Finding the best fit: Examining the decision making of augmentative and alternative communication professionals in the UK using a discrete choice experiment

Edward J.D. Webb[i,ii] Yvonne Lynch[iii,iv] David Meads[ii,v] Simon Judge[iii,vi,vii]

Nicola Randall[iii,vi,viii] Juliet Goldbart[iii,ix] Stuart Meredith[iii,x]

Liz Moulam[iii,xi] Stephane Hess[xii,xiii] Janice Murray[iii,xiv]

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[i] Corresponding author; e.j.d.webb@leeds.ac.uk; +44 113 343 2982; Leeds Institute of Health Sciences (LIHS), Level 10 Worsley Building, Clarendon Way, Leeds, LS2 9NL, UK. OrcID: 0000-0001-7918-839X
[ii] Leeds Institute of Health Sciences, University of Leeds
[iii] Faculty of Health, Psychology and Social Care, Manchester Metropolitan University
[iv] lynchyv@tcd.ie
[v] d.meads@leeds.ac.uk
[vi] Barnsley Assistive Technology Team, Barnsley Hospital NHS Foundation Trust
[vii] Simon.judge@nhs.net
[viii] nicola.randall1@nhs.net
[ix] j.goldbart@mmu.ac.uk
[x] meredithsn@hotmail.com
[xi] lizmoulam@aol.com
[xii] Choice Modelling Centre and Institute for Transport Studies, University of Leeds
[xiii] s.hess@leeds.ac.uk
[xiv] j.murray@mmu.ac.uk

ABSTRACT

Objectives: Many children with varied disabilities, e.g., cerebral palsy, autism, can benefit from augmentative and alternative communication (AAC) systems. However, little is known about professionals' decision-making when recommending symbol based AAC systems for children. This study examines AAC professionals' preferences for attributes of AAC systems and how they interact with child characteristics.

Design: AAC professionals answered a discrete choice experiment (DCE) survey with AAC system and child-related attributes, where participants chose an AAC system for a child vignette.

Setting: The survey was administered online in the UK.

Participants: 155 UK-based AAC professionals were recruited between 20/10/17 and 4/3/18.

Outcomes: The study outcomes were AAC professionals' preferences as quantified using a mixed logit model, with model selection performed using a stepwise procedure and the Bayesian Information Criterion.

Results: Significant differences were observed in preferences for AAC system attributes, and large interactions were seen between child attributes included in the child vignettes, e.g., participants made more ambitious choices for children who were motivated to communicate using AAC, and predicted to progress in skills and abilities. These characteristics were perceived as relatively more important than language ability and previous AAC experience.

Conclusions: AAC professionals make trade-offs between attributes of AAC systems, and these trade-offs change depending on the characteristics of the child for whom the system is being provided.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This was the first discrete choice experiment (DCE), and only the second stated preference study in the field of augmentative and alternative communication (AAC).
- The study used unusual and innovative methodology by (1) using a Best-worst Scaling case 1 study in attribute selection; (2) having AAC system choices be made in the context of a child vignette

formed from a set of attributes; and (3) introducing a new measure termed relative interaction attribute importance to interpret results.

- Child vignettes were relatively simple, and a single vignette could represent children with very different needs.
- In some ways, the DCE task differed from how augmentative and alternative professionals make decisions in practice.

INTRODUCTION

Many people lack the ability to produce intelligible speech to meet their functional needs for a wide range of reasons, including cerebral palsy, intellectual/developmental delays and autism spectrum disorder. Even within disability types, individuals' communication related needs and abilities are extremely varied. Augmentative and alternative communication (AAC) refers to methods of supporting communication. AAC systems encompass unaided methods including signing, facial expressions, body language, as well as the use of aided systems.[1] This article focused on aided systems, also known as communication aids, which include high-tech electronic devices, such as those used by Stephen Hawking or Britain's Got Talent winner Lee Ridley, as well as low-tech systems, such as boards and communication books.

AAC can improve the lives of people with communication disabilities.[2-4] Appropriate AAC is especially important for the estimated 1 in 200 children in the UK[5-7] who require these kind of supports. Not only are their language and communication abilities still developing and their needs evolving[8-10], the systems used in childhood can potentially have impacts lasting a whole lifetime.[4]

Major advances in the AAC landscape have occurred in recent years.[11 12] These include technological innovation, for example iPads and eye-tracking, though low-tech systems may still offer the best solution in many cases.[13 14] Another development within services is a greater expectation of participation in all aspects of life for people who use AAC,[11 15-17] coupled with advocacy for the right to communicate.[14] New possibilities for AAC have been created by new communication methods such as text messaging[18], email[19] and social media.[20 21]

Despite the benefits AAC can offer, high rates of abandonment (30-50%) of AAC systems by children have been observed[22 23], with causes of abandonment not well understood. AAC systems can be costly (up to £10,000) and require a large amount of professional support.[24] However, when recommended appropriately and well implemented, AAC systems have been suggested to be a cost-effective use of the UK's National Health Service (NHS) resources.[25]

The process through which children receive AAC systems varies, both across and within countries.[26-28] In the UK, the context for this study, children's needs and abilities are commonly assessed by a team of AAC professionals, which may include speech and language therapists, occupational therapists and/or specialist teachers.[29 30] Final recommendations and decision-making about AAC systems are made with variable input from the child and family.

Choosing an AAC system requires consideration of many features. For example, what type of graphic symbols, e.g., photos/stylized pictures/words, to use, how many symbols are available, how they are organized, and how they are accessed.[10 31 32] The large degree of heterogeneity in the population of people who benefit from AAC, and in the systems available, means the assessment and subsequent matching of individual and system is a complex task and unique to each person.[26 28 33]

There is currently a lack of documented evidence for assessment and decision-making processes,[33-35] and what does exist is largely individual case studies.[3 25 36] AAC professionals must often make difficult and complex decisions in a complicated, heterogeneous and rapidly evolving environment, balancing the needs of an individual child, and available resources.[30 37] They must also take account of the cultural and contextual influences shaping each assessment.[13 38] While there have been studies which have highlighted some important factors in decision-making,[6 33 39] available guidelines have tended to focus on the organisational structure of services, rather than decision-making as such.[29 34 40]

The current study addressed the knowledge gaps by providing quantitative evidence about AAC professionals' decision-making using a survey method termed a discrete choice experiment (DCE). DCEs are commonly used in healthcare,[41-43] and can quantify the preferences of patients, health professionals and the public for

treatments, service delivery methods, policies, or other things. In this case, the goal was measuring the preferences of AAC professionals when choosing AAC systems.

This study was part of a wider project entitled *Identifying Appropriate Symbol Communication aids for children who are non-speaking: enhancing clinical decision making* (I-ASC), which examined provision of AAC systems for children in the UK. I-ASC had several components, using different research methods[30 37 44 45] to generate a body of evidence on current practice and recommendations for best practice. This has resulted in resources to aid AAC decision-making available here: https://iasc.mmu.ac.uk.

Although there is a lack of robust evidence surrounding the decision-making process, some factors in successful adoption of AAC have been identified. An AAC system is more likely to be adopted by a motivated child[22] with good support from the child's network.[27 33 44] The AAC system must also meet a child's individual needs and circumstances, which will be unique to every child.[14 22 46]

A previous study from the current research project investigated the AAC decision-making process using a Best-worst Scaling (BWS) case 1 survey.[45] This method was chosen as it could quantify which of several child and AAC system related factors (37 in total) AAC professionals considered most and least important in decision-making.

The current study sought to complement the previous work by examining fewer factors in more detail using a DCE.[43] It aimed to quantify the clinical judgements and trade-offs AAC professionals make between different attributes of AAC systems, and how those trade-offs change depending on children's characteristics, things not possible using BWS case 1. This is the first DCE carried out in AAC, and there were challenges associated with performing a DCE with a target population of AAC professionals (for details see discussion). Thus, an additional goal was to establish the feasibility of using DCEs as a research tool in AAC.

