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Review Article

# Developing Augmentative and Alternative Communication Systems in Languages Other Than English: A Scoping Review

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ABSTRACT

**Introduction:** Access to augmentative and alternative communication (AAC) systems in languages other than English and multilingual AAC systems remains limited for many people with complex communication needs, despite a growing interest in this field, and an acknowledged need for culturally responsive AAC practice.
**Purpose:** The purpose of this scoping review was to identify published research that has reported on the development of components or whole AAC systems in languages other than English, and the linguistic and cultural factors that influenced research methods and AAC system development.
**Method:** Nine databases were systematically searched for published research that presented development of components or whole AAC systems in languages other than English. The Mixed Methods Appraisal Tool was used to assess the quality of studies. Charted data from studies included journal and publication date, research team, language of AAC system, aims of the study, study methodologies, study participants, and type of AAC systems developed. An analytical framework was developed to identify the cultural and linguistic factors that influenced research methods and or AAC system outcomes.
**Results:** A total of 22 studies were included (13 qualitative, one quantitative nonrandomized, six quantitative descriptive, and two mixed-methods studies). Overall quality of studies was high. Some qualitative studies were of lower quality due to limited analysis or interpretation of results. Linguistic factors were extensively reported in the existing literature, whereas cultural factors were rarely explicitly reported.
**Conclusion:** Factors contributing to lack of reporting of cultural considerations are posited with suggestions for future research.
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The foundational work of augmentative and alternative communication (AAC) as a discipline emerged from Western cultural contexts and languages, with early systems developed in Swedish, English, Finnish, and Dutch (Baker & Chang, 2006). However, the development of AAC in languages other than English, including in Eastern cultural contexts, is a growing area of research and practice (Tönsing et al., 2018). People in majority world countries (an alternative term for developing world or third world countries) who disproportionately experience disability can benefit from AAC. Speech-language pathology programs, services, and resources are being developed to respond to this need (Atherton et al., 2020; Muttiah et al., 2016). To contribute to this development, speech-language pathologists predominantly from the United States, Canada, the

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United Kingdom, Australasia, and countries in the European Union are working increasingly in majority world countries with individuals and families who do not speak English as a first language (Staley et al., 2021). Additionally, as Western countries are becoming increasingly multilingual and multicultural, practitioners are looking for multilingual AAC systems to enhance inclusive engagement and provide culturally responsive services (Kulkarni & Parmar, 2017; Tönsing & Soto, 2020). Despite this growth, culturally responsive and multilingual AAC service provision remains limited due to the lack of AAC systems in languages other than English (Tönsing et al., 2018).

AAC aims to support or replace natural speech when a person's speech is inadequate to meet all their communication needs (Beukelman & Mirenda, 2012). An AAC system incorporates multiple components for communication. A variety of symbols can be used, and these can be aided (using external aids) or unaided, using various techniques and strategies to communicate effectively and efficiently (Beukelman & Mirenda, 2012). Aided AAC includes no- or low-tech (nonelectronic) and high-tech (electronic) systems. For the purposes of this review, we have focused on the development of low- and high-tech AAC system aids.

AAC development often involves substantial collaboration between many people and team roles, covering diverse knowledge, skills, and expertise depending on the individual, family, context, and communication systems to be developed. For example, a context-specific low-tech AAC system may require fewer vocabulary items and can be developed using readily available resources by a speech-language pathologist, individual, and their family. More comprehensive AAC systems often require in-depth linguistic knowledge and resources to incorporate and integrate multiple aspects of communication, including the sound system, grammatical structures, vocabulary organization, writing system, and cultural outlook (Baker & Chang, 2006). In addition, developing new high-tech systems typically requires technical expertise in software development and increasingly in machine learning (Elsahar et al., 2019). The visual design of AAC systems also impacts performance, requiring careful consideration and expertise related to graphic, system, and user design (Light et al., 2019).

The Participation Model is commonly used to guide AAC decision making and intervention through a flexible but systematic process to assess and consider the participation patterns, communication needs, and opportunity and access barriers for individuals (Beukelman & Mirenda, 2012). Personalization has long been a focus in the field of AAC, and the Participation Model emphasizes the need for practitioners to consider all of the many complex interconnected characteristics and circumstances for an individual, including their languages and culture, through all stages of the AAC assessment and intervention process.

However, ensuring relevant and sufficient, in-depth linguistic and cultural knowledge within the AAC team for each individual is not always easy given the dynamic and complex interlinkages between language and culture. Pragmatic language considers cultural context, and language is a core parameter of culture. Context shapes meaning, and language shapes context (Stadler, 2018). In some contexts, cultural considerations can easily be minimized or overlooked, due to cultural blindness in dominant (often monolingual) Western cultural contexts. Western culture can assume that white people are "outside of culture," possessing a universal or objective perspective (DiAngelo, 2011). Many other broad sociocultural factors also impact the development of AAC in non–English languages and majority world countries, including history of colonization, income status and economy, urban–rural classification, access to health, education, and technology (Muttiah et al., 2016; Tönsing et al., 2018).

Traditionally, AAC teams involve family members, educators, allied health professionals, engineers, and people with expertise in computer technology (when high-tech systems are considered) to extend the breadth of required knowledge (Beukelman & Mirenda, 2012). People with disabilities have been campaigning for full inclusion and greater input on the issues that affect their lives since the 1990s (Bastable et al., 2021). This is demonstrated by the mantra "nothing about us without us," which now extends beyond disability activism, to include other marginalized groups. Non-White people with disabilities face intersectional disadvantage and discrimination of disability and racism (O'Connor et al., 2019), and the risk is heightened for people with a communication disability whose first language is not English, especially if they do not have access to multilingual AAC systems in their primary languages.

Researchers are increasingly adopting participatory processes and collaborative partnerships with the aim of shifting existing power dynamics from researchers as experts, to enable marginalized people greater engagement in research that affects their lives. Indigenous peoples, including Native Americans, Maori (from Aotearoa, New Zealand), and Yolŋu (Aboriginal Australians from northeast Arnhem land), have stressed the importance of developing AAC through flexible and collaborative processes, building trusting relationships over a long period of time (Amery et al., 2019; Stone, 2019; Stuart & Parette, 2002).

In summary, most AAC systems are developed for English speakers, with an extensive and growing body of research to support design, development, and implementation. Comparatively, very little is known about developing multilingual AAC systems and AAC systems in languages other than English. The purpose of this scoping review was to identify (a) the scope and nature of published research reporting on the development of AAC systems in languages other than English, (b) linguistic and cultural

factors that influenced research methods and AAC systems, and (c) directions for future research.

## Method

### Research Design

A scoping review was conducted following the five-stage process outlined by Arksey and O'Malley (Arksey & O'Malley, 2005), with enhancements by Westphaln et al. (2021). A scoping review was chosen to examine the scope, range, nature, and gaps in existing research to inform future research and practice in multilingual AAC. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) was followed to enhance reporting transparency (Tricco et al., 2018). The research question and search strategy were developed using the population, intervention, comparison, outcome model, incorporating population (languages other than English), intervention (design or development), and outcome (component or whole AAC system).

