Something for everybody? Assessing the suitability of AAC systems for children using stated preference methods

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Abstract

Little is known about what features of AAC systems are regarded as more suitable by AAC professionals for children with different characteristics. A survey was conducted in which participants rated the suitability of AAC systems on a Likert scale from 1 (very unsuitable) to 7 (very suitable) alongside a discrete choice experiment. The survey was administered online to 155 AAC professionals in the UK. Statistical modelling was used to estimate how suitable 274 hypothetical AAC systems were for each of 36 child vignettes. The proportion of AAC systems rated at least five out of seven for suitability varied from 51.1% to 98.5% for different child vignettes. Only 12 out of 36 child vignettes had any AAC systems rated at least six out of seven for suitability. The features of the most suitable AAC system depended on the characteristics of the child vignette. The results show that, while every child vignette had several systems which had a good suitability rating, there were variations, which could potentially lead to inequalities in provision.

Keywords: Clinical decision-making; Likert scale; Stated preferences; Discrete choice experiment; Children

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Introduction

Augmentative and alternative communication (AAC) can improve the lives of many people with communication difficulties (Hajjar et al., 2016, Ryan et al., 2015, Schlosser and Wendt, 2008). For children, provision of AAC is especially important, as it can affect their social participation, as well as their development and learning, having an impact on the rest of their lives (Ryan et al., 2015, Lund and Light, 2006). In recent years, the expectations of people who use AAC to participate in all aspects of society has increased (Williams et al., 2012, Sundqvist and Rönnberg, 2010, Hemsley and Murray, 2015, Hynan et al., 2015, Light et al., 2019b, Williams et al., 2008).

Many different AAC systems exist, with very different features. Children may benefit from AAC due to a wide range of reasons, and may have a variety of conditions such as cerebral palsy and autism spectrum disorder. Children with the same diagnosis each have disparate needs, abilities, and personal circumstances. Selecting a suitable AAC system for a child is thus a highly complex task, requiring the balancing of many different competing concerns, and the process is unique to each child (Lynch et al., 2019, Dietz et al., 2012, Lund et al., 2017).

Research has revealed some important factors in AAC professionals' decision-making (Enderby et al., 2013, Thistle and Wilkinson, 2015, Geytenbeek et al., 2015), such as a child's preferences and family circumstances, and there are guidelines for how AAC services should be organised (Royal College of Speech and Language Therapists, 2009, NHS England, 2016, Choi and Pak, 2006). Still, little is known about how AAC professionals make decisions, or what features lead AAC professionals to judge AAC systems as a suitable match for children with different characteristics (Dietz et al., 2012, Ryan et al., 2015, Thistle and Wilkinson, 2015).

The context for this study is the UK, where it is estimated that 1 in 200 children could benefit from AAC (Gross, 2010, Enderby et al., 2013, Judge et al., 2017). There is some variation across the UK in how children are allocated AAC systems, but in general children's needs, abilities and circumstances are assessed by a multidisciplinary team of AAC professionals, with final recommendations made with some input from children and their support network. The composition of the multidisciplinary team varies, and can include speech and language therapists, occupational therapists, and teachers (NHS England, 2016, Lynch et al., 2019).

The current article is one of three linked studies which examine UK AAC professionals' judgement and decision-making for children, and what factors are most important in matching AAC systems to children. Examining AAC professionals' judgement and decision-making addresses a knowledge gap, and allows it to be examined whether there is a lag between practice and research. It also makes it possible to reflect on how improvements may be made to current practice and whether services may be better organised.

The three linked studies used different methods, and addressed the topic from different angles. The principle research questions for each were:-

1) What is the relative importance of AAC system attributes and child characteristics in AAC professionals' decision-making in daily practice?
2) When choosing an AAC system, what trade-offs do AAC professionals make between different system attributes, and how do such trade-offs change depending on the characteristics of the child they are choosing for?
3) How suitable do AAC professionals judge different AAC systems to be for a child, and how do their judgements change depending on child characteristics?

The first research question, examined in Webb et al. (2019b), revealed how important different factors were in AAC professionals' daily practice. In other words, it showed how important specific factors were on average over the case-mix AAC professionals see. The second research question, examined in Webb et al. (2019a), revealed how AAC professionals make decisions when choosing for an individual child.

The third research question, examined in the current article, adds information about strength of preference, revealing not only what AAC system an AAC professional would choose for a child, but also how suitable they believe the system to be for that child. Such additional information is useful, as it allows comparisons between different children and to examine whether there is an AAC system which is suitable for every child, which the previous study could not. It can also examine how many suitable AAC systems there are for a child, and hence whether restricting the choice of system for that child is likely to have an impact. For example, Webb et al. (2019a) could reveal which AAC systems were most likely to be chosen for children with different characteristics. The current study can in addition compare how suitable those AAC systems are described as being for different children, potentially revealing inequalities with some children having few or no AAC systems considered suitable to meet their needs. In addition, AAC professionals may not necessarily choose the most suitable AAC system for a child, for example due to resource constraints such as cost or instruction time.

All three studies used online surveys. The first study (Webb et al., 2019b) used a survey method termed best-worst scaling object case (Cheung et al., 2016). It produced measures of relative importance for lists of 18 AAC system attributes and 19 child attributes.
The results of the first study were used to select a subset of six AAC system attributes and four child attributes to examine in more detail (Webb et al., 2020). The attributes were included in a discrete choice experiment (Soekhai et al., 2019), a survey method in which

participants made a series of choices between three hypothetical AAC systems to choose for a child vignette. The levels of the AAC system attributes and the characteristics of the child vignettes varied from question to question. Statistical analysis of responses quantified the trade-offs participants made between different AAC system attributes, and how these trade-offs changed depended on the child vignette they were choosing for.

The current study used data from the same DCE survey, but focusses on responses to an additional task. In each question, participants selected an AAC system, then rated how suitable the system was for the child. Thus, the current study is concerned with cardinal measures of an AAC system's suitability for a child, rather than trade-offs between different AAC system attributes.

All three linked studies were part of a wider research project entitled Identifying Appropriate Symbol Communication aids for children who are non-speaking: enhancing clinical decision-making (I-ASC) (Murray, Lynch, Goldbart, Moulam, Judge, Webb, Jayes, Meredith, Whittle, Randall, et al., 2021).The project used a variety of research methods (Judge et al., 2019a, Lynch et al., 2019a, Murray et al., 2019) to study AAC provision for children in the UK. The evidence produced by the project has been used in the creation of a suite of resources for AAC professionals to support best practice, which is available for free at https://iasc.mmu.ac.uk/.

Detailed results of the I-ASC study are given in Murray, Lynch, Goldbart, Moulam, Judge, Webb, Jayes, Meredith, Whittle, Randall, et al. (2021), but Figure 1 gives a schematic representation of the explanatory model of decision-making that the project produced. The current study and the two linked ones address the concept of feature matching, i.e. matching the characteristics of the child with the most relevant AAC system attributes. In the I-ASC explanatory model, feature matching was considered within three organising themes: (i) child characteristics, (ii) communication aid attributes, and (iii) access features.

Participants included in other elements of the I-ASC study described how they considered and made trade-offs across the decision-making process. At a feature matching level this included consideration of particular child characteristics, for example the child's motivation to communicate, their abilities to learn or their likely decline in learning capacity. Regarding AAC system attributes, we found consideration of the child's physical and cognitive characteristics. This included communication aid size and weight, which were important for very small children or for children who were ambulatory. Communication aid appearance, voice quality, and reliability were also salient features. The software attributes prioritized reflected both the needs of the child and those providing support.

In summary, this aspect of the I-ASC exploration concluded that those charged with the responsibility for proposing specific communication aids face a complex task that includes identifying the particular child characteristics, access features, and communication aid attributes. These must be considered in the recommendations for each child. The key challenge is that these are not separate, fixed components of the decision-making process, but are constantly moving, with some being more fluid and others more stable as teams reach their decisions.

Method

Participants

The target population was AAC professionals working in the UK who contributed to AAC decision-making for children. This included AAC professionals who worked with both children and adults. Responses were collected online from participants recruited using the email lists of the I-ASC project and Communication Matters (a UK-wide AAC charity and chapter of the International Society for Augmentative and Alternative Communication), as well as project members' personal contacts. In addition, the survey was advertised on the I-

ASC project's website and social media. The survey was open for responses from 20 October 2017 until 4 March 2018.

At the beginning of the survey, participants indicated their consent to taking part and answered the question "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." Those who responded no were directed to answer only demographic questions and were not shown the DCE tasks. A total of 172 people submitted complete responses, of which 155 answered yes to the above question and completed the DCE tasks.