METHODS

Survey development

No stated preference work existed in AAC prior to the current project, and there were a large number of potential attributes with little evidence as to which to include in a DCE. A BWS case 1 study was hence performed initially and the results used to guide attribute selection for the DCE. In line with good practice and to ensure attributes were meaningful and relevant, qualitative methods were used to generate attributes.[47 48] Attributes for the BWS study were generated through focus groups and interviews with AAC professionals, people who use AAC, their families, and other stakeholders; systematic literature reviews; and input from an expert panel. For more details see section 2 of Webb et al. [45]

The BWS study produced relative importance scores for 19 child and 18 system attributes given in Appendix A. DCE attributes were selected from these during consensus discussions between authors with expertise in AAC, speech and language therapy, and health economics. The selection criteria were that attributes should: (1) form coherent and realistic descriptions of children and systems; (2) address the research aims of the wider research project, e.g., a focus on symbol communication systems; (3) include mainly attributes with high relative importance scores in the BWS study; and (4) be small in number so choice tasks would not over-burden respondents. Consensus was achieved via unstructured discussions until all authors were in agreement. This resulted in four child and five system attributes. The attributes are listed in Tables 1 and 2, together with non-specialist descriptions for the benefit of the general reader. (For a further introduction see Beukelman and Mirenda.[17])

In summary, the child attributes captured a child's language ability, experience with AAC, attitude/motivation to communicate with AAC, and whether the child is expected to regress, plateau or progress in communication ability. A total of 54 child vignettes were formed from the set of child attributes. Authors with expertise in AAC and speech and language therapy identified and removed 18 child vignettes representing unrealistic combinations, leaving 36.

AAC system attributes broadly captured the vocabulary set(s) provided by manufacturers, vocabulary size and organisation, type of graphic symbols used, and how consistent the navigational layout of words/symbols is when accessing items. It was not stated whether a system was high-tech or low-tech, although certain levels,

e.g., vocabulary sets with staged progression, are more common with high-tech systems. Authors with experience in AAC and speech and language therapy removed 158 unrealistic combinations from the 432 AAC systems which could be formed from the system attributes, leaving 274.

Prior experience from the BWS study suggested it would be difficult to recruit a large respondent sample, so to maximise the information captured a relatively heavy response burden of 12 choices between three systems was selected for the DCE. Participants were shown three child vignettes, referred to as Child A, B and C, and made four choices for each child vignette. An example task is shown in Appendix B.

The survey's statistical design (i.e., which levels of the AAC system attributes were presented in each question) was generated using NGene[i], with 60 choice tasks split into five blocks. The design sought to maximise D-efficiency, a measure of how much information it is possible to extract from survey responses.[49]

The survey was piloted by five AAC professionals and consequently the wording of some attributes and levels altered.

Survey administration

The DCE was administered online for ease of recruitment. Recruitment was carried out via AAC professionals' email distribution lists (the project's own list and the mailing list of the UK wide charity Communication Matters[ii]). In addition, invitations were sent via publicly available lists and websites, and the professional contacts of authors. Adverts were also placed on the project website and online media. Responses were collected between 20/10/17 and 4/3/18. Ethical approval was received from an NHS Research Ethics Committee (REC reference 6/NW/0165) and informed consent obtained from participants at the start of the survey.

Participants began by confirming they contributed towards AAC decision-making for children, and those who indicated they did not progressed directly to demographic questions that were at the end of the survey (for

[i] ©ChoiceMetrics
[ii] www.communicationmatters.org.uk

details, see Appendix A).[i] Three child vignettes and one survey block were randomly allocated to each participant. The order of system attributes was randomised between participants, but consistent within participants, and which systems appeared on the left, middle and right of the screen was also randomised.

Analysis

Analysis of participants' choices was grounded in random utility theory. This standard approach[50] assumed participants chose the object which maximised their utility. The utility of an object was modelled as depending partly on the object's attributes and partly random, the latter component capturing the influence of all factors not included in the model. In a given choice scenario t, participant i chose which of three AAC systems to allocate to child c. The utility to participant i of allocating AAC system $s \in \{1,2,3\}$ to child c in choice scenario t was

$$u_{isc} = \alpha_s + \beta_{ic} x_s + \varepsilon_i$$

where α_s was an alternative specific constant for AAC system s, x_s was a vector of dummy variables indicating AAC system levels, β_{ic} was a vector of coefficients which differ across participants and children, and ε_i was a random error term.

The coefficient on level l of system attribute a, β_{ialc}, depended on the characteristics of the child vignette according to

$$\beta_{ialc} = \gamma_{ial0} + \gamma_{ial} z_c$$

[i] The precise wording of the question was: *"I confirm my work involves assessing children for aided AAC systems and I contribute to the decision making in relation to the language and vocabulary organisation within AAC systems."* During testing it was revealed that some AAC professionals did not have sufficient input into the decision making process in their day-to-day practice for the DCE questions to be meaningful, e.g., occupational therapists specialising in optimising physical access to an AAC system recommended by other members of the team, and this question was designed to filter out such respondents.

where γ_{ial0} was a constant giving the preference for a system attribute at baseline child levels, z_c was a vector of dummy variables indicating vignette levels and γ_{ial} was a vector of coefficients, allowing for heterogeneity in relative preference for AAC system attributes depending on child characteristics.

A full model with all interaction terms included too many parameters to estimate reliably. Thus, parameters were eliminated in a stepwise process and a final preferred mixed logit model was identified using the Bayesian Information Criterion (BIC). The mixed logit model incorporated participant heterogeneity by allowing AAC system attribute parameters to be random, following a normal distribution with both means and variances depending on child characteristics. For details, see Appendix C.

Models were estimated using the CMC Choice Modelling Centre Code for R version 1.1[51] and all analysis was carried out using R version 3.3.1. Statistical significance was assessed at the 5% level after adjusting for multiple testing using Holm's sequential Bonferroni correction.[52]

Results were presented using a new measure termed *relative interaction attribute importance* (RIAI) which assessed how big an impact child attributes have on AAC professionals' decision-making. RIAI is analogous to relative attribute importance, often used to present DCE results, [53] and may be calculated either with respect to a single choice object attribute or overall with respect to all choice object attributes. For a formal definition of RIAI, see Appendix D.

Patient and public involvement

One author (SM) is an AAC user, and one (LM) is the parent of an AAC user, and both were involved in all stages of research development and delivery.

RESULTS

A total of 172 participants completed the survey, of whom 155 indicated they contributed to decision-making regarding AAC systems and answered DCE questions. Summary statistics of their demographics and professional experience are given in Table 3. Most participants were female (~90%) and white. We believe

this to be reasonably representative of the population of AAC professionals in the UK.[i] The mean age of DCE participants was around 40, with a range from 24 to 65, and they had on average 10 years' experience of AAC. Around 75% of DCE participants had a speech and language therapy background, with no other background reported by more than 10%. Those who did not answer DCE questions were less likely to have a speech and language therapy background (~50%), with teacher (~20%) and occupational therapist (~30%) more common.

Approximately 30% of the sample worked with all age groups, while 50-60% worked with pre-school, primary school and secondary school aged children. Participants were asked for the three most common diagnoses encountered in their work, with ~80% stating physical disability, 70% stating intellectual disability/developmental delay and 65% stating autism spectrum disorder.

Turning to DCE responses, respondents chose the left-hand option 37.6% of the time, and the central and right-hand options 33.1% and 29.2% of the time respectively, significantly different from an equal distribution (one sample Kolmogorov-Smirnov $p = 0.002$).

Table 4 contains the results of the final preferred model, with 24 coefficients. Figure 1 illustrates the RIAI of child attributes for each system attribute and overall. The constant terms in Table 4 give participants' preferences for AAC system allocation when shown a child vignette with all attributes at baseline levels. This baseline vignette is as follows: *"Child A/B/C has delayed expressive and receptive language and no previous AAC experience. Child A/B/C does not appear motivated to communicate through any methods and means. Child A/B/C is predicted to regress in skills and abilities (regression)."* It represents what was considered by the researchers as the most challenging profile that can be formed from the set of child attributes.