### Search Strategy

A comprehensive search of the peer-reviewed research, theses, and dissertations was undertaken for research published between 1970 and 2020, in which the field of AAC has grown, geographically and linguistically (Baker & Chang, 2006). The search strategy was developed and adapted for each database in consultation with an experienced librarian and peer reviewed. A total of nine databases were searched for studies. The first author searched for studies in eight databases: Linguistics and Language Behaviour Abstracts and ProQuest Dissertation (via ProQuest), Academic Search Premier, CINAHL Plus with Full Text, Communication and Mass Media Complete, ERIC and PsycInfo (via EBSCOHost), and Scopus. The first author did not have access to one database, EmCare, which was searched by the second author. We used a search string using Boolean operators in the title and abstract, using search terms to describe the population "language other than English," intervention "development," and outcome "AAC system"; see Supplemental Material S1. All searches were conducted in October 2020 with forward and backward searches completed using Google Scholar in July 2021. Covidence systematic review management software was used to manage the citations, screening, and selection process (Veritas Health Innovation, 2021).

### Selection of Studies

Studies were included in this review if they met the following three inclusion criteria: (a) study reported on the development of AAC in a language other than English, was accessible and able to be translated using Google Translate; (b) the primary aim of the study was system development or design; and (c) the study reported on the development of a whole AAC system or components of AAC systems that were being developed. In the case of components of AAC systems, the study had to specify the AAC system/device that the AAC component was being developed for. The first and second authors independently screened all the titles and abstracts (Phase 1) with 94% agreement and reviewed the full text (Phase 2) with 75% agreement to determine inclusion. All discrepancies in Phase 1 and Phase 2 were discussed and resolved. The study selection process is depicted in the PRISMA flow chart, see Figure 1.

### Quality Appraisal

The Mixed Methods Appraisal Tool (MMAT), Version 2018 (Hong et al., 2018), was used to assess quality of qualitative, quantitative, and mixed-methods studies. The first and second authors appraised the quality of all included studies, with 90% agreement for quality appraisal. Discrepancies were discussed and resolved. No studies were excluded based on quality. Quality appraisal of studies is presented in Supplemental Material S2.

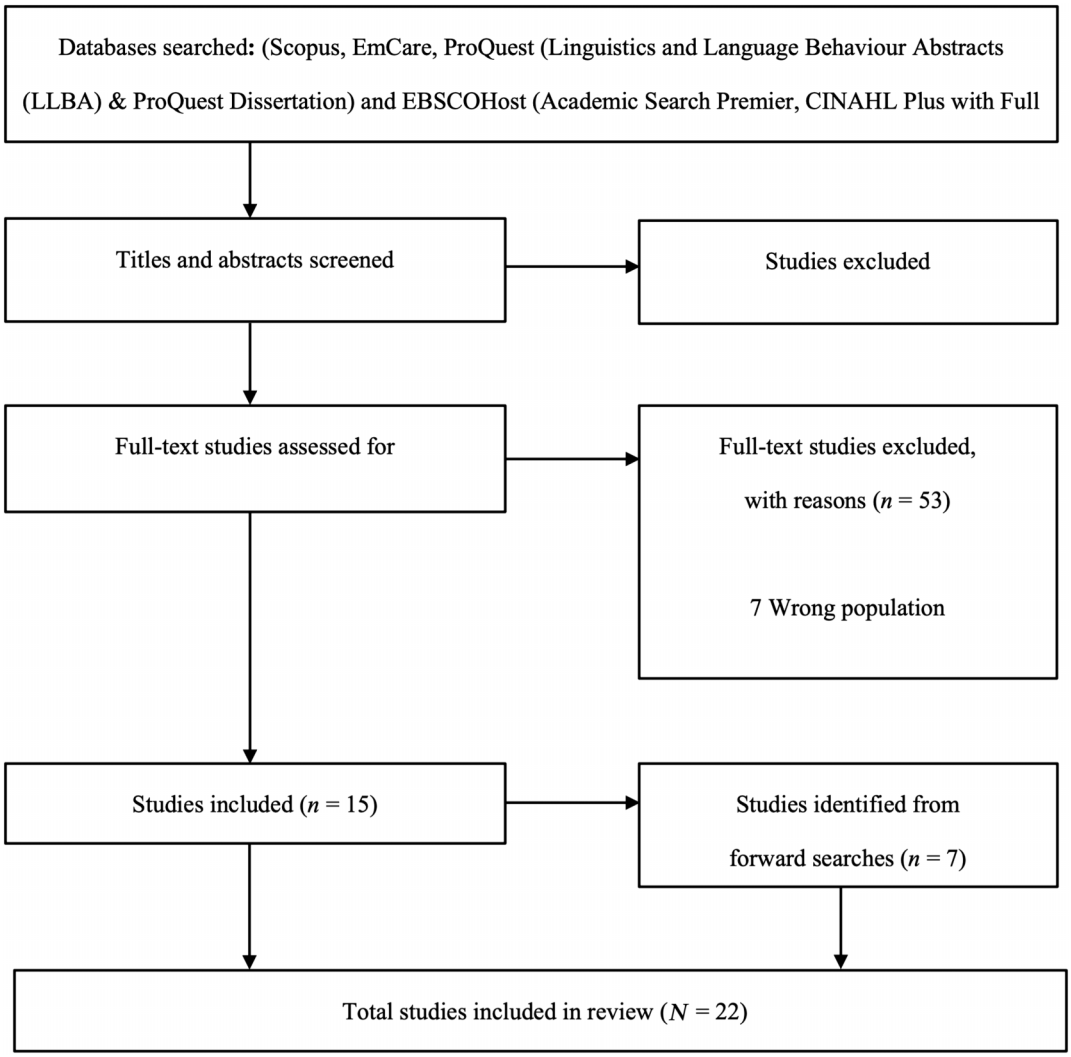
### Charting the Data

Each study was described in terms of (a) journal and publication date, (b) research team, (c) language of the AAC system, (d) study aims, (e) research method, (f) participants, and (g) AAC system developed; see Table 2. These details were charted (i.e., extracted or coded) to present pertinent information related to the purpose, processes, and people involved in carrying out, reporting, and participating in AAC system research in languages other than English. Details related to the research team were charted to capture intercultural and multidisciplinary collaborations in AAC. NVivo Qualitative Research Software was used to manage data from included studies (QSR International Pty Ltd., 2019).