Participant demographics

Participant demographics are summarised in Table 3. For participants who completed the DCE, most were female (*n*=140, 90.3%) and of white ethnicity (*n*=137, 88.4%). Most had a professional background as a speech and language therapist (*n*=125, 75.5%). They were 40 years old on average, with 11 years of professional experience. A majority reported each of physical conditions (*n*=128, 82.6%) intellectual disability/delay (*n*=107, 69.0%) and autism spectrum (*n*=101, 65.2%) as among the three most common diagnoses they encountered in their practice.

The demographics of participants who did not complete the DCE were largely similar to those who did. However, they were slightly older on average, at 46 years, and were more likely to have a professional background as an occupational therapist (*n*=5, 29.4% compared to *n*=11, 7%) and less likely to have a background in speech and language therapy (*n*=8, 47.1% compared to *n*=125, 75.5%).

Table 4 details the areas in which participants reported working. The sample of participants who completed the DCE included respondents from every area of the UK, although some areas were overrepresented and some were under-represented For example, Yorkshire and the

Humber represented 14.2% of the sample compared to 8.2% of the UK population, and South West England represented 5.2% of the sample, compared to 8.4% of the UK population (Office for National Statistics, 2020).

Procedures

Attribute development. The development of DCE attributes and levels has previously been reported (Webb et al., 2019b, Webb et al., 2020). In summary, lists of 18 AAC system attributes and 19 child characteristics were constructed using focus groups and interviews with AAC professionals, people who use AAC, their families and other stakeholders (Murray et al., 2019b, Lynch et al., 2019b), as well as systematic reviews of the literature (Judge et al., 2019b) and input from an expert panel. These lists were used in a best-worst scaling (BWS) case 1 survey (Webb et al., 2019b), which elicited the relative importance ascribed to each attribute/characteristic by a group of 93 AAC professionals.

Sets of five AAC system attributes and four child attributes were selected from among the BWS attributes by the research team. The selection criteria were that: (a) attributes formed coherent descriptions of AAC systems/children; (b) attributes reflected the specific aims of the I-ASC project; (c) most attributes were of high relative importance according to the BWS survey results; and (d) the number of attributes was not so large as to overburden DCE survey respondents. For details of this process, see Webb et al. (2020). The final list of attributes and levels for the DCE is given in Table 2.

Survey design and implementation. In each DCE task, participants were shown a child vignette formed from the set of child attributes. An example is:

> Child A has receptive language exceeding expressive language. Child A is able to use AAC for a few communicative functions. Child A is motivated to communicate through symbol communication systems. Child A is predicted to plateau in skills and abilities.

Participants were shown three hypothetical AAC systems described in terms of the attributes in Table 2, and asked which they would choose for the child vignette. After making their choice, participants were asked to rate how suitable their chosen AAC system was for the child vignette using a Likert scale which ranged from one (very unsuitable) to seven (very suitable). An example choice task is shown in Figure 2.

It is possible to form 54 child vignettes and 432 AAC systems from the sets of attributes. A total of 18 child vignettes and 158 AAC systems were identified by the authors as representing unrealistic combinations and excluded from being used in the survey. For each participant, from the remaining list of 36 child vignettes, three were drawn to answer questions for. For each vignette, they made four choices, meaning a total of 12 DCE tasks. The statistical design of the DCE, i.e. which AAC systems participants chose between, was constructed using Ngene.[1] The design was chosen to maximise D-efficiency, which may be thought of as a measure of how much information it is possible to extract from survey responses (Kuhfeld et al., 1994). The design had 60 tasks which were divided into five blocks of 12. Each participant was randomly allocated to answer a block of 12 questions, with random allocations of blocks and child vignettes independent of each other.

The survey was piloted with five AAC professionals. In response to feedback, small changes were made to wording and visual presentation to improve clarity.

Statistical analysis

Analysis of responses used a random utility theory framework (Louviere et al., 2000) which assumed individuals assigned a utility to each option. The utility of each option was modelled as depending partly on the attributes of AAC systems as well as having a random component, which represented all aspects of the decision-making process not explicitly captured by the

[1] Ngene is a product of ChoiceMetrics Pty Ltd, Australia, www.choice-metrics.com

model. Individuals were then assumed to choose the AAC system with the highest utility, and rated AAC systems higher if they had a higher utility.

Ratings and choices were analysed jointly using choice-ordered logit models (Webb and Hess, 2019) which had a set of parameters representing how individuals made their decisions. Statistical techniques were used to find the parameters which maximised the probability of observing the choice and ratings participants made. The full model with parameters for every interaction between AAC system and child attributes had too many parameters to estimate robustly. Therefore, an iterative process was used in which a series of models with only one parameter were estimated. The parameter which contributed most to explaining how participants made their decision was selected for inclusion. A further series of models with two parameters were then estimated, and again the parameter which contributed most to explaining participants' decision-making was selected. This continued until all parameters were included. The final model was then selected using the Akaike information criterion (Akaike, 1974), a measure of how well a model fits a dataset. Technical details of the model estimation are given in the online supplementary material.

The final model was used to predict participants' ratings for every AAC system for every child vignette. It was then calculated for each child vignette what percentage of AAC systems had a rating of at least five out of seven, and what percentage had a rating of at least six out of seven. All model estimation was carried out using the Apollo choice modelling package for R (Hess and Palma, 2019).

Results

The raw results for model estimation are given in Table A.1 in the online supplementary material.

Table 5 gives for each child vignette the percentage of all 274 AAC systems included in the survey which were rated above five and above six. All child vignettes had at least

51.1% of AAC systems rated above five, and for 19 out of 36 child vignettes this percentage was above 90%. For 24 out of 36 child vignettes, no AAC system was rated at six or above. However, some child vignettes had a range of AAC systems rated at least six, for example five vignettes had over 10% of AAC systems rated at least six for suitability, and one vignette over 20%.

Eleven of the 24 child vignettes without an AAC system rated six or higher were predicted to regress in skills and abilities, whereas eight were predicted to plateau and four were predicted to progress. In contrast, out of the 12 vignettes with an AAC system rated at least six, seven were predicted to progress in skills and abilities, four to plateau and one was predicted to regress. All but one of the 12 child vignettes with at least one AAC system rated six or above for suitability were motivated to communicate using AAC.

Figure 3 shows the ratings of the single most suitable AAC system for all child vignettes. The vignette "delayed receptive and expressive language, no AAC experience, not motivated to communicate, expected to regress in skills and abilities" had the most suitable AAC system with the lowest rating, at 5.62. The vignette "receptive language exceeding expressive language, experience of using AAC for a range of functions, motivated to communicate using AAC, expected to progress in skills and abilities" had the highest rated most suitable system, at 6.62. The difference of 1 between the ratings of the most suitable AAC system represents 14.3% of the available scale from one to seven.

Descriptions of what the most suitable AAC systems were for each vignette are given in Table A 2 in the online supplementary material. The results are summarised in Figure 4 which illustrates how often a given AAC system feature was part of a child vignette's most preferred system. Vocabulary sets with staged progression were a feature for 21 out of 36 child vignettes. Only a single child vignette had no pre-provided vocabulary set as a feature of a most suitable AAC system. Having fewer than 50 items was only seen as a feature of the most suitable AAC systems for two child vignettes.

For most child vignettes (20), the highest rated AAC system had pragmatic vocabulary organisation, with the most suitable system having visual scene organisation for only two child vignettes. When photos were a feature of a most suitable AAC system, this was associated with lower ratings for those systems, in contrast to text, which was associated with higher rated most suitable AAC systems. Ideographs were not a feature of the most suitable AAC system for any child vignette. An idiosyncratic layout was a feature of the most suitable AAC system for all child vignettes.

Discussion

The results show that participants rated the suitability of AAC systems differently depending on the characteristics of the child vignette they were presented with. There was considerable variation in the fraction of AAC systems which were highly rated, and the features of the most suitable AAC systems varied for different child vignettes. This is not surprising, as it is in line with the analysis of participants' choices (Webb et al., 2019a) and with previous findings in the literature (Johnson et al., 2006, Light and McNaughton, 2014). However, it is an encouraging sign of the face validity of the current study's approach.

The current study's methods allowed the calculation of how participants rated the suitability of 274 AAC systems for each of 36 child vignettes. This in turn allows a comparison between child vignettes in terms of what fraction of AAC systems were given a rating above some threshold.. However, the set of AAC systems used in this survey was not intended to be representative of the characteristics of AAC systems currently available on the market. There could be no available system matching a given description, or there could be several different models all having features which match the description. Thus, for example, if participants rated 50% of AAC systems in this survey at least five out of seven for suitability, it does not mean they would give 50% of currently available AAC systems a similar rating. Yet despite this caveat, the AAC systems presented were considered to be feasible, whether or not they were available “off the shelf”, so the current study’s results do give an indication of the relative numbers of possible AAC systems which were regarded as acceptable or good for different children.