The interaction terms represent how respondents' preferences for AAC systems changed if choosing for a child vignette which differed on a given child attribute.

Vocabulary sets

[i] E.g., data from the Health and Care Professionals Council showed speech and language therapists in the UK were 96% female and the Higher Education Statistics Agency found speech and language therapy students in 2017/18 were 79% white. Source: Royal College of Speech and Language Therapists, personal communication.

For the baseline child vignette, vocabulary sets which are fixed or have staged progression were preferred to no pre-installed vocabulary. Only a single child attribute influenced preferences: Professionals were much more likely compared to the baseline to choose systems with staged progression vocabulary sets over no pre-installed set if the child vignette was predicted progress in skills and ability (odds ratio, OR 3.88) (Table 4).

Consistency of layout

For the baseline child vignette, consistent layout or an idiosyncratic layout was preferred to only having some aspects of system layout consistent for use, with no interactions with child attributes (Table 4).

Vocabulary organisation

For the baseline child vignette there was no significant preference between visual scene, taxonomic or semantic-syntactic vocabulary organisation, whilst pragmatic organisation was preferred. There were two significant interactions between vocabulary organisation and motivation. A child vignette with motivation to communicate using AAC became more likely to be allocated a system with taxonomic (OR 2.03), or semantic-syntactic (OR 2.29) organisation compared to visual scene layout (Table 4).

Size of vocabulary

For the baseline child vignette there were no significant differences in preferences between up to 50 and between 50-1000 vocabulary items, but over 1000 items were considered significantly less appropriate. A mid-size vocabulary (50-1000 items) became more preferable compared to 50 or fewer for a child vignette motivated to communicate using AAC. Over 1000 items became significantly more preferable for child vignettes with each of the following characteristics: receptive language exceeding expressive language, an ability to use a range of AAC functions, motivated to communicate using AAC and predicted to progress (Table 4). All child attributes influenced preferences for vocabulary size. As measured using RIAI, communication ability with AAC (32%) and determination and persistence (28%) were relatively more important than future skills and abilities (22%) and receptive and expressive language (17%) (Figure 1).

Graphic representation

For the baseline child vignette there was no preference between graphic representation using photos or pictographs, but text was less preferred than either, and idiographic symbols were even less preferred. Interactions were seen with two child attributes. Motivation to communicate using AAC increased the probability of choosing pictographic symbols (OR 3.88), idiographic symbols (OR 5.31), or text (OR 4.00) rather than photos. However, being predicted to progress made pictographic symbols less preferable (Table 4).

Overall RIAI of child attributes

Overall, future skills and abilities had the highest RIAI (38%), followed by child's determination and persistence (19%), communication ability with AAC (20%), and receptive and expressive language (12%) (Figure 1).

DISCUSSION

This DCE has revealed AAC professionals' priorities when choosing AAC systems for children, and shown that these priorities change when faced with children with different characteristics. That priorities change in this way is not unexpected, and in line with previous research showing that AAC professionals recognise the importance of matching an AAC system to an individual person's needs.[22 54] However, the current study builds on previous findings by showing the magnitude of preference changes, as for some system attributes their preferences for different levels could completely reverse depending which child vignette was shown. For example, for the baseline child vignette (see Table 4), a system with more than 1000 vocabulary items was less likely to be chosen than one with less than 50 (OR 0.395). However, for a child vignette describing a receptive-expressive language gap, the ability to use AAC for a range of functions, motivation to use AAC and predicted progression, a system with more than 1000 vocabulary items was more likely to be chosen (OR 22.5). Such flexibility is encouraging, as it is in line with one of Williams et al.'s[14] five principles for AAC application: "AAC systems must be highly individualised and appropriate to individual needs" (p.195).

A key finding was that the attribute of the child's determination and persistence had the greatest number of interactions with preferences and was more important in terms of RIAI than language ability or previous experience with AAC. Specifically, the attribute level motivation to communicate using AAC tended to drive participants towards what can be regarded as more ambitious choices, for example more vocabulary items. It may be that participants believed that motivated children are more likely to succeed with such AAC systems, in line with previous findings that attitude towards AAC, and valuing an AAC system are important factors in successful adoption of AAC.[22 54]

Visual scene vocabulary organisation and graphic representation using photos can both involve items/scenes from an individual's own life, and use literal, rather than abstract depictions. Both were less preferred for child vignettes motivated to communicate via AAC. Rather, participants favoured more abstract methods of organisation (taxonomic and semantic-syntactic) and graphic symbols that require more grammar (pictographs, ideographs and text). Preferences for abstract methods of organisation and symbols requiring more grammar may be interpreted as an (unfounded[55]) belief that motivated children will be better able to use more complex AAC systems. An alternative and by no means mutually exclusive interpretation is that lack of motivation requires an AAC system involving familiar cues from their everyday environment.

Previous studies have also studied how AAC professionals choose graphic symbols for children.[56] For example, Thistle and Wilkinson[33] found that cognitive abilities are an important factor, as did Dada et al.[46] The advantage of a DCE was that the precise interactions between child characteristics and symbol type have been enumerated, showing, e.g., which children were more likely to be given AAC systems with photos, and which were more likely to be given systems with text. AAC system preferences did not significantly differ between child vignettes where their skills and abilities were predicted to regress or plateau. However, if a child was predicted to progress, this had a large impact on professional decision-making, with anticipated future skills and abilities ranked as the highest attribute in terms of RIAI. As with motivation, skills and abilities led to more ambitious choices, with more vocabulary items preferred and pictographs depreciated compared to ideographs and text. Such ambitious choices could reflect participants wishing to provide AAC

systems that would fulfil the future needs of children who are anticipated to progress, given the large investment that goes into learning a new AAC system.[57-59] With plateau or regression this was less of a concern.

Photos were still the most preferred aided communication mode unless a child vignette featured both predicted progress *and* motivation to communicate via AAC. This preference for photos possibly indicates that photos remain a good starting point for a child who is not engaged, regardless of prognosis, and may reflect recommendations that recognise the need to reduce the learning demands of AAC systems for some children.[12 60]

Despite unwelcome rates of abandonment, AAC professionals had high expectations of motivated children who were expected to progress, even if their receptive and expressive language were both delayed and they had no previous AAC experience. It has previously been noted that people who use AAC experience an asymmetry between the language they receive and the language they are able to express.[61] One interpretation is that participants wished to minimise asymmetries by choosing text as the expressive output for children they believed could cope with it. These ambitious choices are also encouraging given the greatly increased aspirations for effective societal participation of AAC users.[11 15 16] It is also in line with official guidance[62] and one of Williams et al.'s[14] five principles for AAC: "AAC must support full participation in all aspects of 21st century life" (p.195).

For many of the child vignettes there were non-linear preferences for vocabulary size. Offering between 50 and 1000 items was considered better than 50 or fewer for all child vignettes, although the difference was not always significant. Systems with fewer than 50 items being depreciated may indicate that participants were mindful of limiting children's potential for expression, even for children with lower cognitive ability and poor prognosis.

Findings suggest that respondents preferred levels of AAC systems that require personalisation, e.g., pragmatic vocabulary organisation or an idiosyncratic layout, in line with previous findings that personalisation is important in successful AAC adoption.[28] A preference for personalisation indicates that it

is not possible to achieve the goal of AAC systems being closely tailored to individuals' needs[14 63] with "off-the-shelf" AAC systems: in other words, some personalisation is always necessary.[64 65]

Pre-installed vocabulary sets were always preferred over no pre-provided set, in line with other studies showing that selecting core vocabulary was an important part of AAC professionals' decision-making process.[33 37]

Comparing the DCE results with the previous BWS Case 1 study,[45] some similarities may be observed. For example, graphic representation was the lowest ranked attribute in terms of importance in the BWS to be included in the DCE. In concordance with this finding, when the relative importance of AAC system attributes was calculated for each child vignette in the DCE, graphic representation was never the most important attribute. The relative lack of importance ascribed to graphic representation raises debate about the fundamental components of language construction through aided means and suggests much further research is required.