### Data Analysis

An analytical framework was developed to identify the linguistic and culture-specific considerations that influenced the research method and AAC system outcomes; see Table 1. For the purposes of this review, key terms were defined as follows: (a) *linguistic* relating to "the science of language, including among its fields phonetics, phonemics, morphology, and syntax" (Macquarie Compact Dictionary, 2016, p. 484), and (b) *culture* relating to "the shared, accumulated and integrated set of learned beliefs, habits, attitudes and behaviors of a group of people or community and

**Figure 1.** Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart depicting selection of studies.




the context in which language is developed, used, and the primary vehicle by which it is transmitted" (Speech Pathology Australia, 2016, p. 6). Nine basic parameters of culture were considered: (a) views on individual versus group importance, (b) outlook on time and space, (c) the roles of men and women, (d) class and status systems, (e) core values, (f) language, (g) rituals, (h) work ethic, and (i) beliefs about health (Speech Pathology Australia, 2016). Pragmatics were considered together with cultural considerations; see Table 1. These definitions were appropriate for the context of this review, inclusive of various theoretical perspectives (Hyter, 2014). A key word search within included studies identified those that explicitly used the terms *linguistic** and/or *cultur**. Studies that included both terms were coded inductively and then grouped into emerging categories to create the analytical framework. The framework was then used to analyze all studies deductively.

The first author determined categories for charting the data, developed the analytical framework in consultation with other authors, charted, and analyzed data for all studies. The second author charted and analyzed data for 27% of studies, with 95% agreement for charting the data, and 72% agreement for data analysis. The authors met to discuss discrepancies and reached consensus on all studies.

## Results

### Scope and Nature of Included Studies

Initial searches produced a total of 2,380 unique articles. From 68 full texts, 15 studies met the inclusion criteria. An additional seven were identified from forward searches, and no studies were identified from backward

**Table 1.** Analytical framework.

| Overarching considerations | Linguistic knowledge, resources, and considerations that influenced research methods and AAC systems | | | | Culture-specific considerations that influenced research methods and AAC systems | |
|---|---|---|---|---|---|---|
| **Subcomponent** | **Vocabulary representation** | **Semantics** | **Morphology and syntax** | **Phonetics and phonology** | **Culture-specific considerations on research method** | **Culture-specific considerations on AAC system** |
| Relating to | Ways that vocabulary is presented | Vocabulary, meaning of words/concepts | Minimal units, phrases, and sentences | Production and perception of sounds, organization, and representation of sounds | Research process and cultural context of study | Components of AAC systems and cultural context of study, including pragmatics and use of language |
| Examples | Language text/orthography, icons/pictograms, animated icons, audio | Linguistic databases, corpora, definitions, vocabulary included in AAC, vocabulary organization | Morphological rules, syntax/grammar rules, parts of speech, grammatical features (e.g., tense, aspect, gender, mood, modality, type) word or phrase order, sentence structure or type | Phonetic/phonological units of analysis, text to speech system, recorded/digitized/ synthesized speech | Cultural/language background of research team (explicit), sampling and recruitment of participants, consultation with users, specific data collection, or analysis procedures | Culture-specific names, vocabulary, icons, symbols, characters, knowledge, concepts, metaphors |

*Note.* AAC = augmentative and alternative communication.

searches. A total of 22 studies were included for review. Flow of studies and reasons for exclusion are presented in Figure 1. Two manuscripts that reported on different aspects of the same study (Bhattacharya & Basu, 2009, 2010) were combined, and data were charted and analyzed only once for the study. Two included studies were translated to English for data charting and analysis (Heikkilä et al., 2019; Huertás & Nohama, 2014). Study quality and charted data presented in Tables 1 and 2 are discussed below.

### Study Quality

A detailed breakdown of the MMAT scores for studies is presented in Supplemental Material S2. Included studies were qualitative descriptive ($n$ = 13), quantitative, nonrandomized ($n$ = 1), descriptive ($n$ = 6), and mixed-methods studies ($n$ = 2). Overall, included studies were of a high quality. Poorer quality was observed in four qualitative studies that did not provide detailed analysis or clear interpretation of results (Benkherrat, 2019; Deliege, 1989; Heikkilä et al., 2019; Huertás & Nohama, 2014). The age of one study (Deliege, 1989), publication type, and translation to English are also factors that may have contributed to poorer quality in reporting of these studies (Heikkilä et al., 2019; Huertás & Nohama, 2014). Poorer quality was also noted in a mixed-methods study that did not provide a rationale for their research design or adequately report on qualitative aspects of the study (Johnson et al., 2006).

### Study Journals and Publication Dates

Studies were published in a range of journals ($n$ = 14), as chapters in edited books ($n$ = 4), conference proceedings ($n$ = 2), and student theses ($n$ = 2). Most studies were published in the discipline of computer science and engineering ($n$ = 12), followed by communication and assistive technology ($n$ = 7), and health journals ($n$ = 2). This reflects most of the disciplines involved in AAC system development research.

Studies were published between the years 1984 and 2020, with just over half of included studies published in the last 10 years, since 2012 ($n$ = 13). Four studies were published in the previous decade from 2002 to 2012, and only four studies were published in the 2 decades prior, 1982–2002.

### Research Teams

Research teams were often multi- and interdisciplinary, from a range of professional backgrounds and affiliations including computer science, engineering, software design, web design, technology innovation, health care workers, speech-language pathologists, assistive technology specialists, and graphic designers. One study was explicit about the cultural and linguistic background of a researcher (Johnson et al., 2006).

### Languages of AAC Systems

Studies reported on AAC system development in 17 languages. European Spanish was the most common language ($n$ = 5). European languages (Spanish, French, Swedish, Dutch, Finnish, and Czech) were the focus for more than half of studies ($n$ = 12), including one study reporting on development of an AAC system for seven European languages (Blomberg et al., 1986). Development of AAC systems in Asian languages (Mandarin Chinese, Korean, Japanese, Bengali, and Hindi) were included in several studies ($n$ = 6), as well as South American languages (Brazilian Portuguese and Peruvian Spanish; $n$ = 3), and one developed in an African language (Somali; Johnson et al., 2006). No studies reported on the development of AAC in Indigenous or linguistic minority languages.

### Aims of the Studies

The aim of studies was to develop low-tech ($n$ = 3) and/or high-tech AAC systems or components ($n$ = 20). High-tech AAC was developed using existing software, purpose-built web-based software, or applications for tablets and mobile devices. Several studies aimed to develop a high-tech AAC component, such as text to speech or natural language generation ($n$ = 4). A small number of studies aimed to develop dedicated AAC devices ($n$ = 4).

### Study Methodologies

A participatory, user-centered, inclusive, or human-centered design methodology was used in several studies, to enable collaboration with people with communication disabilities (Daems et al., 2016; Hervás et al., 2020; Lundälv et al., 2014; Mertl & Frič, 2019). Qualitative, descriptive methods were used in more than half of included studies ($n$ = 13). Seven studies included further details about methods, including the use of participant observation, interviews, questionnaires, prototype development, and user testing methods were typically used to determine AAC user needs, inform development, and evaluate AAC systems (Daems et al., 2016; Deliege, 1989; de Oliveira et al., 2016; Heikkilä et al., 2019; Huertás & Nohama, 2014; Lundälv et al., 2014; Mertl & Frič, 2019). Content analysis and descriptive statistics were used to analyze data in one study (Mertl & Frič, 2019).