If an average rating of five of more out of seven is taken as good in terms of suitability, and six out of seven taken as excellent[2], then for all child vignettes at least half of AAC systems were a good fit. However, there was still much variation in the number of AAC systems which were a good fit, from a low of 51.1% to a high of 98.5%. In addition, more variation is revealed in terms of excellent systems. Most child vignettes had no AAC systems which were an excellent fit, yet for one child vignette (which could in some ways be considered to be most “able”) 20.4% of AAC systems were considered excellent for suitability. For many child vignettes almost all AAC systems were a good fit, yet only a small fraction were an excellent fit.

The language and communication attributes of AAC systems represented in this study form one part of the overall decision-making process (Murray, Lynch, Goldbart, Moulam, Judge, Webb, Jayes, Meredith, Whittle, & Randall, 2021). That most systems seemed to be rated good for most child vignettes may suggest that there is a weak underlying decision-making rationale. Equally, that there were only a small number of vignettes with AAC systems rated over six suggests that in most cases no stand-out system (and thus decision rationale) emerged. This finding might also suggest that these AAC system attributes are relatively unimportant compared to other attributes not included in this study, although the extensive attribute development process weights against this possibility..

[2]The reader may instead choose to interpret five as an acceptable rating and six as good, for example, but the meaning of our discussion is unchanged.

The vignettes where there were AAC systems ranked over 6 could broadly be described as those where the child was described as more able and motivated, and this suggests that decision-making rationale are clearer in these cases.

This finding also implies that there is at least the potential for inequalities in AAC provision to arise. For some children, fewer AAC systems are well suited to them, so that barriers to accessing some systems, such as cost or requiring a large amount of AAC practitioner input to set up, may disproportionately affect them, compared to children for whom many AAC systems are suitable. In light of this finding, it is encouraging that some dedicated funding for AAC systems is available, and Webb et al. (2019b) found that UK AAC professionals ascribed low importance to cost in their decision-making. However, other evidence suggests cost can play a significant role in AAC professionals' decision-making in other countries (Van Niekerk et al., 2018), and future research could usefully address the extent towards which this leads to inequalities in AAC provision.

Previous evidence has shown a need for lower learning demands of AAC systems for some children (Light et al., 2019c, Light et al., 2019d). This need may have led participants to rate only AAC systems with low learning demands highly for some children, explaining some of the observed variation in the number of systems with high suitability ratings. In particular, it is a plausible explanation as to why child vignettes which were predicted to regress in skills and abilities had fewer AAC systems with high suitability ratings.

In line with the above observation, graphic representation using photos, which is considered to have lower learning demands, were commonly a feature of the most suitable AAC system for child vignettes predicted to regress in skills and abilities and without motivation to communicate using AAC. Graphical representation using photos was associated with having a lower rated most suitable AAC system, and text, with greater learning demands, was associated with having a higher rated most suitable AAC system. The implication is that for children who require an AAC system with low learning demands, not only were there fewer systems which were a good match, even the most suitable systems were not an ideal match.

Another factor in how many AAC systems were given high suitability ratings was whether a child vignette was motivated to communicate using AAC or not. For vignettes in which the child was motivated to communicate using AAC, many more AAC systems tended to be rated as good or excellent for suitability. Such motivation was also an important factor in the DCE results, where it led participants to make what could be regarded as more ambitious choices, for example a large vocabulary, or graphic representation using ideographic symbols rather than photos. The current study has given context to this finding by suggesting that, although motivation to communicate using AAC was an important determinant of participants' choices, the consequences of such choices were not necessarily large, as participants regarded many less preferred AAC systems as well suited for motivated children. These findings are in line with previous evidence that attitudes towards AAC, and valuing an AAC system are important factors in successfully adopting AAC (Johnson et al., 2006, Light and McNaughton, 2014), so that motivated children are still likely to succeed, even with an AAC system which is not a perfect match.

The study's analysis also reveals which AAC systems participants regarded as most suitable for each child vignette. A caveat is that, although combinations of attributes which were regarded as unrealistic were excluded by the research team, there is no guarantee that for each AAC system included in the current study, an AAC system exists in the real world which has similar characteristics – although it would not be unusual to construct or adapt one using AAC software.

Very few child vignettes had a highest rated AAC system with fewer than 50 vocabulary items. This is in line with findings from the DCE, which showed that participants were always more likely to choose AAC systems with more than 50 vocabulary items than systems with fewer than 50, regardless of the child vignette they were choosing for.

There were significant differences between child vignettes in terms of how highly rated the most suitable AAC systems were, up to 14.3% of the rating scale's available range. This may reflect that, for some children the best available AAC system was not as suitable to their needs and abilities as for other children. However, previous findings have shown that personalising an off-the-shelf AAC system is an important factor in whether a child successfully adopts it (Dietz et al., 2012, Light and McNaughton, 2013, King et al., 2008). Thus it may be that participants would have given similar ratings to the most suitable AAC system for all child vignettes if it was clear that they would be personalised to the individual child.

Figure 3 shows the number of times each AAC system level was part of a child vignette's most preferred system, and certain characteristics appeared much more often than others. For example, ideographic symbols was never chosen, whereas all most preferred systems featured an idiosyncratic layout. There are several potential reasons for such variation. It could be that favouring certain AAC system characteristics is the result of an ecologically and evidentially valid decision rationale. Alternatively it could represent a bias towards the features of AAC systems which participants considered available, or had experience of in practice. Future research could useful explore further the reasons that AAC professionals regard some AAC system features as most suitable for a wide range of children.

Although DCEs are common in healthcare (Soekhai et al., 2019, Clark et al., 2014), this is the first study we are aware of that combines choices with ratings. An advantage of this approach is that it gives more information and makes it possible to answer other research questions than with a standard DCE with low extra participant burden and minimal additional resources to gather the data. More studies in future may wish to use a similar method.

This study has some limitations. It is possible to calculate a numerical rating for each AAC system and to test whether any differences are statistically significant. However, it is not possible to know how meaningful participants considered the difference between, for example, an AAC system rated five out of seven and one rated six out of seven to be. It may be that they considered two such AAC systems to be very similar, or they could have believed that the higher rated system would have a significantly positive effect on a child's future for many years. Future studies using a similar method may wish to investigate giving participants guidance as to how to interpret a unit difference in the rating scale.

The ratings for AAC systems are derived from statistical modelling of a limited number of choices for each individual, and so participants may have given different responses if the context was changed to rating an AAC system directly. However, with 36 child vignettes and 274 AAC systems, rating every system for every vignette would have required participants to complete 864 rating tasks, which is unfeasible. In addition, DCE choices and ratings were gathered at the same time and participants' ratings may have been influenced by the previous choice task. However, incorporating the Likert scale as part of a DCE had many practical advantages, as discussed above. In addition, recruiting participants to both the BWS and DCE surveys was difficult given the low numbers of AAC professionals in the UK, estimated at around 800 (Communication Matters, private correspondence). Thus it was uncertain whether recruiting participants for a third survey would be practical.

It was mentioned above that the set of AAC systems used in the survey were not necessarily reflective of the AAC systems available on the market. Although all systems were feasible, many would not be available off the shelf, and in practice would require practitioners to adapt an existing AAC vocabulary set . The skills, willingness and culture of doing this is likely to vary across practice settings. Additionally the availability of AAC systems will vary from place to place (particularly across countries) and the AAC systems and vocabularies placed on the market will change over time.

This study has a relatively low sample size compared to many similar studies in healthcare (Soekhai et al., 2019, Clark et al., 2014). However, as noted above, the number of AAC professionals in the UK is small, so that the sample size represents a sizeable fraction of the target population.

Conclusion

This study complements the earlier BWS and DCE studies, with all three studies examining the decision-making of AAC professionals choosing AAC systems for children from a different perspective. There have also been synergies from performing the studies together in a single research project. The results, together with the findings of the wider research project have been used to help create practical resources to help AAC professionals working with children in their everyday practice. The suite of resources is freely available at https://iasc.mmu.ac.uk/.

There is much scope for future research to build on the findings of the current study. For example, it would be useful to examine whether the findings about the suitability of hypothetical AAC systems presented here concur with AAC professionals' opinions about the suitability of real life systems. In addition, the current study highlighted areas in which inequalities in provision could occur, and in future, it could be examined whether such inequalities are found. Finally, it would be fruitful to explore whether AAC professionals' opinions about the suitability of AAC systems are in agreement with other stakeholders such as people who use AAC and their families. This latter issue is of particular importance given the likely impact on how motivated a child is to use an AAC system, and on how motivated a family is to provide support.