Many differences to the BWS findings can also be seen. Language abilities were the most important child attribute in the BWS, yet its RIAI in the DCE was below predicted future abilities, ranked sixth in the BWS. However, differences do not necessarily imply contradiction, as the two methodologies did not measure the same thing. The BWS measured the importance of AAC system attributes over the case mix AAC professionals encounter in practice, whereas for the DCE respondents were presented with a specific child vignette.

Receptive and expressive language had the lowest RIAI overall, with only a single interaction term in the final model. This contrasts with some previous findings that a child's language abilities play a large role in selecting an appropriate AAC System.[13 28 30 37] One possible explanation is that the aspects of language ability which were most relevant were captured in this study by other child attributes, but this remains a question to be addressed by future research.

The current study has demonstrated the feasibility of conducting a DCE with a target population of AAC professionals. The demonstration of feasibility is noteworthy given the relative rarity of DCEs studying health professionals' decision-making. For example in a systematic review[41] of DCEs in health published between 2013 and 2017, only 13% included a sample of health professionals. In addition, there were particular challenges associated with performing a DCE with AAC professionals. The target population in the UK is small, meaning it was uncertain that sufficient participants for a successful study could be recruited. There were also concerns that participants might not find the DCE format acceptable, as they might have rejected having to make compromises between AAC system attributes in the context of providing a system for a child. Yet despite informal feedback that some respondents found the tasks uncomfortable, many were still willing to complete them. Finally, as interactions between child characteristics and AAC systems are so important, it was necessary to present hypothetical child vignettes, making tasks more complicated than in a typical DCE.

Despite these potential pitfalls, the DCE was successfully carried out, and having demonstrated the feasibility of the method in this area, further DCE studies should be considered in future.

Limitations

The current study has several limitations. The sample size was relatively small (155 participants, compared to a median for healthcare DCEs of 401[41]). However, many studies exist with smaller sample sizes (e.g., Spinks et al.[66] with 35), and it was possible to estimate robust statistical models. Furthermore, it would have been difficult to collect a larger sample, as 155 participants represented a large proportion of the population of AAC professionals in the UK working with children, which was estimated at around 800.[i]

The DCE task may not match how UK AAC professionals make decisions in practice. Typically, many participants have the opportunity to work with families and children, as well as part of an AAC team, which could include diverse areas of clinical and personal expertise. Teams also generally make recommendations, rather than unilaterally choosing a system. However, there is evidence that AAC professionals compare the

[i] Communication Matters, personal correspondence

attributes of AAC systems in everyday practice,[13] and that they make trade-offs between system attributes,[37] akin to DCE tasks. In addition, it is still useful to study the individual decision-making of AAC professionals. Lynch et al.[30] reported that a wide variety of team structures are used, and the mode of service delivery can have an influence on outcomes. Gathering evidence on individual-level decision-making can thus inform an assessment of how different ways of organising services influence decisions.

The DCE tasks presented one-off static decisions made by a single individual. In reality the decision-making environment is dynamic, with children developing over time, and often having two or more devices over the course of their childhood. These differences are a limiting factor in the external validity of results.

Attributes and levels use a mixture of speech and language therapy terms, e.g., receptive and expressive language, and more AAC specific language, e.g., staged vocabulary progression. Mixing these terms may have made it more difficult for respondents from any one professional speciality to interpret all of them.[44] However, this issue is not limited to the current study, but reflects an ongoing struggle in AAC to establish a common language.[44] In addition, respondents may have been unfamiliar with the generic term ideographic symbols, since only a single commercial set of ideographic symbols is in popular use in the UK (Minspeak[i]).

Respondents were more likely to choose AAC systems on the left of the screen and less likely to choose ones on the right. However, the risk of bias was mitigated by allowing for alternative specific constants and randomising the position in which AAC systems were presented.

Compared to the real children AAC professionals encounter, the child vignettes were simple, and lacked information which influences decision-making, such as the child's preferences[33] and contextual factors.[30] However, this is an inherent limitation of the DCE methodology, and vignettes with a greater number of attributes and levels would have made decisions overly burdensome, and therefore were not included. Significant interactions between AAC systems and child attributes implied that the vignettes were meaningful enough that respondents changed their preferences in response to them, often dramatically.

[i] © Semantic Compaction Systems, Inc.

For a given child vignette, it was only possible to determine relative preferences for system attributes, rather than absolute preferences. Consequently, it is not possible to tell how suitable a given system is for a given child vignette, which is important as some presented a challenging profile for which it may be hard to find a suitable AAC system.

CONCLUSION

A lack of rigorous evidence on how to best assess and provide AAC systems for children has previously been identified,[25 34 44] as well as a gap between research and current practice.[11] In the light of this, the current study's results are encouraging, as it shows AAC professionals following best practice in many areas, for example ensuring AAC systems suit individual needs, and having high expectations for many children.

However, there is still demand from AAC professionals for better support in decision-making,[33 37] and undoubtedly current practice could be improved. The results of the current study, together with evidence from the wider research project, have been used to create a heuristic and suite of resources, available at https://iasc.mmu.ac.uk. It is hoped these resources will aid AAC professionals in their clinical practice and help them provide the best possible service for children.

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Data availability: Survey data is not publicly available as respondent consent was not obtained for this. However, it is available on request to the corresponding author or to Leeds Institute of Health Sciences if a formal data sharing agreement is entered into.

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Table 1: Child attributes and levels including brief descriptions

Child attributes and levels	Description†
Receptive and expressive language (1)	Child's ability without AAC to understand communication from (receptive) and communicate with others (expressive)
*Delayed	Both receptive and expressive abilities below expectation given child's age
Receptive language exceeding expressive language	Ability to understand communication from others greater than ability to communicate with others
Communication ability with AAC (3)	How well a child can communicate when using AAC
*No previous AAC experience	Has never communicated using AAC before
Able to use AAC for a few communicative functions	Can use AAC for some basic functions, e.g. simple requests
Able to use AAC for a range of communicative functions	Can use AAC for more complex tasks, e.g. constructing sentences
Child's determination and persistence (4)	Attitude of child towards communication and using AAC
*Does not appear motivated to communicate through any methods and means	Child is not inclined to develop communication skills
Motivated to communicate through symbol communication systems	Child has demonstrated motivation and willingness to use AAC
Only motivated to communicate through methods other than symbol communication	Child may be motivated to communicate, but is not inclined to use AAC
Predicted future skills and abilities (6)	Professional assessment of how child's communication abilities will develop
*Regression	Abilities projected to become worse in future, e.g. due to a degenerative condition such as Rett syndrome
Plateau	Abilities will not change significantly in future, e.g. a child aged 16-17
Progression	Communication abilities will develop in future

Note: * indicates baseline level; numbers in parentheses indicate attributes' rank in relative importance from Webb et al. [45] †Descriptions are not intended as rigorous definitions of AAC terminology, but as a rough guide for the non-AAC specialist reader.