Quantitative methods were used in seven studies. Existing communication assessments and protocols (modified Picture Exchange Communication System [PECS] and the Communication Matrix) were used to evaluate AAC systems in two of these (An et al., 2017; Vaughan, 2018). AAC systems were also evaluated using experiments to match target and generated sentences, error types, intelligibility, and compare AAC system components with commercial equivalents (García-Méndez et al., 2019; Iida & Campbell, 2003; Nakazono et al., 2010). Other studies

**Table 2.** Charted data.

| Journal and publication date | Research team | Language of AAC system | Aims of the study | Study methodologies | Study participants | Types of AAC system developed |
|---|---|---|---|---|---|---|
| An et al. (2017) Molecular Autism | Peking University, School of Life Sciences, App China, Stars and Rain Education Institute, Academy of Arts and Design, Inway Design, G-Wearables, Inc. | Mandarin Chinese | Develop an AAC system application for tablet and mobile devices | Adapted Picture Exchange Communication System (PECS) training procedures | 10 children with autism spectrum disorder | Yuudee (Xiaoyudi) PECS application, with 400 icons organized categorically |
| Andres (2006) International Journal of Computer Processing of Oriental Languages | Prentke Romich Company | Mandarin Chinese | Develop a high-tech component for an AAC system | Assigned icons to high-frequency vocabulary (Chinese radicals) | None | Mandarin Chinese icon set and grammar keys for Pathfinder keyboard, 55 Minsymbols based on cultural metaphors |
| Baldassarri et al. (2014) Procedia Computer Science (Conference proceedings) | Computer Science Department, Engineering Research Institute | European Spanish | Develop web-based AAC system software | Described software, evaluated through questionnaire (15 closed and two open questions). | 295 participants, web users | AraBoard Constructor (create and edit boards, one-32 cells) and AraBoard Player (visualize boards), ARASAAC pictograms and uploaded images |
| Benkherrat (2019) Intelligent Systems and Applications | ECAM-EPMI Graduate School of Electrical Engineering, Aix-Marseille University, Sensory and Cognitive Neuroscience Laboratory, France | French | Develop web-based AAC system software | Described system components | 15 children with autism spectrum disorder | Digital PECS with icons, animated pictograms, and speech synthesis, categorical organization |

(*table continues*)

**Table 2.** *(Continued).*

| Journal and publication date | Research team | Language of AAC system | Aims of the study | Study methodologies | Study participants | Types of AAC system developed |
|---|---|---|---|---|---|---|
| Bhattacharya & Basu (2009, 2010) Assistive Technology and International Journal of Computers and Applications | Indian Institute of Technology, Department of Computer Science and Engineering | Bengali and Hindi, India | Develop a dedicated AAC system device | Collaborated with users. Described system components. Participants generated sentences using AAC systems. Analyzed questionnaires (perceptions of icons and communication rate). Analyzed time, cognitive load, and physical effort | Eight children with cerebral palsy, Frederich's ataxia, or multiple sclerosis | Sanyog, natural language processing, icon-based word to sentence generator, text to speech, on-screen keyboard, prediction, and message storage |
| Blomberg et al. (1986) Speech Transmission Laboratory–Quarterly Progress and Status Reports (STL-QPSR) | Department of Speech Communication and Music Acoustics | Swedish, European Spanish, German, Norwegian, Danish, French, Italian | Develop a high-tech component for an AAC system | Described system components and case applications | None | VoxBox text to speech system, in Multi-Talk device, Blisstalk electronic communication board, talking terminals, and newspapers |
| Choi et al. (2012) Lecture Notes in Computer Science | Department of Computer Science, Centre for Quality of Life Technology | Korean | Develop web-based AAC system software | Described system components | None | Software to create communication boards (two+ cells), 3,000 symbols, text and sounds for each |
| Daems et al. (2016) Engineering for Society | Thomas More University, Belgium, and Volgograd State Technical University, Department of Software Engineering, Russia | Dutch | Develop an AAC system application for tablet and mobile devices | Human-centered design. Version 1 created from caregiver interviews and evaluation. Version 2 developed and tested by participants using semistructured interviews and questionnaires | 25 people with intellectual disabilities, 20 caregivers from six organizations | AbleChat application and web editor, six-12 pictogram homepage with keyboard, text, pictograms in categories and text-to-pictogram translation |
| Deliege (1989) Speech Communication | Institute for Perception Research, Eindhoven University of Technology | Dutch | Develop a dedicated AAC system device | Described input, speech synthesis, and intonation modules. Used evaluation questionnaire (operation and usefulness) | Nine people with cerebral contusion, CVA, laryngectomy or post-operative | Small, portable, battery-powered keyboard device, with speech synthesis and message storage |

(*table continues*)

**Table 2.** *(Continued).*

| Journal and publication date | Research team | Language of AAC system | Aims of the study | Study methodologies | Study participants | Types of AAC system developed |
|---|---|---|---|---|---|---|
| de Oliveira et al. (2016) Lecture Notes in Computer Science | Federal University of Pará, Faculty of Computing State University of Pará, Assistive Technology and Accessibility Development Center, Belém, Brazil | Brazilian Portuguese | Develop an AAC system software application for tablet devices | Observed people with special needs' use of assistive technology in daily routines. Developed prototypes. Evaluated with usability tests, questionnaire, and compared with two commercial applications | 12 speech therapists, occupational therapists, psychologists, occupational therapy, and linguistic students | VoxLaps application to create and edit user profiles and communication boards with synthesized speech |
| García-Méndez et al. (2019) Expert Systems with Applications | University of Vigo, School of Telecommunications, Telematics Engineering Department, GTI research group, Spain | European Spanish | Develop high-tech components for an AAC system | Described and evaluated natural language generation (matching target and generated sentences, error type, and quantitative quality rating). Compared coverage with other lexicons | None | Natural language generation, aLexiS lexicon, and grammar to generate complete sentences for the PictoDroid Lite communicator |
| Heikkilä et al. (2019) Honours thesis | Metropolia University of Applied Sciences, Physiotherapy | Finnish | Develop a low-tech AAC system | Exploratory study. Described system. Observed exercise class, used interviews to inform vocabulary selection and design | A special school classroom teacher and physiotherapist | Single A4 page communication board for exercise classes, 35 images |
| Hervás et al. (2020) Journal of Ambient Intelligence and Humanized Computing | Complutense University of Madrid, Faculty of Informatics, Institute of Knowledge Technology, and Francisco de Vitoria University, Higher Polytechnic School, Madrid, Spain | European Spanish | Develop an AAC system software application for tablet devices | User-centered design, described system. Collected message composition video data, evaluated time, pictogram sequencing and use. Qualitative feedback questionnaire | Special education teacher of children with autism spectrum disorder | PictoEditor application incorporating prediction, saving, and sharing messages |

(*table continues*)