References

AKAIKE, H. 1974. A new look at the statistical model identification. *IEEE transactions on automatic control,* 19**,** 716-723.

ALLIANO, A., HERRIGER, K., KOUTSOFTAS, A. D. & BARTOLOTTA, T. E. 2012. A review of 21 iPad applications for augmentative and alternative communication purposes. *Perspectives on Augmentative and Alternative Communication,* 21**,** 60-71.

CHEUNG, K. L., WIJNEN, B. F., HOLLIN, I. L., JANSSEN, E. M., BRIDGES, J. F., EVERS, S. M. & HILIGSMANN, M. 2016. Using best–worst scaling to investigate preferences in health care. *Pharmacoeconomics,* 34**,** 1195-1209.

CHOI, B. C. & PAK, A. W. 2006. Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. *Clinical & investigative medicine,* 29**,** 351.

CLARK, M. D., DETERMANN, D., PETROU, S., MORO, D. & DE BEKKER-GROB, E. W. 2014. Discrete Choice Experiments in Health Economics: A Review of the Literature. *PharmacoEconomics,* 32**,** 883-902.

DIETZ, A., QUACH, W., LUND, S. K. & MCKELVEY, M. 2012. AAC assessment and clinical-decision making: The impact of experience. *Augmentative and Alternative Communication,* 28**,** 148-159.

ENDERBY, P., JUDGE, S., CREER, S. & JOHN, A. 2013. Examining the Need for and Provision of AAC Methods in the UK. *Advances in Clinical Neuroscience & Rehabilitation,* 13**,** 20-23.

GEYTENBEEK, J. J., VERMEULEN, R. J., BECHER, J. G. & OOSTROM, K. J. 2015. Comprehension of spoken language in non-speaking children with severe cerebral palsy: an explorative study on associations with motor type and disabilities. *Developmental Medicine & Child Neurology,* 57**,** 294-300.

GROSS, J. 2010. Augmentative and alternative communication: a report on provision for children and young people in England. Office of the Communication Champion.

HAJJAR, D. J., MCCARTHY, J. W., BENIGNO, J. P. & CHABOT, J. 2016. "You Get More Than You Give": Experiences of Community Partners in Facilitating Active Recreation with Individuals who have Complex Communication Needs. *Augmentative and Alternative Communication,* 32**,** 131-142.

HEMSLEY, B. & MURRAY, J. 2015. Distance and proximity: research on social media connections in the field of communication disability. Taylor & Francis.

HESS, S. & PALMA, D. 2019. Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application. *Journal of Choice Modelling***,** 100170.

HYNAN, A., GOLDBART, J. & MURRAY, J. 2015. A grounded theory of Internet and social media use by young people who use augmentative and alternative communication (AAC). *Disability and rehabilitation,* 37**,** 1559-1575.

JOHNSON, J. M., INGLEBRET, E., JONES, C. & RAY, J. 2006. Perspectives of speech language pathologists regarding success versus abandonment of AAC. *Augmentative and Alternative Communication,* 22**,** 85-99.

JUDGE, S., ENDERBY, P., CREER, S. & JOHN, A. 2017. Provision of powered communication aids in the United Kingdom. *Augmentative and Alternative Communication,* 33**,** 181-187.

JUDGE, S., RANDALL, N., GOLDBART, J., LYNCH, Y., MOULAM, L., MEREDITH, S. & MURRAY, J. 2019a. The language and communication attributes of graphic symbol communication aids–a systematic review and narrative synthesis. *Disability Rehabilitation: Assistive Technology***,** 1-11.

JUDGE, S., RANDALL, N., GOLDBART, J., LYNCH, Y., MOULAM, L., MEREDITH, S., MURRAY, J. J. D. & TECHNOLOGY, R. A. 2019b. The language and communication attributes of graphic symbol communication aids–a systematic review and narrative synthesis. 1-11.

KING, G., BATOROWICZ, B. & SHEPHERD, T. A. 2008. Expertise in research-informed clinical decision making: Working effectively with families of children with little or no functional speech. *Evidence-Based Communication Assessment Intervention,* 2**,** 106-116.

KUHFELD, W. F., TOBIAS, R. D. & GARRATT, M. J. J. O. M. R. 1994. Efficient experimental design with marketing research applications. 31**,** 545-557.

LIGHT, J. & MCNAUGHTON, D. 2013. Putting people first: Re-thinking the role of technology in augmentative and alternative communication intervention. *Augmentative and Alternative Communication,* 29**,** 299-309.

LIGHT, J. & MCNAUGHTON, D. 2014. Communicative competence for individuals who require augmentative and alternative communication: A new definition for a new era of communication? : Taylor & Francis.

LIGHT, J., MCNAUGHTON, D., BEUKELMAN, D., FAGER, S. K., FRIED-OKEN, M., JAKOBS, T. & JAKOBS, E. 2019a. Challenges and opportunities in augmentative and alternative communication: Research and technology development to enhance communication and participation for individuals with complex communication needs. *Augmentative and Alternative Communication,* 35**,** 1-12.

LIGHT, J., MCNAUGHTON, D., BEUKELMAN, D., FAGER, S. K., FRIED-OKEN, M., JAKOBS, T., JAKOBS, E. J. A. & COMMUNICATION, A. 2019b. Challenges and opportunities in augmentative and alternative communication: Research and technology development to enhance communication and participation for individuals with complex communication needs. 35**,** 1-12.

LIGHT, J., MCNAUGHTON, D. & CARON, J. 2019c. New and emerging AAC technology supports for children with complex communication needs and their communication partners: State of the science and future research directions. *Augmentative and Alternative Communication,* 35**,** 26-41.

LIGHT, J., WILKINSON, K. M., THIESSEN, A., BEUKELMAN, D. R. & FAGER, S. K. 2019d. Designing effective AAC displays for individuals with developmental or acquired disabilities: State of the science and future research directions. *Augmentative and Alternative Communication,* 35**,** 42-55.

LOUVIERE, J. J., HENSHER, D. A. & SWAIT, J. D. 2000. *Stated choice methods: analysis and applications*, Cambridge university press.

LUND, S. K. & LIGHT, J. 2006. Long-term outcomes for individuals who use augmentative and alternative communication: Part I–What is a "good" outcome? *Augmentative and Alternative Communication,* 22**,** 284-299.

LUND, S. K., QUACH, W., WEISSLING, K., MCKELVEY, M., DIETZ, A. J. L., SPEECH, & SCHOOLS, H. S. I. 2017. Assessment with children who need augmentative and alternative communication (AAC): Clinical decisions of AAC specialists. 48**,** 56-68.

LYNCH, Y., MURRAY, J., MOULAM, L., MEREDITH, S., GOLDBART, J., SMITH, M., BATOROWICZ, B., RANDALL, N. & JUDGE, S. 2019a. Decision-making in communication aid recommendations in the UK: cultural and contextual influencers. *Augmentative and Alternative Communication***,** 1-13.

LYNCH, Y., MURRAY, J., MOULAM, L., MEREDITH, S., GOLDBART, J., SMITH, M., BATOROWICZ, B., RANDALL, N., JUDGE, S. J. A. & COMMUNICATION, A.

2019b. Decision-making in communication aid recommendations in the UK: cultural and contextual influencers. 1-13.

MURRAY, J., LYNCH, Y., MEREDITH, S., MOULAM, L., GOLDBART, J., SMITH, M., RANDALL, N. & JUDGE, S. 2019. Professionals' decision-making in recommending communication aids in the UK: competing considerations. *Augmentative and Alternative Communication 35*(3), 1-13.

Murray, J., Lynch, Y., Goldbart, J., Moulam, L., Judge, S., Webb, E., Jayes, M., Meredith, S., Whittle, H., & Randall, N. (2021). The decision-making process in recommending electronic communication aids for children and young people who are non-speaking: the I-ASC mixed-methods study. *Health Services and Delivery Research*, *8*(45), 1-158.

NHS ENGLAND 2016. Guidance for commissioning AAC services and equipment. NHS England.

OFFICE FOR NATIONAL STATISTICS 2020. Population Estimates for UK, England and Wales, Scotland and Northern Ireland: Mid-2018, using April 2019 local authority district codes.

ROYAL COLLEGE OF SPEECH AND LANGUAGE THERAPISTS 2009. Resource manual for commissioning and planning services for SLCN. Royal College of Speech and Language Therapists.