Table 2: AAC System attributes and levels, including brief descriptions

AAC System attributes and levels	Description†
Vocabulary sets (1)	Words and/or symbols pre-provided with system "out of the box", e.g. as part of a software package for a high-tech system
*No vocabulary set	AAC practitioners/child's support network provides all vocabulary content
Fixed vocabulary set	A single fixed set of vocabulary which may be customised
Vocabulary set with staged progression	A series of vocabulary sets with pre-determined progression through them that simulate language development. E.g. an initial set including just basic words, with subsequent sets introducing more grammatical structure. May be customised.
Consistency of layout (2)	How consistent positions of words/symbols are in system interface, and how consistent navigation to find different symbols is
*Consistency of some aspects of layout	Words/symbols in multiple categories appear in different positions across categories, but always in the same place in a given category
Consistency of all aspects of layout	All/nearly all words/symbols always appear in same position in interface
Idiosyncratic layout	Layout that has been personalised for an individual child
Type of vocabulary organisation (5)	How words/symbols are organised within the system
*Visual scene	Interface shows photos, most likely of scenes familiar to the child, with areas of it highlighted to represent words
Taxonomic	Words/symbols organised according to subject, analogous to non-fiction books in a library
Semantic-syntactic	Words/symbols organised according to sentence structure, e.g. verbs, nouns, adjectives
Pragmatic	Words/symbols organised around function in language rather than grammar, e.g. request, mood
Size of vocabulary (7)	How many words/symbols system can output
*Up to 50 vocabulary items	Implies only simple communication functions possible
50-1000 vocabulary items	Implies combining words/symbols to create grammatical structures
More than 1000 vocabulary items	Does not imply more complex communication than 50-1000 items, but means a greater load on child's memory
Graphic representation (12)	Type of symbols used by system
*Photos	Photographs, possibly of items or environments personal to the child
Pictographic symbol set	Non-photorealist pictures with specific meanings attached. May be accompanied by text
Ideographic symbol system (with rules or encoding)	Stylised symbols combined with fixed rules and grammar analogous to Chinese/Japanese characters, e.g. Minspeak
Text	Text unaccompanied by other symbols

Note: * indicates baseline level; numbers in parentheses indicate attributes' rank in relative importance from prior BWS study (reported in Webb et al. [45]). †Descriptions are not intended as rigorous definitions of AAC terminology, but as a rough guide for the non-AAC specialist reader.

Table 3: Demographics and professional experience of participants

		mean	s.e
Age (years)		40.8	11
Experience (years)		11.4	9.2
% of role relating to AAC		53.7	34.3
		N	%
Gender	Female	155	90.1
	Male	10	5.81
	Prefer not to say	7	4.07
Ethnicity	White - English/Welsh/Scottish/Northern Irish/British	149	86.6
	White – other	12	6.98
	Other	6	3.49
	White – Irish	5	2.91
Professional background	Speech and language therapist	125	72.7
	Occupational therapist	16	9.3
	Teacher	14	8.14
	Other	12	6.98
	Assistive technology specialist	5	2.91
	Clinical scientist	5	2.91
Age groups worked with	Primary school age	99	57.6
	Secondary school age	94	54.7
	Pre-school age	85	49.4
	All age groups	56	32.6
	Higher education	30	17.4
	Further education	21	12.2
	Other	12	6.98
	Adults	10	5.81
Among most common three diagnoses seen in practice	Physical disability (e.g. neuromuscular, cerebral palsy etc.)	140	81.4
	Intellectual Disability/Developmental Delay	118	68.6
	Autism spectrum disorder	113	65.7
	Syndromes	61	35.5
	Neurological	45	26.2
	Specific Speech/Language Impairment	22	12.8
	Dyspraxia	14	8.14

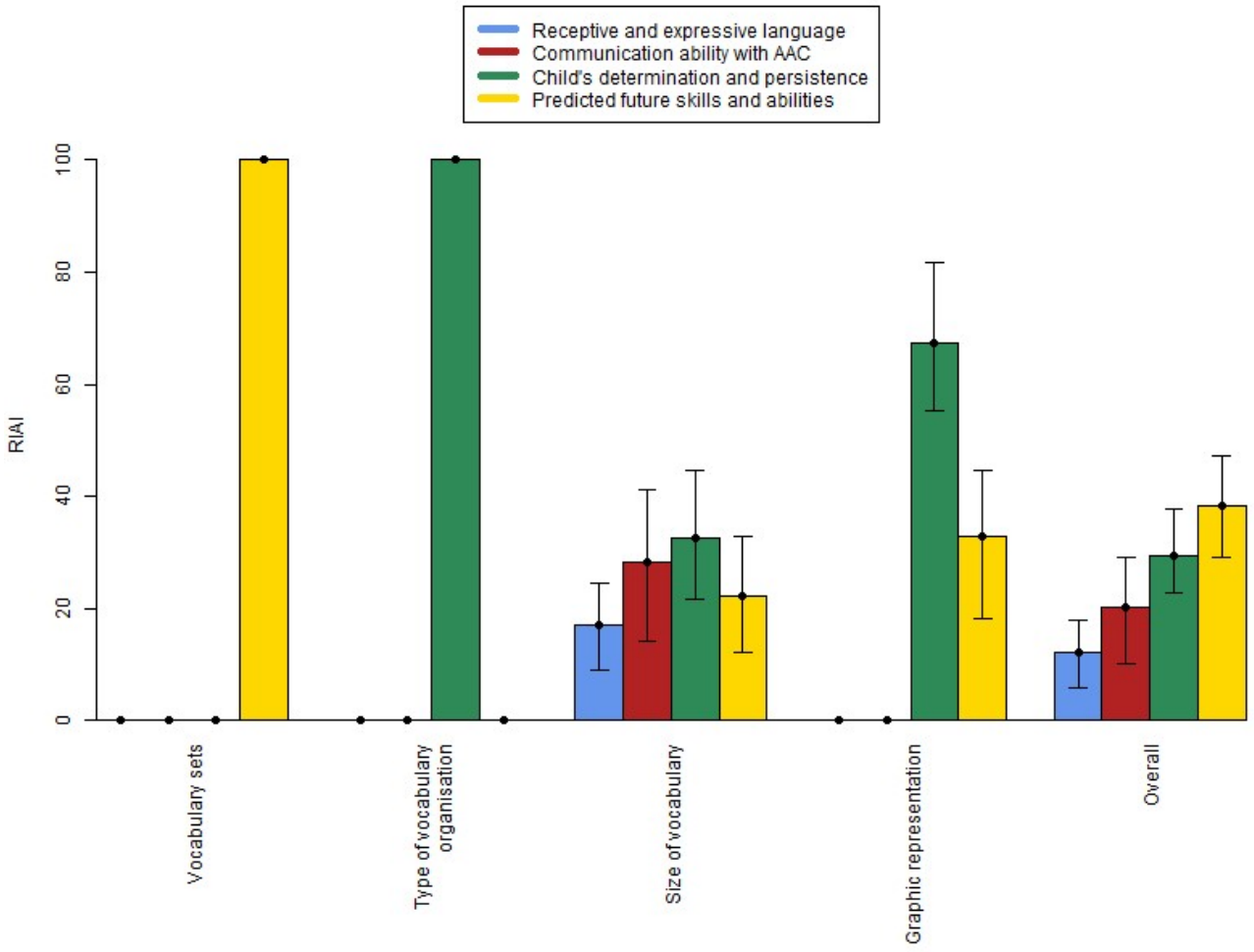
Note. For some questions, participants could select more than one response, thus some percentages do not sum to 100%

Table 4: Parameter means and standard deviations for final mixed logit model. * indicates significance at the 5% level corrected using Holm's sequential Bonferroni [52], s.e. = standard error