**Table 2.** *(Continued).*

| Journal and publication date | Research team | Language of AAC system | Aims of the study | Study methodologies | Study participants | Types of AAC system developed |
|---|---|---|---|---|---|---|
| Huertás and Nohama (2014) Brazilian Congress of Biomedical Engineering (Conference proceedings) | Federal Technological University of Paraná, Post-Graduate Course in Electrical Engineering and Industrial Informatics, Brazil | Brazilian Portuguese | Develop an AAC system application for tablet and mobile devices | Developed prototype. User testing and descriptive evaluation of progress, usability, and autonomy using questionnaire form. | Children and adults with communication difficulties at special school and Rehabilitation Hospital | Speaker application to create communication boards, six-eight symbols/screen, categorical organization, recorded sentences |
| Hunnicutt (1984) Speech Transmission Laboratory–Quarterly Progress and Status Reports (STL-QPSR) | Royal Institute of Technology, Stockholm | Swedish, French, English | Develop a dedicated AAC system device | Case study. Described system structure. | None | Blisstalk communication board, 504 spaces for symbols and labels, arranged by part of speech |
| Iida and Campbell (2003) International Journal of Speech Technology | Keio Research Institute at SFC, Keio University; Japan Science and Technology Agency (JST), Core Research for Evolutional Science and Technology scheme (CREST); ATR Human Information Sciences Research Laboratories | Japanese | Develop a dedicated AAC system device | Described system and layouts. Recorded speech corpora, created source databases, synthesized test sentences, measured objective distances, perceptual experiments, evaluated feasibility with commercial equivalent. | One adult with amyotrophic lateral sclerosis, 40 informants | Chatako-AID device with Japanese characters, and text to speech with personalized voice synthesis |
| Johnson et al. (2006) Informatics in Primary Care | University of Manchester, School of Nursing, Midwifery and Social Work and School of Informatics. Included a Somali research assistant | Somali, English | Develop a low-tech AAC system and high-tech AAC systems using existing software | Purposive snowball sampling and data collection by Somali researcher. Analyzed response times, verbal to symbol disagreement, relevance of responses from video test data. Thematic analysis of interviews. | 20 healthy, native Somali-speaking adults living in the United Kingdom | 10-page communication book, one question per page, bilingual text, and symbols. Digital version (on PC laptop and tablet) using Clicker 4 |

(*table continues*)

**Table 2.** *(Continued).*

| Journal and publication date | Research team | Language of AAC system | Aims of the study | Study methodologies | Study participants | Types of AAC system developed |
|---|---|---|---|---|---|---|
| Lundälv et al. (2014) Technology and Disability | DART Centre for AAC and AT, computer software, web design | Swedish, Dutch, Spanish, English | Develop high-tech components for AAC systems | Inclusive and universal design. Prototyped and iteratively tested software in pilot evaluations. | End users, experts, and developers | Concept-Coding Framework (CCF) Symbol Servicer plugin for SymbolWriter (LibreOffice Writer), Special Access to symbol charts (Windows), and SymbolDroid application |
| Mertl and Frič (2019) Technology and Disability | University of West Bohemia, New Technologies Research Centre, Czech Republic | Czech | Develop an AAC system application for tablet and mobile devices | Participatory/user-centered design. Designed application, conducted observation, informal interviews, and questionnaire. Analyzed data using content analysis and descriptive statistics | 20 adults with temporary voice problems, permanent voice impairment, or total laryngectomy | Key-to-Voice application with predefined sentences, pictograms, and synthesized speech |
| Nakazono et al. (2010) NTT Technical Review | Engineers, user designers, PhD student, consultation with fire departments | Japanese | Develop a high-tech AAC system using existing software | Analyzed emergency conversations, developed flow chart and questions, assigned participants to scenarios, evaluated achievement time and intelligibility | 26 people with hearing disability, without hearing disability, or foreigners | Visualized universal talking environment (VUTE) Flash communication aid for conversing during an emergency |
| Vaillant (1998) Natural Language Engineering | Computer Science Group, with Rehabilitation Centre of Kerpape | French | Develop web-based AAC system software | Described system architecture, interface, analysis mechanism, and sentence generation and qualitative feedback. | Four people with cerebral palsy | Intelligent Voice Prosthesis (PVI) software with natural language processing, icon-based word-to-sentence generator, and text to speech |
| Vaughan (2018) Master's thesis | University of Kansas, Speech, Language, Hearing graduate degree program | Peruvian Spanish | Develop low-tech AAC systems | Described systems, observed intervention sessions, translator assisted. Used communication Matrix, evaluated perceptions with pre- and post-intervention survey rating scales. | One person with Rett syndrome, one with traumatic brain injury and their two mothers | Tactile and eye-gaze yes/no boards, with symbols, photos, and text |

*Note.* AAC = augmentative and alternative communication; ECAM-EPMI = École catholique des arts et métiers - EPMI, French engineering College; ARASAAC = Aragonese Center of Augmentative and Alternative Communication; CVA = cerebrovascular accident; AT = assistive technology.

measured achievement time, communication rate, cognitive load, and physical effort (Bhattacharya & Basu, 2009, 2010; Nakazono et al., 2010).

Mixed-methods studies were quantitative-dominant and evaluated response times, pictogram use and sequencing, relevance of response, and verbal-to-symbol disagreement (Hervás et al., 2020; Johnson et al., 2006). They also analyzed qualitative data using thematic analysis of interview and questionnaire responses (Hervás et al., 2020; Johnson et al., 2006).

### Study Participants

People with disabilities and/or who use AAC were involved in just over half of the studies as participants ($n$ = 13). Caregivers and people without disabilities were also included in several studies (Daems et al., 2016; Iida & Campbell, 2003; Nakazono et al., 2010). Other studies recruited participants without disabilities, including health, allied health and linguistics students and professionals, special education teachers, or native adult speakers of the study language (de Oliveira et al., 2016; Heikkilä et al., 2019; Hervás et al., 2020; Johnson et al., 2006). Five studies did not involve participants or engage with end users at all (Andres, 2006; Blomberg et al., 1986; Choi et al., 2012; García-Méndez et al., 2019; Hunnicutt, 1984).