RYAN, S. E., SHEPHERD, T., RENZONI, A. M., ANDERSON, C., BARBER, M., KINGSNORTH, S. & WARD, K. 2015. Towards Advancing Knowledge Translation of AAC Outcomes Research for Children and Youth with Complex Communication Needs. *Augmentative and Alternative Communication,* 31**,** 137-147.

SCHLOSSER, R. W. & WENDT, O. 2008. Effects of augmentative and alternative communication intervention on speech production in children with autism: A systematic review. *American Journal of Speech-Language Pathology,* 17**,** 212-230.

SOEKHAI, V., DE BEKKER-GROB, E. W., ELLIS, A. R. & VASS, C. M. 2019. Discrete choice experiments in health economics: past, present and future. *PharmacoEconomics,* 37**,** 201-226.

SUNDQVIST, A. & RÖNNBERG, J. 2010. A qualitative analysis of email interactions of children who use augmentative and alternative communication. *Augmentative and Alternative Communication,* 26**,** 255-266.

THISTLE, J. J. & WILKINSON, K. M. 2015. Building evidence-based practice in AAC display design for young children: Current practices and future directions. *Augmentative and Alternative Communication,* 31**,** 124-136.

VAN NIEKERK, K., DADA, S., TÖNSING, K. & BOSHOFF, K. 2018. Factors perceived by rehabilitation professionals to influence the provision of assistive technology to children: A systematic review. *Physical occupational therapy in pediatrics,* 38**,** 168-189.

WEBB, E. J. & HESS, S. 2021. Joint modelling of choice and rating data: theory and examples. *Journal of choice modelling, 40*

WEBB, E. J., LYNCH, Y., MEADS, D., JUDGE, S., RANDALL, N., GOLDBART, J., MEREDITH, S., MOULAM, L., HESS, S. & MURRAY, J. 2019a. Finding the best fit: examining the decision-making of augmentative and alternative communication professionals in the UK using a discrete choice experiment. *BMJ Open,* 9.

WEBB, E. J., MEADS, D., LYNCH, Y., JUDGE, S., RANDALL, N., GOLDBART, J., MEREDITH, S., MOULAM, L., HESS, S. & MURRAY, J. 2020. Attribute selection for a discrete choice experiment incorporating a best-worst scaling survey.

WEBB, E. J., MEADS, D., LYNCH, Y., RANDALL, N., JUDGE, S., GOLDBART, J., MEREDITH, S., MOULAM, L., HESS, S. & MURRAY, J. 2019b. What's important in AAC decision making for children? Evidence from a best–worst scaling survey. *Augmentative and Alternative Communication*, 1-15.

WILKINSON, K. M. & MITCHELL, T. 2014. Eye tracking research to answer questions about augmentative and alternative communication assessment and intervention. *Augmentative and Alternative Communication,* 30, 106-119.

WILLIAMS, M., BEUKELMAN, D. & ULLMAN, C. 2012. AAC text messaging. *Perspectives on Augmentative and Alternative Communication,* 21, 56-59.

WILLIAMS, M. B., KREZMAN, C., MCNAUGHTON, D. J. A. & COMMUNICATION, A. 2008. "Reach for the stars": Five principles for the next 25 years of AAC. 24, 194-206.

Table 1

Child attributes and levels

Attribute	Levels
Receptive and expressive language	Delayed
	Receptive language exceeding expressive language
Communication ability with AAC	No previous AAC experience
	Abe to use AAC for a few communicative functions
	Able to use AAC for a range of communicative functions
Child's determination and persistence	Does not appear motivated to communicate through any methods and means
	Motivated to communicate through symbol communication systems
	Only motivated to communicate through methods other than symbol communication
Predicted future skills and abilities	Regression
	Plateau
	Progression

Table 2

AAC system attributes and levels

Attribute	Levels
Vocabulary sets	No vocabulary set*
	Fixed vocabulary set
	Vocabulary set with staged progression
Size of vocabulary	Up to 50 vocabulary items*
	50-1000 vocabulary items
	More than 1000 vocabulary items
Consistency of layout	Consistency of some aspects of layout*
	Consistency of all aspects of layout
	Idiosyncratic layout
Type of vocabulary organisation	Visual scene*
	Taxonomic
	Semantic-syntactic
	Pragmatic
Graphic representation	Photos*
	Pictographic symbol set
	Ideographic symbol system (with rules or encoding)
	Text

Note. * indicates baseline level.

Table 3

Participant demographics

	Completed DCE		Did not complete DCE	
	N	%	N	%
Mean age (sd)	40.2	10.9	46.1	10.9
Mean years of experience (sd)	11.4	9.15	11.6	9.87
Female	140	90.3	15	88.2
White ethnicity	137	88.4	12	70.6
Professional background - speech and language therapist	117	75.5	8	47.1
Professional background - occupational therapist	11	7.1	5	29.4
Professional background - assistive technology specialist	5	3.23	0	0
Professional background - teacher	11	7.1	3	17.6
Professional background - other	12	7.74	0	0
Common diagnoses - autism spectrum	101	65.2	12	70.6
Common diagnoses – physical	128	82.6	12	70.6
Common diagnoses - dyspraxia	12	7.74	2	11.8
Common diagnoses - intellectual disability/delay	107	69	11	64.7
Common diagnoses - neurological	39	25.2	6	35.3
Common diagnoses - speech/language disorder	19	12.3	3	17.6
Common diagnoses - syndromes	56	36.1	5	29.4
N	155		17	

Note. DCE = discrete choice experiment; sd = standard deviation

Table 4

Areas in which participants worked

	Completed DCE		Did not complete DCE	
	N	%	N	%
North West England	20	12.9	2	11.8
North East England	5	3.23	1	5.88
Yorkshire and Humber	22	14.2	1	5.88
West Midlands	12	7.74	1	5.88
East Midlands	11	7.1	1	5.88
East of England	14	9.03	3	17.6
South West England	8	5.16	0	0
South East England	32	20.6	3	17.6
London	18	11.6	4	23.5
Northern Ireland	5	3.23	0	0
North Wales	3	1.94	0	0
South Wales	5	3.23	0	0
Mid-Wales	3	1.94	0	0
Southern Scotland	7	4.52	0	0
Central Scotland	11	7.1	1	5.88
Northern Scotland	6	3.87	0	0
Non-UK	4	2.58	0	0
N	155		17	

Note. DCE = discrete choice experiment

Table 5

For each child vignette, the proportions of systems rated at least five and at least six

Receptive and expressive language	Experience of AAC	Motivation to communicate	Predicted future skills and abilities	Systems rated 5 and over (%)	Systems rated 6 and over (%)
Delayed	No experience	Motivated (non-AAC)	Regress	51.1	0
Receptive > expressive	No experience	Motivated (non-AAC)	Regress	53.6	0
Delayed	No experience	Not motivated	Regress	70.8	0
Delayed	No experience	Motivated (non-AAC)	Plateau	71.2	0
Delayed	Few functions	Not motivated	Regress	71.9	0
Receptive > expressive	No experience	Not motivated	Regress	73	0
Delayed	No experience	Motivated (non-AAC)	Progress	73.7	0
Receptive > expressive	No experience	Motivated (non-AAC)	Plateau	73.7	0
Receptive > expressive	No experience	Motivated (non-AAC)	Progress	75.2	0
Receptive > expressive	Few functions	Not motivated	Regress	75.5	0
Delayed	No experience	Not motivated	Plateau	82.5	0
Delayed	Few functions	Not motivated	Plateau	83.6	0
Delayed	No experience	Not motivated	Progress	86.1	0
Receptive > expressive	No experience	Not motivated	Plateau	86.1	0
Delayed	Few functions	Not motivated	Progress	87.6	0
Receptive > expressive	Few functions	Not motivated	Plateau	88	0
Receptive > expressive	Few functions	Not motivated	Progress	88.7	0
Receptive > expressive	Few functions	Motivated (AAC)	Regress	93.4	0
Receptive > expressive	No experience	Motivated (AAC)	Regress	94.2	0
Delayed	No experience	Motivated (AAC)	Regress	95.6	0
Delayed	Few functions	Motivated (AAC)	Regress	95.6	0
Delayed	Range of functions	Motivated (AAC)	Regress	95.6	0
Delayed	No experience	Motivated (AAC)	Plateau	98.5	0
Delayed	Few functions	Motivated (AAC)	Plateau	98.5	0
Receptive > expressive	No experience	Not motivated	Progress	86.5	0.365
Receptive > expressive	Few functions	Motivated (AAC)	Plateau	97.1	2.19
Receptive > expressive	No experience	Motivated (AAC)	Plateau	97.1	3.28
Delayed	Range of functions	Motivated (AAC)	Plateau	98.5	3.28

