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Abstract

The Picture Exchange Communication System (PECS) is an Augmentative and Alternative Communication (AAC) system which is widely used to support children with developmental disabilities. In the present study, we surveyed individuals responsible for implementing PECS in special educational settings in the United Kingdom (N=283). We explored knowledge of and adherence to the intervention, with a view to identifying training and support needs. Specifically, we examined participants' knowledge, implementation accuracy, training experiences, access to resources, and attitudes towards PECS. We developed hierarchical logistic regression models to explore the association between training experience and both knowledge and use of PECS. We pre-registered our methods, predictions and the analysis plan on the Open Science Framework (OSF). We found considerable variation in practitioner knowledge and implementation of PECS. Formal training predicted greater knowledge and more accurate implementation when practitioner role and the degree of setting support were accounted for. While PECS was rated by a large majority to be effective and practical, many participants identified that time and the availability of resources were barriers to implementation. We also found that the purpose of PECS was not always fully understood by practitioners, and we identified some consistent gaps in knowledge and implementation. This study contributes new infor- mation regarding the real-world use of PECS in educational settings and offers new insights for supporting practitioners.

Keywords: Picture Exchange Communication System, PECS, AAC, treatment fidelity, communication

Introduction

A significant proportion of autistic individuals and people with intellectual disabilities demonstrate difficulties in developing functional speech. It is estimated that up to 20%-30% of autistic children with intellectual disabilities are nonverbal or minimally verbal into school age (Lord et al., 2004; Tager-Flusberg & Kasari, 2013). Lack of verbal language can significantly impact the quality of life of individuals with intellectual disabilities; evidence indicates that deficits in language predict the development of behaviors of concern (Hastings et al., 2013; McClintock et al., 2003), and fewer adaptive and pro-social behaviors (Anderson et al., 2007; Hudry et al., 2010). Augmentative and alternative communication (AAC) systems such as manual sign language, gestures, voice output communication aids, and speech-generating devices (SGDs) can be used to develop communication skills where they are lacking. Increasing awareness and adoption of evidence based AAC interventions is therefore an important aim. It is also critical that individuals tasked with delivering these interventions are provided with the necessary training and resources to implement them effectively.

The Picture Exchange Communication System (PECS) is a widely used AAC system specifically designed for minimally verbal learners whose speech has not developed, is unintelligible, or is not functional (Bondy & Frost, 1994). PECS users exchange pictures or symbols to communicate wants, needs and ideas. PECS is a manualized intervention involving six discrete implementation phases (Frost & Bondy, 2002). During Phases 1 to 3, a learner is taught to: (1) exchange a single picture for preferred items or activities, (2) persist in communicative attempts, and (3) discriminate between different pictures. In later phases, learners are taught to use carrier phrases such as “I want” and modifiers (e.g., big/small; Phase 4), answer

questions (e.g., “What do you want?”; Phase 5), and to comment (e.g., “I see car”; Phase 6). The ultimate goal of PECS is to achieve flexible, independent, and functional communication across a range of contexts.

There is an emerging evidence base supporting the use of PECS as an alternative communication system. Flippin et al. (2010) undertook a systematic review and meta-analysis of the literature to examine the effects of PECS on both communicative behavior and speech development in young autistic learners. The review found small to moderate gains in communicative attempts, and small to negative effects on speech outcomes in the children taught to use PECS. Based on these findings, the authors concluded that PECS should be considered a promising, but not yet established evidence-based intervention for improving communication skills in minimally verbal young autistic children. Ganz et al. (2012) undertook a meta-analytic review of the existing single-case experimental design studies undertaken on PECS. They concluded that PECS produces moderately positive effects on functional communication skills. These conclusions are supported by a number of other systematic and meta-analytic reviews (e.g., Brignell et al., 2018; Lamb et al., 2018; Preston & Carter, 2009). Moreover, a recent comprehensive review of interventions for autistic learners commissioned by the National Autism Center, deemed PECS an ‘Emerging Treatment” on the basis of the available evidence (National Standards Report, 2015). While the existing reviews and meta-analytic studies investigating the use of PECS have been largely positive, a number of issues have been identified in these syntheses. For example, maintenance and generalization of PECS skills have been evaluated infrequently, and measures of social validity are rarely reported (Flippin, et al., 2010; Preston & Carter, 2009; Sulzer-Azaroff et al., 2009; Tincani & Devis, 2011).