AAC system attribute		Child attribute	Parameter mean	s.e.	σ	s.e.
Vocabulary sets (baseline none)	Fixed	Constant	0.283*	0.0966	0.131	0.258
	Staged progression	Constant	0.364*	0.141	0.941*	0.206
		Predicted to progress	1.36*	0.221	-1.09*	0.343
Consistency of layout (baseline some aspects)	Consistency of all aspects	Constant	0.892*	0.121	0.15	0.126
	Idiosyncratic layout	Constant	1.46*	0.14	0.757*	0.134
Type of vocabulary organisation (baseline visual scene)	Taxonomic	Constant	0.0629	0.165	0.383	0.257
		Motivated to communicate through symbol communication systems	0.707*	0.206	-0.563	0.295
	Semantic-syntactic	Constant	-0.178	0.166	0.549	0.234
		Motivated to communicate through symbol communication systems	0.826*	0.197	-0.112	0.296
	Pragmatic	Constant	0.443*	0.123	0.723*	0.152
Size of vocabulary (baseline 50 items)	50-1000 items	Constant	0.131	0.143	0.43	0.166
		Motivated to communicate through symbol communication systems	1.01*	0.232	-0.731	0.329
	More than 1000 items	Constant	-0.929*	0.213	1.02*	0.33
		Receptive language exceeding expressive language	0.692*	0.186	0.489	0.367
		Able to use AAC for a range of communicative functions	1.14*	0.319	-0.419	0.762
		Motivated to communicate through symbol communication systems	1.31*	0.272	-0.751	0.556
		Predicted to progress	0.902*	0.233	0.981	0.657
Graphic representation (baseline photos)	Pictographic symbol set	Constant	-0.41	0.183	0.0722	0.248
		Motivated to communicate through symbol communication systems	1.36*	0.24	-0.363	0.428
		Predicted to progress	-0.814*	0.217	1.12	0.385
	Ideographic symbol system	Constant	-1.25*	0.207	0.823*	0.216
		Motivated to communicate through symbol communication systems	1.67*	0.268	0.069	0.297
	Text	Constant	-0.709*	0.159	0.615*	0.204
		Motivated to communicate through symbol communication systems	1.39*	0.231	-1.12*	0.282

Note. Constants give preferences when choosing for the baseline child vignette: *"Child A/B/C has delayed expressive and receptive language and no previous AAC experience. Child A/B/C does not appear motivated to communicate through any methods and means. Child A/B/C is predicted to regress in skills and abilities (regression)."*
σ indicates standard deviation. Parameter variance for level l of AAC system attribute a when choosing for child c is given by $\sigma_{alc}^2 = (\sigma_{al0} + \sigma_{al} Z_c)^2$.

Figure 1: Relative interaction attribute importance for each AAC system attribute and averaged over all attributes. Note that consistency of layout is omitted as there are no interactions with child attributes. Error bars show 95% confidence intervals.



Appendix A – Attributes from best-worst scaling case 1 study

Table B 1: Attributes used in best-worst scaling case 1 survey in Webb et al. [23] and rank in terms of relative importance score

Child attribute	Rank
*Child's receptive and expressive language abilities	1
Support for AAC from communication partners	2
*Communication ability with aided AAC	3
*Child's determination and persistence	4
Physical abilities for access	5
*Predicted future needs and abilities	6
Level of learning ability	7
Insight into own communicative skills	8
Attention level	9
Access to professional AAC support	10
Speech skills and intelligibility	11
Functional visual skills	12
History of aided AAC use	13
Presence of additional diagnoses	14
Level of fatigue	15
Literacy ability	16
Educational stage	17
Primary diagnosis	18
Mobility	19
AAC system attributes	**Rank**
*Vocabulary or language package(s)	1
*Consistency of layout and navigation	2
Ease of customization	3
Durability and reliability	4
*Type of vocabulary organization	5
Number of key presses required to generate symbol or text output	6
*Size of output vocabulary	7
Range of access methods	8
Number of cells per page	9
Portability	10
*Graphic representation	11
Battery life	12
Supplier support	13
Ease of mounting on a range of equipment	14
Cost	15
Additional assistive technology functions	16
Voice	17
Appearance	18

Note. Asterisk indicates attribute included in discrete choice experiment.

Appendix B – Example survey

Note: the AAC system levels and child vignettes shown here are for illustrative purposes and do not represent the statistical design used in the full survey.

Instructions

Thank you for taking part in this survey.

It aims to identify what factors clinicians think are important when making decisions about aided AAC systems for children with communication difficulties.

You will be asked a series of questions. Each one has the same format. A brief description of a child will be given, along with three possible choices of aided AAC systems.

The three AAC systems are described in terms of five characteristics (the systems are identical apart from changes to these five characteristics):-

1. **Vocabulary sets**: Pre-determined vocabulary or language package provided, which can be:-
    - No commercially provided sets
    - Commercially provided sets without language progression
    - Commercially provided sets with language progression
2. **Size of vocabulary**: The size of the output vocabulary available within the aided AAC system, which can be:-
    - Up to 50 vocabulary items
    - 50-1000 vocabulary items
    - More than 1000 vocabulary items
3. **Type of vocabulary organisation**: Primary format used to organise the vocabulary within the aided AAC system, which can be:-
    - Visual scene display
    - Semantic organisation
    - Semantic syntactic organisation
    - Pragmatic organisation

4. **Graphic Representation**: Primary type of graphic symbol used, which can be:-
    - Photo symbols (i.e. a photo symbol set without rules or encoding)
    - Pictographic symbols (i.e. a graphic symbol set without rules or encoding)
    - Ideographic symbols (i.e. a symbol system with rules or encoding)
    - Graphic symbols with text (i.e. a system with either pictographic or ideographic symbols that incorporates an alphabet for generating text)
5. **Consistency of layout**: Consistency of layout of symbols on pages, including when navigating through pages to select desired output, which can be:-
    - Inconsistent layout
    - Somewhat consistent layout
    - Highly consistent layout

Imagine you had to choose between only these three systems. You should indicate which you would prescribe for the child described. If your preferred option is not available, pick the system from the three options that you think best matches the child's needs. There are no right or wrong answers. It is acknowledged that this may feel uncomfortable for you.

In the survey, there are three different children described. You will be asked four questions about each child (12 questions in total).

In acknowledgement of choices being uncomfortable, after each choice, you will be asked to indicate how well you think that system matches the child's needs. (1 = very unsuitable, 7 = very suitable).

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Consent

Your participation in this survey is voluntary. All information is collected anonymously and held in confidence. We hope you complete the survey but you are free to stop responding at any point resulting in your answers will be removed.

❑ I have read and understood the above and consent to taking part.

I confirm my work involves assessing children for aided AAC systems and I contribute to the decision making in relation to the language and vocabulary organisation within aided AAC systems.

❑ Yes

❑ No

If yes go to DCE questions.

If no go to a page with the following:-

Thank you for your interest in this survey. At present we are only recruiting participants who contribute to decision making in relation to the language and vocabulary organisation within aided AAC for children. Over the coming 12 months we will be recruiting people with a wider range of AAC experience to test decision making resources we are developing. If you are interested in this aspect of the project or would like to be notified when the free resources are available, there will be an opportunity at the end to submit your email address.

We would still like to ask you a few questions about your experience with AAC to check the representativeness of participants.

Then go directly to demographics questionnaire.

Question 1

Child A has delayed expressive and receptive language and is able to use aided AAC for a few communicative functions. Child A is motivated to communicate through symbol communication systems. Child A is predicted to regress in skills and abilities (regression).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	50-1000 vocabulary items	50-1000 vocabulary items	50-1000 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Pragmatic	Visual Scene	Visual Scene
Vocabulary sets Pre-determined vocabulary or language package provided	No vocabulary set	Vocabulary sets with staged progression	Fixed vocabulary set
Graphic representation Primary type of graphic symbol used	Ideographic symbol system (with rules or encoding)	Photos	Ideographic symbol system (with rules or encoding)
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Idiosyncratic layout	Idiosyncratic layout	Consistency of some aspects of layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 2

Child A has delayed expressive and receptive language and is able to use aided AAC for a few communicative functions. Child A is motivated to communicate through symbol communication systems. Child A is predicted to regress in skills and abilities (regression).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	50-1000 vocabulary items	50-1000 vocabulary items	50-1000 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Taxonomic	Visual Scene	Pragmatic
Vocabulary sets Pre-determined vocabulary or language package provided	Vocabulary sets with staged progression	No vocabulary set	Fixed vocabulary set
Graphic representation Primary type of graphic symbol used	Text	Pictographic symbol set	Photos
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Consistency of some aspects of layout	Idiosyncratic layout	Consistency of some aspects of layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 3