Receptive > expressive	Range of functions	Motivated (AAC)	Regress	93.4	4.38
Delayed	Few functions	Motivated (AAC)	Progress	95.6	8.76
Delayed	No experience	Motivated (AAC)	Progress	96.7	9.12
Receptive > expressive	Range of functions	Motivated (AAC)	Plateau	97.1	12
Receptive > expressive	Few functions	Motivated (AAC)	Progress	94.5	12.8
Receptive > expressive	No experience	Motivated (AAC)	Progress	94.5	13.1
Delayed	Range of functions	Motivated (AAC)	Progress	96.7	15
Receptive > expressive	Range of functions	Motivated (AAC)	Progress	95.6	20.4

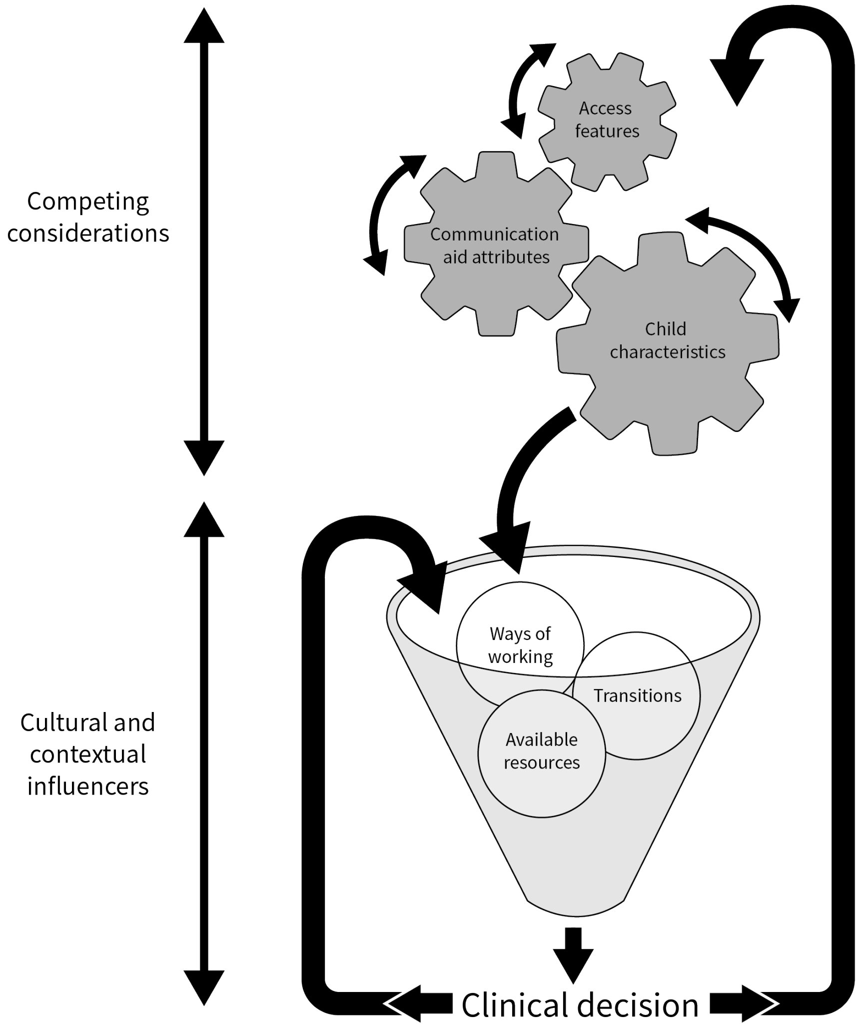

Figure 1. The I-ASC Explanatory Model of Decision Making

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%

Figure 2. Example discrete choice experiment task

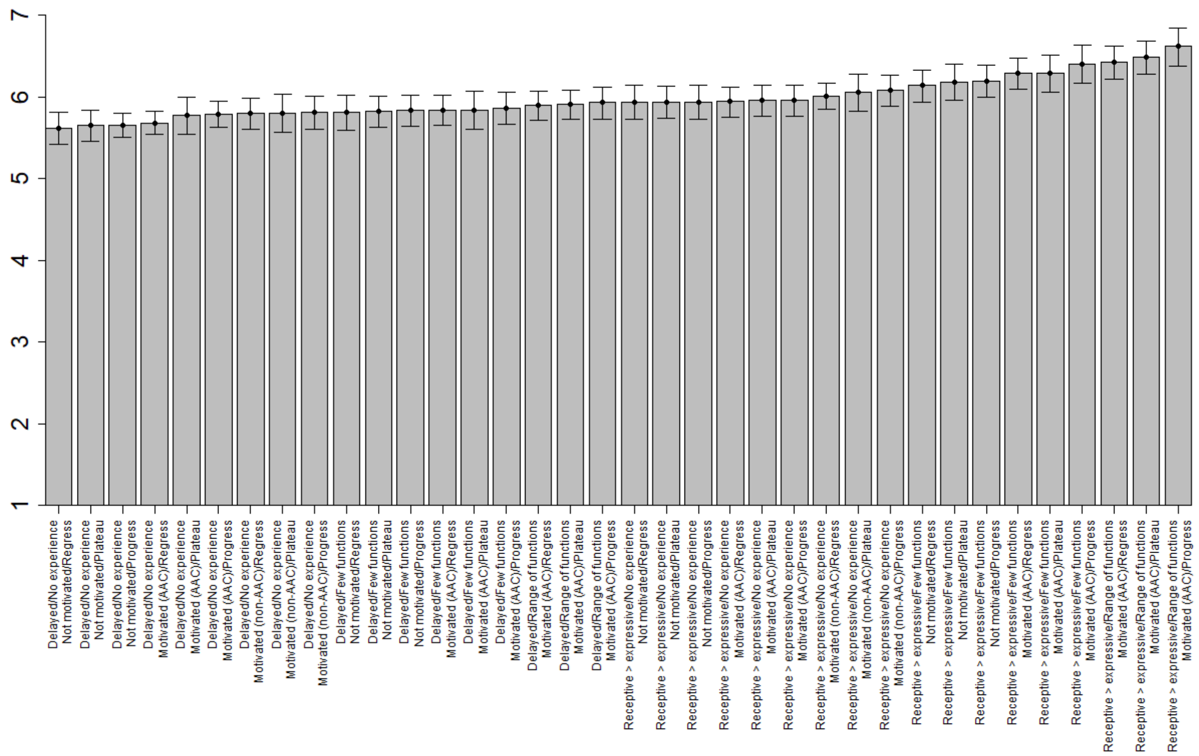

Figure 3. Ratings of the highest rated AAC system for each child vignette

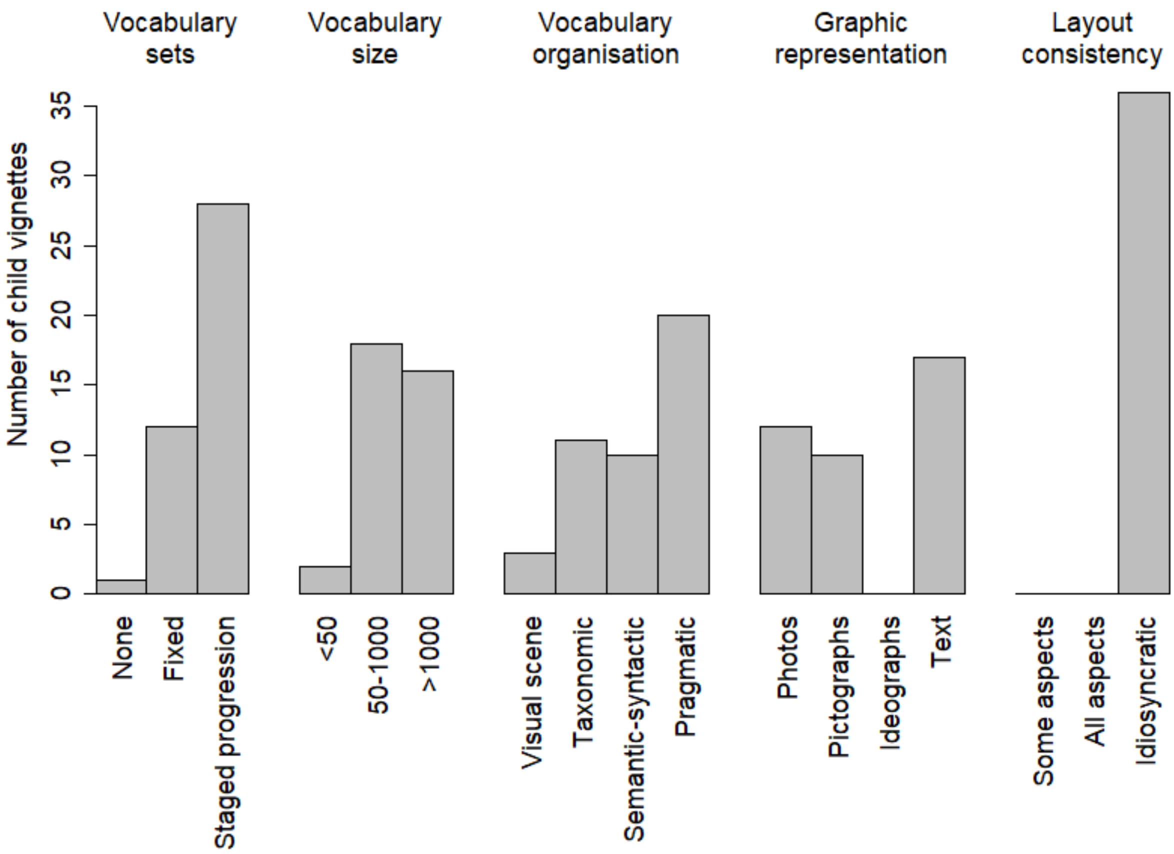

Figure 4. Number of times each AAC system level was part of a child vignette's most preferred system

Supplementary online material – model estimation and selection

Statistical analysis used a random utility theory framework, and choices and ratings were analysed using choice-ordered logit models (Webb and Hess, 2019). The utility participant n gained from choosing AAC system $s\epsilon\{1,2,3\}$ for child c in task t was assumed to take the form

$$u_{ncst}^{choice} = \beta_{nc}x_{nst} + \varepsilon_{ncst}$$

where β_{nc} is a vector of coefficients which differ over children representing n's preferences, x_{nst} is a vector giving the levels of system s shown to individual n in task t and ε_{ncst} is an extreme value distributed error term. The utility participant n obtained from rating the suitability of system s for child c as r, $1 \leq r \leq 7$, was assumed to take the form

$$u_{ncst}^{rating} = \zeta\beta_{nc}x_{nst} + \nu_n + \eta_{ncst}$$

where ζ is a scale parameter, $\upsilon_n\ N(0, \sigma_\upsilon^2)$ is a random effects (RE) term and η_{ncst} is an extreme value distributed error term.

The probability of participant n choosing system s and rating it r in task t is then

$$P_t(chooses, rater|childc$$
$$= \int_{\upsilon_n} \frac{e^{V_{ncst}^{choice}}}{\sum_{k=1}^{3} e^{V_{nckt}^{choice}}} \left(\frac{1}{1 + e^{V_{ncst}^{rating} - \theta_r}} - \frac{1}{1 + e^{V_{icst}^{rating} - \theta_{r-1}}} \right) \varphi(\upsilon_n) d\upsilon_n$$

where $V_{ncst}^{choice} = \beta_{nc}x_{nst}$, $V_{ncst}^{rating} = \zeta\beta_{nc}x_{nst} + \upsilon_n$ and $\theta_0, \theta_1, \ldots, \theta_7$ are utility thresholds with $\theta_{r-1} < \theta_r$, $\theta_0 = -\infty$ and $\theta_7 = \infty$ and $\varphi(\cdot)$ is the probability density function of the normal distribution.

The preferences of participant n for different systems were allowed to vary according to the child presented according to

$$\beta_{nlc} = \gamma_{nl}z_c$$

where β_{nlc} is the scalar parameter representing n's preference for AAC system level l when choosing for child c, γ_{nl} is a vector of parameters and z_c is a vector giving the characteristics of child c.

One level of each AAC system attribute was chosen as a baseline and each AAC system preference parameter was interacted with each level in the set of child attributes, so that the full model contained 132 preference parameters, plus six thresholds, a scale parameter and a random effects term. As this was too many to produce reliable estimates, a selection process was used to select a more parsimonious model.

