/suggestion*, *informal observation*
MMPA schedule	The MMPA schedule for selection response and reinforcement reported in the study.	*concurrent operants arrangement*, *concurrent chains arrangement*
Determination of selection response in MMPA	The behavior used to indicate a selection response for high- and low-tech options during the MMPA.	*reaching toward an option*, *touching a card*, *touching a device*, *handing a card to the therapist/researcher*, *activating a device/switch*, *gazing at an option for a minimum duration*
Control for placement bias	The study reported controlling for placement bias (e.g., alternating options for each trial or for each session).	*yes*, *no*
MMPA data collection	The definition for a session was based on duration (e.g., 5 min) or a fixed number of trials (e.g., 5 trials).	*duration, trial*
Reporting of preference selection data	The manner that the preference selection data were reported.	*percentage of opportunities, rate per minute, percentage of trials selected*
Number of phases where MMPA was administered	The number of phases an MMPA was conducted across the length of the study (e.g., across three different phases).	total number of phases
Timing of MMPA administrations	The point(s) within the study where an MMPA was conducted.	*prior to intervention/training* or *baseline*, *during the intervention/training*, *post-intervention*, *generalization*, *maintenance/follow-up*
Definition for proficiency for manding	The criteria used to determine whether a participant was proficient with manding.	*yes, no*; criteria described (e.g., independent for 80% of trials during three consecutive sessions)
Number of MMPA FCR options	Total number of different FCR options available for selection in the MMPAs.	total number of FCR options
Types of MMPA FCR options	All listed types of FCR options available during the MMPAs. High-tech AAC was defined as an electronic device with speech output used for communication, such as a microswitch or speech-generating device. Low-tech AAC was defined as non-electronic or battery powered instrument used for communication, such as picture cards or a communication board. For studies where the types differed across MMPAs, only those where a high- and low-tech option were available were included.	*vocalization*, *manual sign, low-tech FCR, high-tech FCR*

Table 4 (continued)

Procedural variable	Definition	Data collected
Names of FCR instruments/devices	Product name for any low- or high-tech instrument, device, or software used in the MMPAs.	names of each device or instrument (e.g., PECS cards, GoTalk device)
Number of mand targets	The number of different mands that could be used during the MMPAs (e.g., mands for chips, candy, and drink).	total number available for each mand opportunity and mand modality during MMPAs
Additional measures of social validity	The study included another measure of social validity from any stakeholder (e.g., parent report of preference for FCR option on rating scale).	*yes, no*; type of measure (e.g., rating scale, open-ended report)

Nominal codes are in italics

FCT functional communication training, *MMPA* mand modality preference assessment, *FCT* functional communication response, *AAC* augmentative and alternative communication

Table 5 Operational definitions for MMPA outcome variables

MMPA outcome variable	Definition	Data collected
Number of trials (per participant)	Total number of MMPA trials conducted across all study procedures for a participant.	total number of trials
Percentage of trials selected for each mand modality	The percentage of trials (or opportunities) each mand modality was selected overall, at each phase in the study (e.g., baseline, training, follow-up), and following an acquisition phase.	percentage for each modality across each phase and total
Percentage of trials selected – high- and low-tech comparison only	The percentage of trials (or opportunities) high- and low-tech options were chosen when only considering the high- and low-tech options overall, at each phase in the study (e.g., baseline, training, follow-up) and following the acquisition phase.	percentage for each modality across each phase and total
Definition for mand modality preference	The criteria used to determine the mand modality preference for a participant.	*yes, no*; criteria described (e.g., 70% of trials selected)
Mand modality preference (per participant)	The nominal mand modality preference identified for a participant.	*high-tech, low-tech*; the mand modality identified as preferred (nominally)
Mandy modality preference based on majority selection	The mand modality chosen greater than 50% of trials (overall) and across each study phase (e.g., baseline, intervention, follow-up).	*high-tech; low-tech*; the mand modality chosen more than 50% (total and in each phase) based on the data provided in the article
Mand modality preference based on 70% threshold	The mand modality chosen 70% or greater (overall) and across each study phase (e.g., baseline, intervention, follow-up).	*high-tech; low-tech*; the mand modality chosen 70% or more (total and in each phase) based on the data provided in the article

Nominal codes are in italics

MMPA mand modality preference assessment

Appendix 3

Inter-Rater Agreement for Participant, Procedural, and Outcome Variables

Table 6 Inter-rater agreement for participant variables

Participant variable ($n = 19$)	Percent agreement	Cohen's kappa	Intraclass correlation
Participant age	100	--	1.00
Participant gender	100	1.00	--
Participant race	100	1.00	--
Participant ethnicity	100	1.00	--
Primary language spoken at home	100	1.00	--
Participant diagnosis	95	0.90	--
Participant cognitive ability	90	0.75	--
Participant AAC history	100	1.00	--
Participant vocal communication skills	95	0.88	--

AAC augmentative and alternative communication

Table 7 Inter-rater agreement for procedural variables

Procedural variable ($n = 19$)	Percent agreement	Cohen's kappa	Intraclass correlation
Functional behavioral assessment	100	1.00	--
Outcome of functional behavioral assessment	100	1.00	--
Study provided a rationale for the functional context	90	0.69	--
Functional context for manding	100	1.00	--
Determination of tangibles for manding	95	0.92	--
MMPA schedule	90	0.79	--
Determination of selection response in MMPA	100	1.00	--
Control for placement bias	100	1.00	--
MMPA data collection	100	1.00	--
Reporting of preference selection data	100	1.00	--
Number of MMPA administrations	95	--	0.99
Definition for proficiency for manding	79	0.46	
Number of MMPA FCR options	100	--	1.00
Types of MMPA FCR options	100	1.00	
Number of mand targets	84	--	0.87

MMPA mand modality preference assessment, *FCR* functional communication response

Table 8 Inter-rater agreement for MMPA outcome variables

MMPA outcome variable ($n = 19$)	Percent agreement	Cohen's kappa	Intraclass correlation
Total number of MMPA trials (per participant)	90	--	0.95
Percentage of trials selected for high-tech (total administrations)	90	--	0.99
Percentage of trials selected for low-tech (total administrations)	90	--	0.99
Percentage of trials selected for high-tech (high vs. low only)	95	--	0.99
Percentage of trials selected for low-tech (high vs. low only)	90	--	0.92
Definition for mand modality preference	100	1.00	--
Mand modality preference (per participant)	100	1.00	--
Mandy modality preference based on majority selection	100	1.00	--
Mand modality preference based on 70% threshold	100	1.00	--

MMPA mand modality preference assessment

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Data Availability The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics Approval The Human Subjects Office/IRB at the University of Iowa determined this study to be exempt from Full IRB review.

Conflict of Interest The authors declare that there is no conflict of interest.

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