Child A has delayed expressive and receptive language and is able to use aided AAC for a few communicative functions. Child A is motivated to communicate through symbol communication systems. Child A is predicted to regress in skills and abilities (regression).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	50-1000 vocabulary items	50-1000 vocabulary items	Up to 50 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Semantic-Syntactic	Semantic-Syntactic	Visual Scene
Vocabulary sets Pre-determined vocabulary or language package provided	Vocabulary sets with staged progression	No vocabulary set	Fixed vocabulary set
Graphic representation Primary type of graphic symbol used	Text	Photos	Pictographic symbol set
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Consistency of all aspects of layout	Idiosyncratic layout	Consistency of some aspects of layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 4

Child A has delayed expressive and receptive language and is able to use aided AAC for a few communicative functions. Child A is motivated to communicate through symbol communication systems. Child A is predicted to regress in skills and abilities (regression).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	50-1000 vocabulary items	50-1000 vocabulary items	50-1000 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Visual Scene	Taxonomic	Pragmatic
Vocabulary sets Pre-determined vocabulary or language package provided	Vocabulary sets with staged progression	Fixed vocabulary set	Fixed vocabulary set
Graphic representation Primary type of graphic symbol used	Ideographic symbol system (with rules or encoding)	Text	Photos
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Consistency of some aspects of layout	Consistency of all aspects of layout	Idiosyncratic layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 5

Child B has receptive language exceeding expressive language and no previous AAC experience. Child B is only motivated to communicate through methods other than symbol communication systems. Child B is predicted to maintain current skills and abilities (plateau).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	Up to 50 vocabulary items	50-1000 vocabulary items	More than 1000 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Taxonomic	Visual Scene	Pragmatic
Vocabulary sets Pre-determined vocabulary or language package provided	No vocabulary set	Fixed vocabulary set	Vocabulary sets with staged progression
Graphic representation Primary type of graphic symbol used	Photos	Text	Ideographic symbol system (with rules or encoding)
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Consistency of all aspects of layout	Idiosyncratic layout	Consistency of some aspects of layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 6

Child B has receptive language exceeding expressive language and no previous AAC experience. Child B is only motivated to communicate through methods other than symbol communication systems. Child B is predicted to maintain current skills and abilities (plateau).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	More than 1000 vocabulary items	Up to 50 vocabulary items	50-1000 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Semantic-Syntactic	Semantic-Syntactic	Taxonomic
Vocabulary sets Pre-determined vocabulary or language package provided	Vocabulary sets with staged progression	Fixed vocabulary set	No vocabulary set
Graphic representation Primary type of graphic symbol used	Ideographic symbol system (with rules or encoding)	Photos	Ideographic symbol system (with rules or encoding)
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Idiosyncratic layout	Consistency of some aspects of layout	Consistency of some aspects of layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 7

Child B has receptive language exceeding expressive language and no previous AAC experience. Child B is only motivated to communicate through methods other than symbol communication systems. Child B is predicted to maintain current skills and abilities (plateau).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	Up to 50 vocabulary items	More than 1000 vocabulary items	50-1000 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Taxonomic	Pragmatic	Taxonomic
Vocabulary sets Pre-determined vocabulary or language package provided	Fixed vocabulary set	Vocabulary sets with staged progression	No vocabulary set
Graphic representation Primary type of graphic symbol used	Photos	Ideographic symbol system (with rules or encoding)	Text
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Consistency of all aspects of layout	Consistency of some aspects of layout	Idiosyncratic layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 8

Child B has receptive language exceeding expressive language and no previous AAC experience. Child B is only motivated to communicate through methods other than symbol communication systems. Child B is predicted to maintain current skills and abilities (plateau).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	Up to 50 vocabulary items	More than 1000 vocabulary items	50-1000 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Pragmatic	Semantic-Syntactic	Visual Scene
Vocabulary sets Pre-determined vocabulary or language package provided	Fixed vocabulary set	Fixed vocabulary set	Vocabulary sets with staged progression
Graphic representation Primary type of graphic symbol used	Ideographic symbol system (with rules or encoding)	Ideographic symbol system (with rules or encoding)	Photos
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Consistency of some aspects of layout	Consistency of all aspects of layout	Idiosyncratic layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 9

Child C has delayed expressive and receptive language and no previous AAC experience. Child C is only motivated to communicate through methods other than symbol communication systems. Child C is predicted to maintain current skills and abilities (plateau).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	50-1000 vocabulary items	More than 1000 vocabulary items	Up to 50 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Visual Scene	Pragmatic	Semantic-Syntactic
Vocabulary sets Pre-determined vocabulary or language package provided	Fixed vocabulary set	Fixed vocabulary set	Fixed vocabulary set
Graphic representation Primary type of graphic symbol used	Pictographic symbol set	Pictographic symbol set	Text
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Idiosyncratic layout	Consistency of some aspects of layout	Consistency of all aspects of layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 10

Child C has delayed expressive and receptive language and no previous AAC experience. Child C is only motivated to communicate through methods other than symbol communication systems. Child C is predicted to maintain current skills and abilities (plateau).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	Up to 50 vocabulary items	More than 1000 vocabulary items	Up to 50 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Taxonomic	Semantic-Syntactic	Taxonomic
Vocabulary sets Pre-determined vocabulary or language package provided	No vocabulary set	Vocabulary sets with staged progression	No vocabulary set
Graphic representation Primary type of graphic symbol used	Ideographic symbol system (with rules or encoding)	Ideographic symbol system (with rules or encoding)	Photos
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Consistency of all aspects of layout	Consistency of some aspects of layout	Idiosyncratic layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 11

Child C has delayed expressive and receptive language and no previous AAC experience. Child C is only motivated to communicate through methods other than symbol communication systems. Child C is predicted to maintain current skills and abilities (plateau).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	Up to 50 vocabulary items	50-1000 vocabulary items	50-1000 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Visual Scene	Semantic-Syntactic	Semantic-Syntactic
Vocabulary sets Pre-determined vocabulary or language package provided	No vocabulary set	Vocabulary sets with staged progression	No vocabulary set
Graphic representation Primary type of graphic symbol used	Photos	Pictographic symbol set	Text
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Idiosyncratic layout	Consistency of some aspects of layout	Consistency of all aspects of layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Question 12

Child C has delayed expressive and receptive language and no previous AAC experience. Child C is only motivated to communicate through methods other than symbol communication systems. Child C is predicted to maintain current skills and abilities (plateau).

	System 1	**System 2**	**System 3**
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	Up to 50 vocabulary items	More than 1000 vocabulary items	50-1000 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Semantic-Syntactic	Semantic-Syntactic	Visual Scene
Vocabulary sets Pre-determined vocabulary or language package provided	No vocabulary set	Vocabulary sets with staged progression	Fixed vocabulary set
Graphic representation Primary type of graphic symbol used	Ideographic symbol system (with rules or encoding)	Text	Photos
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Consistency of all aspects of layout	Idiosyncratic layout	Consistency of some aspects of layout

For this child I would choose:

- ❑ System 1
- ❑ System 2
- ❑ System 3

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable).

❑	❑	❑	❑	❑	❑	❑
1	2	3	4	5	6	7

Questionnaire

In this final part of the survey, we'd like to ask you for some information about yourself and your experience with AAC.

We would like to know about the characteristics of the people who complete this survey to check that we have a representative sample. We would also like to check if people with different professional experiences have different opinions.

All responses will be held anonymously and we have no way of tracing your responses back to you as an individual.