A stepwise regression procedure was used, beginning with estimating a series of models with only one preference parameter included. The parameter which produced the best increase in log-likelihood was selected. Another series of models were then run with the selected parameter and one other, and again the parameter with the best increase in log-likelihood was selected. This process continued until a full model with all parameters was estimated. The final model was selected using the Akaike information criterion (Akaike, 1974). Estimation of candidate models was done using simulated maximum likelihood with 100 Halton draws. The final model was re-estimated using 1000 Halton draws. All estimation was carried out using the Apollo choice modelling package for R (Hess and Palma, 2019).
*Figure A **1*** shows the Akaike information criteria for all estimated models, and Table A **1** gives the results of estimating the final model.

Table A 1

Results of estimating final model

AAC system attribute	Interaction with child attribute	Coefficient	Standard error
Vocab sets – Fixed	Not motivated	0.548	0.158
Vocab sets – Fixed	Motivated (non-AAC)	0.481	0.133
Vocab sets – Fixed	Progress	-0.196	0.14
Vocab sets - Staged progression	No experience	0.204	0.113
Vocab sets - Staged progression	Plateau	0.356	0.129
Vocab sets - Staged progression	Progress	0.943	0.138
Vocab size - 50-1000	No experience	-0.343	0.143
Vocab size - 50-1000	Not motivated	0.725	0.215
Vocab size - 50-1000	Motivated (AAC)	0.79	0.131
Vocab size - 50-1000	Motivated (non-AAC)	0.318	0.145
Vocab size - >1000	Delayed	-0.517	0.14
Vocab size - >1000	Range of functions	0.682	0.197
Vocab size - >1000	Motivated (AAC)	0.944	0.165
Vocab size - >1000	Motivated (non-AAC)	0.272	0.167
Vocab size - >1000	Progress	0.643	0.16
Vocab organisation – Taxonomic	Range of functions	0.27	0.207
Vocab organisation – Taxonomic	Motivated (AAC)	0.305	0.118
Vocab organisation - Semantic-syntactic	Motivated (AAC)	0.515	0.126
Vocab organisation - Semantic-syntactic	Motivated (non-AAC)	0.217	0.14
Vocab organisation - Semantic-syntactic	Regress	-0.428	0.139
Vocab organisation – Pragmatic	Delayed	0.405	0.123
Vocab organisation – Pragmatic	No experience	0.211	0.109
Graphic representation – Pictographs	Not motivated	-0.304	0.186
Graphic representation – Pictographs	Motivated (non-AAC)	-0.713	0.198
Graphic representation – Pictographs	Regress	0.23	0.125
Graphic representation – Pictographs	Plateau	0.39	0.143
Graphic representation – Ideographs	Not motivated	-0.767	0.206
Graphic representation – Ideographs	Motivated (non-AAC)	-0.952	0.188
Graphic representation – Text	Motivated (AAC)	0.424	0.119
Graphic representation – Text	Motivated (non-AAC)	-0.527	0.156

Graphic representation – Text	Regress	-0.315	0.139
Layout - All aspects	Not motivated	0.742	0.167
Layout - All aspects	Motivated (AAC)	0.943	0.115
Layout - All aspects	Motivated (non-AAC)	0.752	0.132
Layout - All aspects	Regress	-0.255	0.144
Layout – Idiosyncratic	Delayed	0.965	0.113
Layout – Idiosyncratic	Receptive > expressive	1.27	0.112
Layout – Idiosyncratic	Regress	0.163	0.152
Scale parameter ζ		0.644	0.091
Random effects parameter ν		2.25	0.353
θ_1		-4.44	0.347
θ_2		-2.39	0.245
θ_3		-1.03	0.200
θ_4		0.738	0.195
θ_5		2.75	0.217
θ_6		5.52	0.294

Note. Coefficient labels use shorthand. For the full list of attributes and levels see Tables 1 and 2.