The available evidence suggests that PECS is also widely used. In an international survey of over 500 parents of autistic children, Green et al. (2006) reported that PECS was being used by 28% of respondents, with a further 31% reporting having used it in the past. In a survey of 160 parents focusing exclusively on the United Kingdom, Denne et al. (2017) reported that PECS was currently used by 19% of respondents, with an additional 23% having used it previously. While these data suggest that PECS is a popular intervention, how frequently it is used or taught in educational settings remains unknown. Whilst UK-wide statistics are currently lacking, in England 14.6% of children have a special education need or disability (SEND) (Department of Education [DfE], 2018) with around half (8%) attending special schools (DfE, 2018). Around 35% of these pupils have, as their primary need, speech, language and communication difficulties (DfE, 2018). Given these statistics, it is likely that PECS is a widely used intervention in special schools in the UK.

One of the strengths of PECS is that it is a manualised intervention. Manuals can help to facilitate consistency between different implementers, provide structure for therapeutic sessions and facilitate staff training (McMurran & Duggan, 2005). Using treatment manuals for well-tested interventions in clinical and educational settings also helps to promote the use of evidence-based practices. When compared to individualized treatment regimens, manualized treatments have been shown to be associated with better treatment outcomes (Mann, 2009; Shapiro et al., 2012; Vande Voort et al., 2010). Unfortunately, there is very little data on how PECS is actually used within special schools. To our knowledge, there are no published studies that have explored, for example, which professionals are tasked with implementing PECS, the extent to which it is implemented consistently, or the training level of those implementing it. These are important questions given that PECS is a complex

intervention that can be challenging to implement in the absence of specialized training and ongoing support (Bondy & Frost, 2001). Pyramid Educational Consultants, the organisation that licences the PECS system, recommend that implementers undertake a minimum level of specialized training by certified trainers prior to beginning the intervention (Pyramid Educational Consultants, n.d.). Indeed, there is some evidence to suggest that minimal training in PECS can lead to poor treatment integrity outcomes. For example, Barnes et al. (2011) evaluated variations of PECS training and found that the use of verbal and written instructions in combination with video examples, led to failures in treatment fidelity. Conversely, a number of studies have demonstrated that when PECS training is comprehensive (e.g., Behavioral skills training) novice trainees can achieve high levels of implementation fidelity (Ganz et al. 2012; McCoy & McNaughton, 2019).

Using evidence-informed interventions is clearly desirable; however, interventions that are not implemented as intended might be unlikely to produce the outcomes demonstrated in the original research establishing their effectiveness (Bond et al., 2011; McCall, 2009; Perepletchikova, 2011). Given how widely it is used, it is likely that some personnel involved in implementing PECS in educational settings will not have received formal training in PECS nor have been provided with the recommended support and guidance to implement it correctly. The purpose of the current study was threefold. First, to determine how well PECS is understood and implemented by personnel working in special education schools in the UK. Second, to determine whether practitioner knowledge and implementation of PECS is associated with PECS training experience. Third, and finally, we sought to explore participants' attitudes towards PECS, particularly with respect to its usefulness and the level of support available to aid implementation.

Predictions

We hypothesized that participants that had received formal training (specifically, Level 1 or Level 2 training) in how to implement PECS would score higher on the measures of knowledge and implementation of PECS, relative to those participants who have received informal, minimal or no training. The details of the proposed causal model and analysis plan are outlined in the method section. All of our predictions were preregistered and are available at the Open Science Framework (OSF) link https://osf.io/kqwtp/?view_only=fc8a261f911c443e8fd324cfed85c666

Method

Procedure

Convenience sampling was used with prospective participants recruited via social media (e.g., Twitter, Facebook) and email invitations sent directly to schools (e.g., existing contacts known to the research team). Participants took part in the study via an online survey. To be eligible to participate, respondents needed to be currently implementing PECS in a professional capacity within a special educational need setting/school setting in the UK.