### Types of AAC Systems Developed

Low-tech AAC systems ranged from yes/no and single page communication boards and displays (Heikkilä et al., 2019; Vaughan, 2018), to a 10-page communication book (Johnson et al., 2006). All low-tech systems used visual symbols with text labels and, in one case, photos and tactile letters (Vaughan, 2018). Existing computer software (Clicker 4 and Adobe Flash Player) was used to develop high-tech AAC systems with symbols, text, and motion pictograms (Johnson et al., 2006; Nakazono et al., 2010). Custom-designed web-based AAC system software incorporated visual symbols, animations, text, and sound files for digital PECS (Benkherrat, 2019), and to generate high-tech communication boards (Baldassarri et al., 2014; Choi et al., 2012). In another study, additional components such as natural language processing and text to speech were also incorporated (Vaillant, 1998). Applications for mobile and tablet devices developed in six studies incorporated predefined recorded sentences and visual symbols in categories, as well as scanning, symbol prediction, text to speech, saving and sharing messages, and other customizable features in some apps (An et al., 2017; Daems et al., 2016; de Oliveira et al., 2016; Hervás et al., 2020; Huertás & Nohama, 2014; Mertl & Frič, 2019). High-tech dedicated devices incorporated an icon-based word-to-sentence generator, keyboards, text to speech, or personalized voice (synthesized speech) with prediction and message storage capacity (Bhattacharya & Basu, 2009, 2010; Deliege, 1989; Iida & Campbell, 2003). An electronic communication board with 504 vocabulary spaces arranged by part of speech was also developed (Hunnicutt, 1984). Component technologies for high-tech AAC systems included natural language generation, text to speech, and server plugins for open-source applications (Blomberg et al., 1986; García-Méndez et al., 2019; Lundälv et al., 2014). An icon set and grammar keys for a dedicated device keyboard were also developed (Andres, 2006).

## Linguistic Considerations for AAC System Development

Linguistic considerations that influenced study methods and AAC systems are presented in Table 3. Linguistic considerations were reported in most studies, related to vocabulary representation (100% of studies), semantics (95% of studies), morphology and syntax (59% of studies), and phonetics and phonology (68% of studies).

### Vocabulary Representation

All studies used the text, characters, or script of the specific study language to represent vocabulary in AAC systems. One study used bilingual text labels (Johnson et al., 2006), and another used tactile letters (Vaughan, 2018). Visual symbols were also used to represent vocabulary in 19 of the 22 studies. Half of the studies incorporating visual symbols used an existing symbol database (Aragonese Centre for AAC pictograms, Blissymbols, Picture Communication Symbols, Beta and Sclera pictograms, or Minsymbols). Otherwise, locally developed visual symbols were used (Bhattacharya & Basu, 2009, 2010; Choi et al., 2012) or specific details were not provided. Some AAC systems enabled images and/or photographs to be imported (An et al., 2017; Baldassarri et al., 2014; Vaughan, 2018) or incorporated motion pictograms, moving pictures, or animated pictographs (Benkherrat, 2019; Nakazono et al., 2010; Vaillant, 1998). Audio representation of vocabulary in AAC systems was also reported in 15 studies, summarized under the Phonetics and Phonology section below.

### Semantics

Semantic features were discussed in 21 of 22 studies. Primary source data, including symbol databases (discussed above), text or speech corpora (collections of written text), and lexicons (lists of vocabulary, with or without definitions) were used in 15 studies. Most commonly, vocabulary in AAC systems was reported to relate to high-frequency characters/vocabulary, general conversation, and daily activities ($n$ = 8). Three studies reported context-specific vocabulary for favorite items, exercise class, or health and pain (An et al., 2017; Heikkilä et al., 2019; Mertl & Frič, 2019). The semantic organization of

**Table 3.** Linguistic and culture-specific considerations influencing research methods and AAC systems.

| Linguistic considerations | | | | Culture-specific considerations | |
|---|---|---|---|---|---|
| **Vocabulary representation** | **Semantics** | **Morphology and syntax** | **Phonetics and phonology** | **Influence on research method** | **Influence on AAC system** |
| Text labels/characters of language (An et al., 2017; Andres, 2006; Baldassarri et al., 2014; Benkherrat, 2019; Bhattacharya & Basu, 2009, 2010; Blomberg et al., 1986; Choi et al., 2012; Daems et al., 2016; de Oliveira et al., 2016; Deliege, 1989; García-Méndez et al., 2019; Heikkilä et al., 2019; Hervás et al., 2020; Huertás & Nohama, 2014; Hunnicutt, 1984; Iida & Campbell, 2003; Johnson et al., 2006; Lundälv et al., 2014; Mertl & Frič, 2019; Nakazono et al., 2010; Vaillant, 1998; Vaughan, 2018) | Symbol databases (see column 1), text corpora (from news articles, poems, stories, folk tales, familiar materials, manuals, short sentences, sentences covering diphones) (Bhattacharya & Basu, 2009, 2010; García-Méndez et al., 2019; Iida & Campbell, 2003; Nakazono et al., 2010), lexicons (Blomberg et al., 1986; García-Méndez et al., 2019; Hunnicutt, 1984; Iida & Campbell, 2003; Lundälv et al., 2014; Vaillant, 1998) | Grammatical features: tense, aspect, type, modality, mood, linear and nonlinear morphology, word order (Bhattacharya & Basu, 2009, 2010), number, gender, person, tense, conjugation class (García-Méndez et al., 2019), morphological rules (García-Méndez et al., 2019; Hunnicutt, 1984), form, inflectional endings, definiteness, phrase order (Hunnicutt, 1984), morphological lexicons (García-Méndez et al., 2019) | Phonetic strings and rules, grapheme–phoneme rules, pronunciations (Blomberg et al., 1986), number rules (Blomberg et al., 1986; Deliege, 1989; Hunnicutt, 1984), phoneme inventory (Choi et al., 2012), pseudophonetic notation, intonation contours (Deliege, 1989), diphone inventory, pronunciation rules (Deliege, 1989; Hunnicutt, 1984), rules for prosody, loudness, and speed controls (Hunnicutt, 1984), phonemic representation, phoneme waveforms, prosodic, contextual and RMS energy features, start time information, voicing probability (Iida & Campbell, 2003) | Used five questions and user testing to consider images (Huertás & Nohama, 2014) | Culture-specific symbols and vocabulary (Choi et al., 2012), culturally representative character (Nakazono et al., 2010), cultural considerations in image selection (Huertás & Nohama, 2014), cultural metaphors, concepts, and knowledge in vocabulary and symbol representation and organization (Andres, 2006) |

(*table continues*)