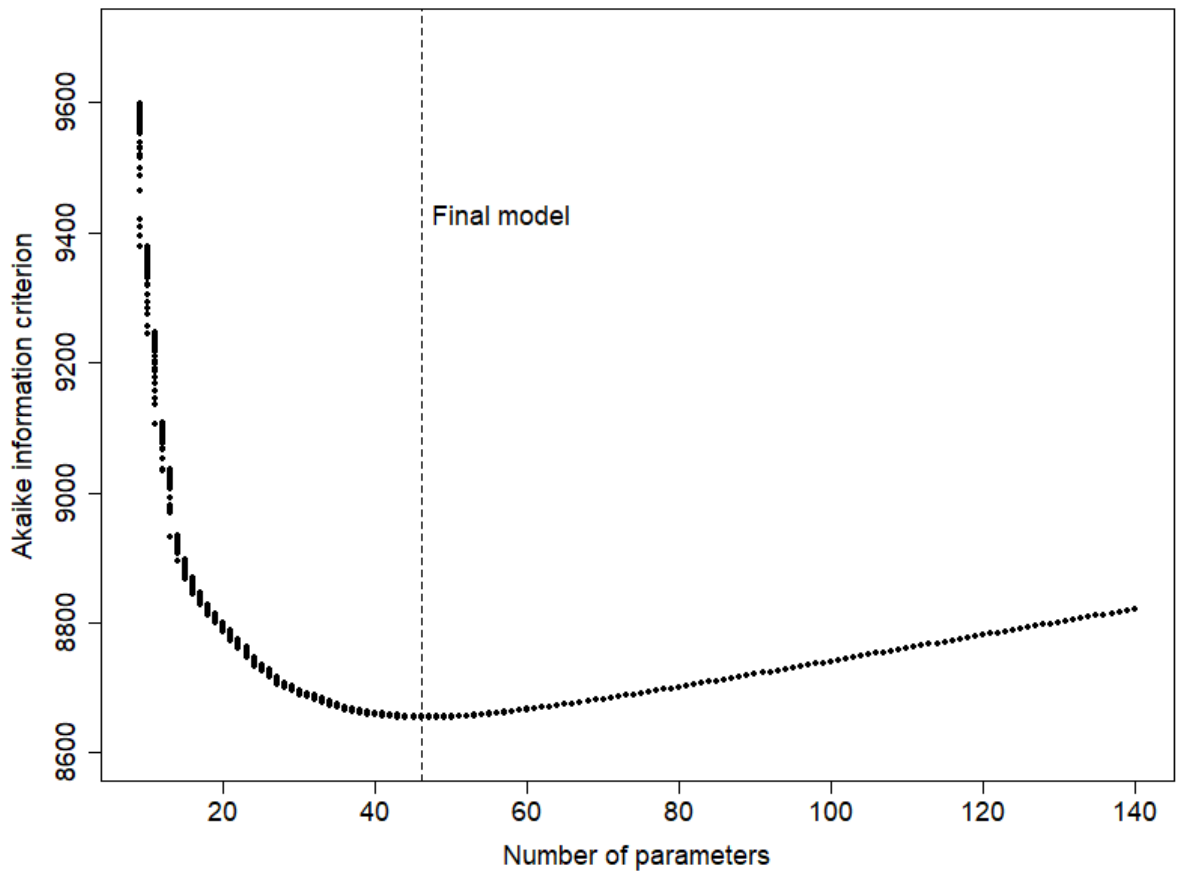

Figure A 1. Akaike information criteria of estimated models

Table A 2

Description of the highest rated system(s) for each child vignette

Child vignette				Highest rated system(s)					
Receptive and expressive language	Experience of AAC	Motivation to communicate	Predicted future skills and abilities	Vocab sets	Vocab size	Vocab organisation	Graphic representation	Layout consistency	Rating
Receptive > expressive	No experience	Motivated (non-AAC)	Plateau	Staged progression	50-1000	Semantic-syntactic	Photos	Idiosyncratic	5.62
Delayed	No experience	Motivated (non-AAC)	Plateau	Staged progression	50-1000	Pragmatic	Photos	Idiosyncratic	5.65
Receptive > expressive	No experience	Motivated (non-AAC)	Regress	Fixed	<50	Pragmatic	Photos	Idiosyncratic	5.65
Delayed	No experience	Motivated (non-AAC)	Regress	Fixed	<50	Pragmatic	Photos	Idiosyncratic	5.68
Receptive > expressive	No experience	Not motivated	Plateau	Staged progression	50-1000	Pragmatic	Pictographs	Idiosyncratic	5.77
Delayed	Few functions	Motivated (AAC)	Regress	None Fixed Staged progression	50-1000	Pragmatic	Pictographs	Idiosyncratic	5.79
Receptive > expressive	No experience	Not motivated	Regress	Fixed	50-1000	Pragmatic	Photos	Idiosyncratic	5.79
Delayed	No experience	Not motivated	Plateau	Staged progression	50-1000	Pragmatic	Pictographs	Idiosyncratic	5.8
Delayed	No experience	Motivated (AAC)	Regress	Staged progression	50-1000	Pragmatic	Pictographs	Idiosyncratic	5.81

Receptive > expressive	Few functions	Not motivated	Plateau	Fixed	50-1000	Visual scene Taxonomic Semantic-syntactic Pragmatic	Pictographs	Idiosyncratic	5.81
Delayed	No experience	Not motivated	Regress	Fixed	50-1000	Pragmatic	Photos	Idiosyncratic	5.82
Delayed	No experience	Motivated (non-AAC)	Progress	Staged progression	50-1000	Pragmatic	Photos	Idiosyncratic	5.83
Receptive > expressive	Few functions	Not motivated	Regress	Fixed	50-1000	Visual scene Taxonomic Pragmatic	Photos	Idiosyncratic	5.84
Delayed	Few functions	Not motivated	Plateau	Fixed	50-1000	Pragmatic	Pictographs	Idiosyncratic	5.84
Delayed	Few functions	Not motivated	Regress	Fixed	50-1000	Pragmatic	Photos	Idiosyncratic	5.87
Receptive > expressive	Few functions	Motivated (AAC)	Regress	Fixed Staged progression	>1000	Taxonomic	Pictographs	Idiosyncratic	5.9
Receptive > expressive	Few functions	Not motivated	Progress	Staged progression	50-1000	Visual scene Taxonomic Semantic-syntactic Pragmatic	Photos Text	Idiosyncratic	5.91
Delayed	No experience	Motivated (AAC)	Plateau	Staged progression	50-1000	Pragmatic	Text	Idiosyncratic	5.93

Receptive > expressive	No experience	Motivated (non-AAC)	Progress	Staged progression	>1000	Semantic-syntactic	Text	Idiosyncratic	5.93
Delayed	Few functions	Not motivated	Progress	Staged progression	50-1000	Pragmatic	Photos	Idiosyncratic	5.94
							Text		
Delayed	Range of functions	Motivated (AAC)	Regress	Fixed	>1000	Taxonomic	Pictographs	Idiosyncratic	5.94
				Staged progression					
Delayed	Few functions	Motivated (AAC)	Plateau	Staged progression	50-1000	Semantic-syntactic	Text	Idiosyncratic	5.94
Delayed	No experience	Not motivated	Progress	Staged progression	50-1000	Pragmatic	Photos	Idiosyncratic	5.96
							Text		
Receptive > expressive	No experience	Motivated (AAC)	Regress	Staged progression	>1000	Taxonomic	Pictographs	Idiosyncratic	5.96
Receptive > expressive	No experience	Not motivated	Progress	Staged progression	>1000	Pragmatic	Text	Idiosyncratic	6.01
Delayed	Range of functions	Motivated (AAC)	Plateau	Staged progression	>1000	Taxonomic	Text	Idiosyncratic	6.05
Receptive > expressive	Few functions	Motivated (AAC)	Plateau	Staged progression	>1000	Semantic-syntactic	Text	Idiosyncratic	6.08
Receptive > expressive	No experience	Motivated (AAC)	Plateau	Staged progression	>1000	Semantic-syntactic	Text	Idiosyncratic	6.14
Receptive > expressive	Range of functions	Motivated (AAC)	Regress	Fixed	>1000	Taxonomic	Pictographs	Idiosyncratic	6.18
				Staged progression					
Delayed	Few functions	Motivated (AAC)	Progress	Staged progression	>1000	Semantic-syntactic	Text	Idiosyncratic	6.2
Delayed	No experience	Motivated (AAC)	Progress	Staged progression	>1000	Pragmatic	Text	Idiosyncratic	6.28

Receptive > expressive	Range of functions	Motivated (AAC)	Plateau	Staged progression	>1000	Taxonomic	Text	Idiosyncratic	6.29
Delayed	Range of functions	Motivated (AAC)	Progress	Staged progression	>1000	Taxonomic	Text	Idiosyncratic	6.4
Receptive > expressive	Few functions	Motivated (AAC)	Progress	Staged progression	>1000	Semantic-syntactic	Text	Idiosyncratic	6.43
Receptive > expressive	No experience	Motivated (AAC)	Progress	Staged progression	>1000	Semantic-syntactic	Text	Idiosyncratic	6.48
Receptive > expressive	Range of functions	Motivated (AAC)	Progress	Staged progression	>1000	Taxonomic	Text	Idiosyncratic	6.62
Delayed	Few functions	Not motivated	Regress	None; fixed; staged progression	50-1000	Visual scene; taxonomic; semantic-syntactic	Photos; pictographs; ideographs; text	Idiosyncratic	5.5