Participants

A total of 283 participants completed the survey. The most common professional backgrounds were classroom teachers or teaching assistants (80%). Of the remainder, 5% were Speech and Language Therapists or Occupational Therapists, 8% were school administrators, 11% identified as behavior support staff, and 1% of respondents as ‘other’. Table 1 displays the relevant participant characteristics (INSERT TABLE 1).

Table 1. *Descriptive statistics for participants.*

	N	%
School Administrators		
Assistant Head Teachers	7	2.5
Head Teacher Deputies	2	0.7
Special Education Needs Coordinators (SENCOs)	13	4.6
Classroom Teachers and Assistants		
Teachers	108	38.2
Learning Support Assistants (LSAs)	29	10.2
Teacher Assistants (TAs)	54	19.1
Higher Level Teaching Assistants (HLTAs)	34	12
Emotional Literacy Support Assistants (ELSAs)	2	0.7
Speech and Language Therapists and Occupational Therapists		
Speech and Language Therapists	9	3.2
Speech and Language Assistants	4	1.4
Occupational Therapy Assistant	1	0.4
Behavior Support Staff		
Board Certified Behavior Analysts	3	1.1
Board Certified Assistant Behavior Analyst	1	0.4
Applied Behavioral Analysis (ABA) Tutors	3	5.7
Behavior Therapists	7	2.5
ABA Supervisors	3	1.1
Other		
Nurses	2	0.7
Student-Intern	1	0.4
Highest education level		
High school diploma	86	30.4
Bachelor's degree or equivalent	75	26.5
Master's degree or equivalent	122	43.1
Training in the use of PECS		
PECS Level 1 (Basic) – 2-day workshop	68	24
PECS Level 2 (Advanced) - 2-day workshop	48	17
Other Pyramid Training workshops (e.g. guide to managing challenging behavior, PECS in your curriculum, transitioning from PECS to SGDs, etc.)	20	7.1
Informal training (or in-house training)	62	21.9
None	85	30
Experience in education		
Less than 2 years	9	3.1
2 to 5 years	61	21.6
6 to 9 years	50	17.7
10 to 14 years	65	23
15 + years	98	34.6
Experience with PECS		
Less than 2 years	39	13.8
2 to 5 years	98	34.6
6 to 9 years	54	19.1
10 to 14 years	53	18.7
15 + years	39	13.8

Survey Development

The survey was developed by the research team in consultation with two Speech and Language Therapists and one Behavior Analyst who had all received Level 1 training in PECS and were experienced in implementing the intervention with children with communication difficulties. In addition, the PECS Training Manual 2nd Edition (Frost & Bondy, 2002) was used to inform the items on the survey relating to PECS knowledge and implementation (Sections 2 and 3). Initial draft versions of the survey were reviewed by two subject matter experts in PECS for relevance, accuracy and clarity of the wording. Each reviewer was provided a copy of the survey after which they independently provided feedback. A revised version of the survey was then pilot tested with 26 individuals currently implementing PECS, using a paper-based format. Respondents provided item-by-item feedback on the clarity of wording of the survey. The finalized survey consisted of 50-items divided into five discrete sections (a copy is available at https://osf.io/kqwtp/?view_only=fc8a261f911c443e8fd324cfed85c666). Section One consisted of questions related to the participants' role in the setting; general educational background; training in PECS; the number of years implementing PECS; and number of years in education. Section Two assessed participants' *knowledge* of how to implement PECS. This comprised 13 statements concerning how PECS should be implemented (e.g., "Introducing PECS to a new learner requires two instructors"). For each statement, participants selected one of the following response options: *True*, *False* or *Don't Know*. In Section Three, the statements determined how respondents *implemented* PECS. Here, participants responded by selecting *True, False* or *Don't Know* to 12 statements about how PECS is implemented in their place of work (e.g., "A reinforcer assessment and/or preference assessment is conducted prior to, or