Q. What is your age? _____ years.

Q. What is your gender?

❑ Male ❑ Female ❑ Other ❑ Prefer not to say

Q. How would you describe your ethnicity?

- ❑ White - English/Welsh/Scottish/Northern Irish/British
- ❑ White -Irish
- ❑ White - Gypsy or Irish Traveller
- ❑ White - Any other White background
- ❑ Mixed/Multiple ethnic group - White and Black Caribbean
- ❑ Mixed/Multiple ethnic group - White and Black African
- ❑ Mixed/Multiple ethnic group - White and Asian
- ❑ Mixed/Multiple ethnic group - Any other Mixed/Multiple ethnic background
- ❑ Asian/Asian British - Indian
- ❑ Asian/Asian British - Pakistani
- ❑ Asian/Asian British – Bangladeshi
- ❑ Asian/Asian British - Chinese
- ❑ Asian/Asian British - Any other Asian background
- ❑ Black/ African/Caribbean/Black British - African

- ❑ Black/ African/Caribbean/Black British - Caribbean
- ❑ Black/ African/Caribbean/Black British - Any other Black/African/Caribbean background
- ❑ Arab
- ❑ Other

Q. For how many years have you worked with AAC? _____ years.

Q. What is your professional background? You may select more than one option if applicable.

❑ Occupational therapist

❑ Speech and language therapist

❑ Assistive technology specialist

❑ Clinical scientist

❑ Teacher

❑ Other

Q. If you selected Other, please specify.

_____

Q. How much of your role relates to AAC? _____%.

(e.g. 1 day per week = 20%, 2 days a week = 40%, etc.)

Q. How would you characterise your role? Pick the one that best describes your role.

- ❑ I refer on anyone who may benefit from AAC
- ❑ I assess and implement AAC. I seek support from within my own team for decisions made
- ❑ I assess and implement AAC. I seek support from outside my own team for
- ❑ decisions made
- ❑ I assess and implement AAC. I act as a support for others in relation to AAC
- ❑ decision making
- ❑ I assess only. I provide support to others outside my team in relation to
- ❑ AAC decision making
- ❑ Other

Q. If you selected Other, please specify.

_____

Q. Out of the list below, select the three most common diagnoses you encounter in your work.

- ❑ Autism Spectrum Disorder
- ❑ Physical disability (e.g. neuromuscular, cerebral palsy etc.)
- ❑ Dyspraxia
- ❑ Intellectual Disability/Developmental Delay
- ❑ Neurological
- ❑ Specific Speech/Language Impairment
- ❑ Syndromes
- ❑ Unknown
- ❑ Other

Q. If you selected Other, please specify.

_____

Q. Who do you provide services for? (Please choose all that apply.)

- ❑ All age groups
- ❑ Preschool age
- ❑ Primary school age
- ❑ Secondary school age
- ❑ Higher education
- ❑ Further education
- ❑ Adults
- ❑ Other

Q. If you selected Other, please specify.

_____

Q. What is the geographical area covered by your service? (Please choose all that apply.

- ❑ North West England
- ❑ North East England
- ❑ Yorkshire and Humber
- ❑ West Midlands
- ❑ East Midlands
- ❑ East of England

- ❑ South West England
- ❑ South East England
- ❑ London
- ❑ Northern Ireland
- ❑ North Wales
- ❑ South Wales
- ❑ Mid-Wales
- ❑ Southern Scotland
- ❑ Central Scotland
- ❑ Northern Scotland
- ❑ Non-UK

End of survey

Thank you for your participation in this survey.

Your responses will contribute to the results of the I-ASC project and support the development of decision making resources for use in AAC assessments.

You can follow the progress of our research project on our website, on Facebook or on Twitter.

Figure A 1: Example discrete choice experiment task

Child B has delayed expressive and receptive language and able to use aided AAC for a few communicative functions. Child B is only motivated to communicate through methods other than symbol communication systems. Child B is predicted to maintain current skills and abilities (plateau).

	System 1	System 2	System 3
Graphic Representation Primary type of graphic symbol used	Ideographic symbols	Photo symbols	Pictographic symbols
Consistency of layout Consistency of layout of symbols on pages, including when navigating through pages to select desired output.	Highly consistent layout	Somewhat consistent layout	Inconsistent layout
Vocabulary sets Pre-determined vocabulary or language package provided	Commercially provided sets without language progression	Commercially provided sets with language progression	Commercially provided sets without language progression
Size of vocabulary The size of the output vocabulary available within the aided AAC system.	More than 1000 vocabulary items	50-1000 vocabulary items	Up to 50 vocabulary items
Type of vocabulary organisation Primary format used to organise the vocabulary within the aided AAC system	Pragmatic organisation	Semantic syntactic organisation	Visual scene display
For this child I would choose:	○	○	○

On a scale from 1 to 7, how good a match is your chosen device for this child? (1=very unsuitable, 7=very suitable)

1 = very unsuitable	2	3	4	5	6	7 = very suitable
○	○	○	○	○	○	○

35%

Appendix C – Final preferred model selection process

A full model with all interaction terms and two alternative specific constants implies 98 parameters, which is too many to reliably estimate given the amount of data collected and given that many interactions are expected to be of very low magnitude. Thus, a strategy was required to identify a suitable model with fewer parameters.

The first stage was estimating a series of stepwise multinomial logit (MNL) models, beginning with a model with all 98 parameters. The parameter with the highest p-value, excluding the γ_0 constant terms, was eliminated, and a model with 97 parameters was estimated. Then the parameter with the lowest p-value was excluded and a new model run, and so on in an iterative process until only the 12 γ_0 constant terms remained (one for each non-baseline system level).

The Bayesian Information Criterion (BIC) was used to select the preferred MNL model. This model was then re-estimated as a mixed logit (MIXL) model to account for participant heterogeneity. (The process did not begin by estimating a series of stepwise MIXL models due to the difficulty and greatly increased computational resources required to estimate MIXL models with a large number of parameters.) The β \coefficients on system attribute levels were assumed to be drawn from normal distributions with means given by

$$\bar{\beta}_{alc} = \gamma_{al0} + \gamma_{al} z_c$$

and variances given by

$$\sigma_{alc}^2 = (\sigma_{al0} + \sigma_{al} z_c)^2.$$

If p is the number of parameters of the preferred MNL model, then models with between p – 3 and p + 3 parameters were re-estimated as MIXL models. The BIC for each MIXL model is given in **Error! Reference source not found.**.

The MIXL model minimising the BIC was chosen as the final preferred model.

Table C 1: Bayesian information criteria (BIC) for estimated mixed logit models

Number of parameters	BIC
22	3502.25
23	3487.80
24	3482.30
25	3489.18
26	3493.07
27	3502.28
28	3509.34

Appendix D – Relative interaction attribute importance

Relative information attribute importance (RIAI) measures the amount that preferences for attributes of choice objects are impacted by a given interaction attribute associated with a choice situation relative to other interaction attributes. It may be calculated either with respect to a single choice object attribute or overall with respect to all choice object attributes.

RIAI is calculated with respect to a single choice object attribute by taking the difference between the greatest increase an interaction attribute causes to a choice object attribute's part worth utility and the greatest decrease, expressed as a percentage of the differences for all interaction attributes. Formally, the RIAI for interaction attribute i with respect to choice attribute c is

$$RIAI_{ic} = 100\left(\frac{\gamma_{ic}^{max} - \gamma_{ic}^{min}}{\sum_{j=1}^{N_I} \gamma_{jc}^{max} - \gamma_{jc}^{min}}\right)$$

where γ_{ic}^{max} and γ_{ic}^{min} are respectively the maximum and minimum coefficients for interaction attribute i with respect to choice attribute c and N_I is the number of interaction attributes. The overall RIAI for i is similarly calculated as

$$RIAI_{i} = 100\left(\frac{\gamma_{i}^{max} - \gamma_{i}^{min}}{\sum_{j=1}^{N_I} \gamma_{j}^{max} - \gamma_{j}^{min}}\right)$$

Where now γ_{i}^{max} and γ_{i}^{min} are respectively the maximum and minimum coefficients for interaction attribute i across all choice attributes.