**Table 3.** *(Continued).*

| Linguistic considerations | | | | Culture-specific considerations | |
|---|---|---|---|---|---|
| **Vocabulary representation** | **Semantics** | **Morphology and syntax** | **Phonetics and phonology** | **Influence on research method** | **Influence on AAC system** |
| Symbol databases, including: ARASAAC pictograms (Baldassarri et al., 2014; de Oliveira et al., 2016; Hervás et al., 2020; Lundälv et al., 2014), Blissymbols (Blomberg et al., 1986; Hunnicutt, 1984; Lundälv et al., 2014), Picture Communication Symbols (PCS; Heikkilä et al., 2019; Johnson et al., 2006), Beta and Sclera pictograms (Daems et al., 2016), Minsymbols (Andres, 2006), icons from stamp book (Bhattacharya & Basu, 2009, 2010), Symbols developed by Ewha Womens University, Seoul (Choi et al., 2012)<br><br>General reference to pictures, symbols, pictograms, pictographs (An et al., 2017; Benkherrat, 2019; Heikkilä et al., 2019; Huertás & Nohama, 2014; Mertl & Frič, 2019; Vaughan, 2018), uploaded images (Baldassarri et al., 2014), photographs (An et al., 2017; Vaughan, 2018) | Core vocabulary/high-frequency characters (Andres, 2006), vocabulary for simple routines, games, storytelling, activities, emotions, songs (Baldassarri et al., 2014), common/daily, basic tasks (de Oliveira et al., 2016; Huertás & Nohama, 2014; Johnson et al., 2006; Vaughan, 2018), activities (e.g., school, toys and games) and social necessity (e.g., cleanliness; Benkherrat, 2019), general conversation (while travelling; Daems et al., 2016), favorite items and activities (reinforcers; An et al., 2017), exercise class (Heikkilä et al., 2019), phrases for health and pain (Mertl & Frič, 2019) | Parts of speech (Andres, 2006; Bhattacharya & Basu, 2009, 2010; Blomberg et al., 1986; de Oliveira et al., 2016; García-Méndez et al., 2019; Heikkilä et al., 2019; Hervás et al., 2020; Hunnicutt, 1984; Lundälv et al., 2014), syntax lexicons (García-Méndez et al., 2019), telegraphic grammar, Bliss syntax, natural language syntax (Hunnicutt, 1984), syntactic trees, taxemes (Vaillant, 1998), Bunsetsu (Japanese syntactic unit) (Iida & Campbell, 2003), sentence rules (Benkherrat, 2019; García-Méndez et al., 2019), sentence type (García-Méndez et al., 2019; Johnson et al., 2006), orthographic rules (García-Méndez et al., 2019). | Text to speech, keyboard to speech (Benkherrat, 2019; Bhattacharya & Basu, 2009, 2010; Blomberg et al., 1986; Choi et al., 2012; de Oliveira et al., 2016; Deliege, 1989; Hunnicutt, 1984; Iida & Campbell, 2003; Mertl & Frič, 2019), personalized speech synthesis voice (Mertl & Frič, 2019) "system reads aloud word"/"text read aloud" (Hervás et al., 2020; Nakazono et al., 2010), recorded speech (An et al., 2017; Huertás & Nohama, 2014; Johnson et al., 2006), uploaded audio files (Baldassarri et al., 2014; de Oliveira et al., 2016) | Language- and culture-specific researcher carried out sampling, recruitment, and all data collection (Johnson et al., 2006) | Participants liked hearing recordings of their own language and using it to communicate (Johnson et al., 2006), importance of natural intonation for crucial terms (e.g., "*kyuuin";* Iida & Campbell, 2003) |

(*table continues*)

**Table 3.** *(Continued).*

| Linguistic considerations | | | | Culture-specific considerations | |
|---|---|---|---|---|---|
| **Vocabulary representation** | **Semantics** | **Morphology and syntax** | **Phonetics and phonology** | **Influence on research method** | **Influence on AAC system** |
| Motion pictograms/ moving pictures/ animated pictographs (Benkherrat, 2019; Nakazono et al., 2010; Vaillant, 1998), tactile letters (Vaughan, 2018) | Organized by category (An et al., 2017; Benkherrat, 2019; de Oliveira et al., 2016; Hervás et al., 2020; Huertás & Nohama, 2014; Mertl & Frič, 2019), parts of speech (Heikkilä et al., 2019), hierarchy (Bhattacharya & Basu, 2009, 2010; Choi et al., 2012), keyword tags (Choi et al., 2012) | | | Translator used for non–English-speaking participants (Vaughan, 2018) | Name of AAC system derived from Sanskrit (Bhattacharya & Basu, 2009, 2010) |

*Note.* Information relate to audio representation of vocabulary is presented in column 4 "Phonetics and phonology" and also relevant to column 1 "Vocabulary representation." AAC = augmentative and alternative communication.

the AAC system was also specified in almost half of studies ($n$ = 10) arranging vocabulary by category, part of speech, hierarchical structure, or keyword tags.

### Morphology and Syntax

Morphological and syntactic features of AAC were also presented in 13 studies. Most commonly, studies mentioned parts of speech ($n$ = 9). In some cases, more specific morphological rules and grammatical features of language (tense, aspect, type, modality, mood, number, etc.) were reported (Bhattacharya & Basu, 2009, 2010; García-Méndez et al., 2019; Hunnicutt, 1984). Seven studies presented sentence rules and language-specific syntactic features in the development of AAC ($n$ = 7).

### Phonetics and Phonology

Phonetic or phonological features were reported in 15 studies. Studies that reported on text to speech development also included specific details on phoneme and diphone inventories, representations and waveforms, phonetic strings, grapheme–phoneme rules, and so forth; see Table 3 (Blomberg et al., 1986; Choi et al., 2012; Deliege, 1989; Hunnicutt, 1984; Iida & Campbell, 2003). Audio representation of vocabulary was also commonly reported in AAC systems, including text to speech (synthesized speech; $n$ = 7), personalized voice (synthesized speech; $n$ = 1), recorded speech ($n$ = 3), uploaded audio files ($n$ = 2), or "read words/text aloud" unknown method ($n$ = 2).

## Culture-Specific Considerations for AAC System Research and Development

Culture-specific considerations related to research method and AAC system outcomes were much less frequently reported than linguistic considerations, in only 14% and 32% of studies, respectively. Culture-specific considerations that influenced AAC system design and/or research methods are presented in Table 3.

Culture-specific considerations related to the research method were explicitly reported in only three studies. Simple questions and a user-testing approach were used to identify the best images for the (cultural) context in one study (Huertás & Nohama, 2014). Participant sampling and data collection were conducted by a researcher who spoke the study language and whose cultural identity aligned with the study context in another (Johnson et al., 2006). In the third, a translator was used with non–English-speaking participants (Vaughan, 2018).

Culture-specific considerations that influenced AAC systems were identified in seven studies. In most cases, these related to selection of culture-specific vocabulary or visual symbols. In one study, a culturally representative character was incorporated (Nakazono et al., 2010). Cultural metaphors, concepts, and knowledge were used to select visual symbols in another (Andres, 2006). Culture-specific considerations were also identified in relation to audio representation of vocabulary, through use of recorded voice from a native speaker, and correct intonation (Iida & Campbell, 2003; Johnson et al., 2006). In one instance, the name of the AAC system was derived from the study language (Bhattacharya & Basu, 2009, 2010).

## Discussion

The focus of this review was on identifying the scope and nature of research published between 1970 and 2020 that reported on the development of AAC in languages other than English, and on the cultural and linguistic factors that influenced the development of AAC systems. We found that prior to 2000, the small body of literature reporting on the development of AAC systems in languages other than English was limited to European languages. Although still not extensive, there has been a substantial increase in research about AAC systems in majority world languages, including in Asian, South American, and African languages in the last 10 years. Qualitative methods have been predominant in AAC development research, conducted by diverse research teams, often bringing together researchers, professionals, corporate partners, and end-users. Participatory research methods in existing research have been used to facilitate collaboration with people with disabilities, rather than to be responsive to the cultural or linguistic context. However, people with disabilities have, to date, only been involved as participants in just over half of the studies, and not as researchers or advisors. This surprisingly low number of studies highlights that people with disabilities are still not sufficiently and consistently engaged in the design and development of AAC systems in languages other than English.