during, PECS teaching sessions with a learner"). Table 2 and Table 3 detail the full list of statements included in Section 2 and Section 3 of the survey. We used both true and false assertions in both sections of the survey. For each item in Section Two and Section Three of the survey, participant responses were scored as correct or incorrect. *Don't Know* responses were counted as incorrect. This allowed us to calculate a *Knowledge Score* and *Implementation Score* comprising the cumulative correct responses for each participant in Section Two and Section Three in which it was possible to obtain a maximum score of 12 and 13 respectively. In Section Four of the survey, participants were asked about the resources available to assist with implementing PECS, and their role and experiences using PECS. We asked about: i) access to a PECS manual; ii) whether PECS is used at home; iii) responsibility for training others; iv) responsibility for overseeing others implementing PECS; v) responsibility for implementation of PECS; and vi) perceived level of support. In this section we also asked participants to respond to statements about their experiences of learner progress: i) what proportion of learners had progressed to using a sentence strip, and ii) what proportion of learners had progressed to using PECS for commenting. In Section Five, participants indicated their agreement with statements referring to their perceptions of PECS (see Table 4 for each of the items). For each of these statements, participants responded by selecting a response option on a 5-point Likert-style scale from *Strongly Disagree (1) to Strongly Agree (5)*.

Data Analysis

Participants' responses to the survey items were evaluated using descriptive (i.e., percentages, frequencies) and inferential statistics. The primary statistical analysis was designed to estimate the impact of PECS training on knowledge and implementation of PECS (i.e., the scores derived from Section 2 and Section 3). We

registered our analysis in advance of collecting the data and this is available in the preregistration document at the OSF (see aforementioned link). As responses to the relevant survey items were scored as dichotomous (i.e., correct or incorrect), we used a logistic regression modelling approach. Each individual responded to multiple questions as part of survey, so we used a multilevel (i.e., hierarchical) model consisting of a two-level structure in which responses to individual questions (Level 1) were nested within participants (Level 2). Incorporating varying (i.e., random) intercepts for participants allowed us to estimate an intercept for each participant which incorporated information about the variation observed across all the participants scores (McElreath, 2020).

Causal models

Our analysis plan was informed by pilot work that helped us to develop our proposed causal framework. Figure 1 shows the Directed Acyclic Graph (DAG) which specify the proposed causal framework underpinning our statistical approach. A DAG is a heuristic model that describes the relationship between variables in a manner which is transparent and informed by theory. Importantly, the structure of the DAG implies different statistical analyses depending on the causal estimate (the "estimand") of interest (Rohrer, 2018).