Research identified in this review also reflects broader trends focusing on developing high-tech AAC (Iacono et al., 2013), including an increase in AAC apps for mobile technologies, web-based AAC software, and component technologies being developed to enable developers, practitioners, and users to custom-build systems in different languages, using existing symbol databases and text-to-speech systems that can be used across operating systems and devices (Lundälv et al., 2014). While research continues to focus on development of high-tech AAC, requiring substantial linguistic and technological resources, Indigenous people and others who speak minority languages and live with a disability continue to experience intersectional disadvantage without access to communication systems in their own languages.

A significant finding from this review is that linguistic factors influencing AAC were typically reported in studies, whereas culture-specific considerations were rarely

acknowledged. This supports the assertion that an in-depth linguistic knowledge of the content and structure of language is necessary to develop comprehensive AAC systems (Baker & Chang, 2006; Tönsing et al., 2018). It can also be assumed that (explicitly reported or not) cultural considerations influenced all studies. Everything is developed within and influenced by a cultural context, yet this was rarely explicitly acknowledged or reported. Existing research reflects an assumption that cultural difference has minimal influence on AAC research methods and is limited to appropriate selection and representation of vocabulary. Potential influence of culture or worldview on other aspects of system structure and design are not reported.

There are several potential reasons for a lack of explicit reporting of culture-specific considerations in existing research. One reason may relate to the complex relationship between language and culture. For example, one study reported that reproducing natural intonation of crucial terms was important but did not specify whether this was so that terms could be understood linguistically, be culturally acceptable and/or respectful, or both (Iida & Campbell, 2003). Symbol selection also has both linguistic (representation of semantic concepts) and culture-specific components (sociocultural values and acceptability), but neither was extensively discussed in studies in this review.

Differences between the author's cultural context and the study context may have impacted reporting of culture-specific considerations. Two studies that acknowledged culture-specific considerations on the research method were written by authors based in Western countries—about a minority language within the United Kingdom (Somali; Johnson et al., 2006), or about AAC system development work abroad (in Peru; Vaughan, 2018). A relative strength of the research done in Asian contexts is the explicit articulation of some culture-specific considerations in AAC system development. In contrast, discussion of culture-specific considerations is absent in most European studies. This draws attention to the persistent, dominating White and Western cultural norms in the discipline of AAC.

An additional possible explanation for the lack of reporting culture-specific considerations could be the multifaceted nature of AAC, making it impossible to consider all aspects of AAC in any one study (Light et al., 2019). This compartmentalization also reflects Western cultural influence in the field of AAC. Such separation of system components is not compatible with Indigenous cultures whose ontology is inherently holistic and interconnected (Christie, 2005). For Indigenous peoples, "fragmentation has been the consequence of imperialism" (Smith, 2012, p. 29).

## Limitations

Selection of studies was limited by access to resources for translation and interpretation of studies in non-English languages. The authors considered the translation of two studies using Google Translate to be sufficient to chart and analyze data required for this study. However, these translations were not independently verified. In future studies, appropriate people should be employed to provide a more accurate translation of studies and be available for consultation during data charting and analysis.

Authors of this review have a background in AAC, speech-language pathology, allied health, and working collaboratively in intercultural contexts. Our understanding and interpretation of computer science and technology literature was limited by the scope of our professional knowledge. Future review teams should be composed of people from a range of professional backgrounds to confidently consider the breadth of existing literature.

## Directions for Future Research

Based on the results of this review, several recommendations and directions for future research are suggested. Firstly, there is a need for more published literature on AAC system development in languages other than English, given the large and growing number of people requiring AAC who do not speak English as their primary language. In particular, research on the development of AAC systems for speakers of Indigenous and other minority languages is urgently needed, given the intersectional disadvantages they experience.

Explicit reporting of details about the cultural context, assumptions, and ideologies that influence AAC system development is also essential. AAC researchers need to consider not just linguistic accuracy (syntax, morphology, semantics, phonetics, and phonology), but also the cultural and pragmatic considerations in how AAC systems are designed and used.

We suggest that new research methods are required to explore AAC system development from different worldviews and cultural standpoints, in particular for Indigenous peoples. While personalization of AAC systems using existing frameworks such as the Participation Model provides some opportunities to accommodate culture-specific considerations in AAC, distinctive research methods are required to ensure AAC systems are developed in culturally responsive and respectful ways. Such methods may involve implementing culture-specific considerations within existing qualitative research methodologies, and/or the development and use of novel methodologies to the field of AAC. For example, Stuart and Parette (2002) argue that the development of Native American AAC systems requires long-term trusting relationships with a wide range of team members involved in development, to enable communication in native languages, work with family members for translation, and use storytelling rather than written forms in research. Stone (2019) also argues for the

building of long-term trusting relationships as a core component of research design and Māori AAC system development. Māori AAC must be developed by and with Māori, in ways that are holistic, cross-disciplinary, reflect and privilege "*mātauranga"* (Māori values), and *"tikanga Māori"* (right social practices), giving "whanau" (extended family) "tino rangatiratanga" (self-determination; Stone, 2019).

## Conclusions

In this scoping review, we identified research reporting on the development of AAC systems in languages other than English and the linguistic and culture-specific considerations that influenced AAC system development. We found that in the last 20 years there has been published research related to the development of AAC systems in languages from across the globe, including across Europe and Asia, with some emerging studies from Africa and South America. Despite this growing body of global research, the existing literature reflects a persisting Western cultural influence on AAC research processes and outputs. Linguistic factors were commonly reported, whereas culture-specific considerations were rarely explicitly acknowledged. Existing research reflects dominant and prevailing ideologies and constructs that consider Western culture to be the norm and cultural difference to have minimal influence on research methods or AAC systems. There is a need for future research to use culturally responsive theoretical frameworks and methods, and to acknowledge and explain the underlying cultural assumptions and ideologies that influence AAC system development.

## Author Contributions

**Rebecca Amery:** Conceptualization (Lead), Data curation (Lead), Formal analysis (Lead), Investigation (Lead), Methodology (Lead), Resources (Lead), Validation (Lead), Writing – original draft (Lead), Writing – review & editing (Lead). **Abirami Thirumanickam:** Formal analysis (Supporting), Investigation (Supporting), Resources (Supporting), Validation (Equal), Writing – review & editing (Supporting). **Ruth Barker:** Conceptualization (Supporting), Methodology (Supporting), Supervision (Equal), Writing – review & editing (Supporting). **Anne Lowell:** Conceptualization (Supporting), Supervision (Supporting), Writing – review & editing (Supporting). **Deborah Theodoros:** Supervision (Supporting), Writing – review & editing (Supporting). **Parimala Raghavendra:** Conceptualization (Supporting), Methodology (Supporting), Supervision (Equal), Validation (Supporting), Writing – review & editing (Supporting).

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