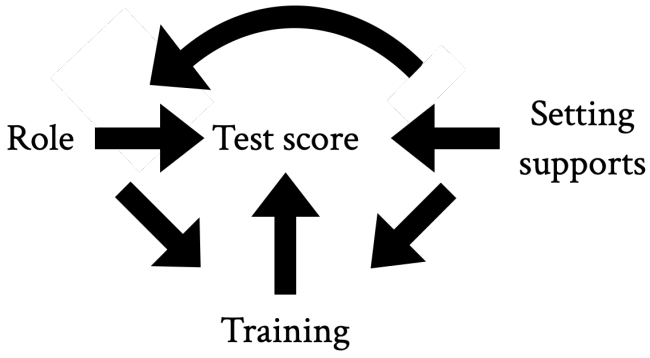

Figure 1. Directed Acyclic Graph for causal model

Causal model. To further explore the impact of training on performance we sought to include context and role of the participant as variables in the causal model. First, we hypothesised that a participant's role in PECS implementation might influence the extent to which they had received PECS training. For example, an individual overseeing the implementation of PECS is more likely to have undertaken the official PECS training. Additionally, someone in a supervisory role may be more likely to be implementing PECS properly due to the requirements of the role (i.e., *formal PECS training ← role → knowledge/implementation score*). Second, we hypothesised that a resource/support rich context would likely increase the chances staff were provided with formal PECS training to staff *and* increase the likelihood that they had access to PECS related materials (e.g., provision of data sheets, PECS manual, PECS books etc.) which might impact treatment integrity independently of having received formal PECS training (i.e., *formal PECS training ← onsite resources → knowledge/implementation score*). Moreover, supportive contexts would be likely to produce better supervisory practices (*onsite resources → role).* Given these assumptions, we included role and participant's rating of how supportive the context was as covariates in the model, effectively blocking the causal effect of these variables on the estimate of the impact of PECS training (i.e., see the so-called *backdoor criterion;* Pearl, Glymour & Jewell, 2016). We did not include qualifications in the model as we hypothesised that while qualifications likely impacted role, it was unlikely to create any other direct or indirect backdoor path to test score. Given the assumptions of the DAG, the coefficients for the impact of PECS training we obtained from the models estimated the magnitude of the relationship between PECS Training (total and direct effect of official PECS training) and the two survey scores, when the predictors in the model (e.g., role, onsite supports) were held

constant. These models we refer to as Model 3 (Knowledge) and Model 4 (Implementation) in the remainder of the manuscript to maintain consistency with our preregistration materials.

In our preregistration, we specified DAGS corresponding to two different causal models. In the supplemental causal model, we hypothesised that the qualification status of a participant would both bias the extent to which they had received formal PECS training *and* (independently) make it more likely that they were proficient in PECS. The rationale was that individuals with higher level of qualification status (e.g., Speech and Language Therapists, Behaviour Analysts) were more likely to be those individuals responsible for overseeing the implementation of PECS and therefore be more proficient in PECS, but also more likely to have undertaken formal PECS training: *formal PECS training* ← *qualifications* → *knowledge/ implementation score*. In the analysis, we therefore included qualifications as a covariate in the model, effectively blocking the causal effect of qualifications on the estimate of the impact of PECS training. We do not report the corresponding analysis in the present manuscript for three reasons. First, the model we report can be seen as a more comprehensive model to the extent that it takes account of factors that the qualifications model does not. Second, we compared the models using Widely Applicable Information Criteria (WAIC) which indicated that the role/supportive context model made the best out-of-sample predictions. Third, we are limited by space constraints. We provide the full justification of both causal models along with the corresponding statistical analysis and model comparison in the supplementary materials.

Statistical models

Our statistical analysis, involved estimating the impact of PECS training (predictor with 5 levels: PECS Level 1, PECS Level 2, informal, other, none) on Knowledge score (Model 3) and Implementation score (Model 4) while including *Role* and *Supportive Context* as covariates in the analysis. Role was determined by responses to questions about supervising and training others as well as having responsibility for implementation (q35, q36 and q37). Participant responses to these questions were grouped into four categories: (1) Answered at least 'Occasionally' to all three questions; (2) Answered at least 'Occasionally' to any two of the questions; (3) Answered at least 'Occasionally' to any one of these three questions; and 4) Answered "Never" to all three questions. Role was included as a fixed categorical predictor in the model. Perception of supportive environment was determined by responses to the question: "How supportive is the setting in which you implement PECS? (e.g., training, resources, supervision)". Participants responses were grouped into the four response categories: (1) Very unsupportive, (2) Somewhat unsupportive, (3) Somewhat supportive, (4) Very supportive. Supportive context was then included in the model as an ordered categorical predictor. Given the assumptions described above, including perceived resources and role as covariates in the model, effectively blocked the effects of these variables on the estimate of the impact of formal training (Pearl, Glymour & Jewell, 2016). In other words, in seeking to understand the relationship between training experience and survey score, the models sought to address the question, "when level of onsite support and role of an individual are already known, how much does type of PECS Training help us to predict scores on the survey?"

Deviations from preregistered analysis: We deviated from the planned analyses in the following way. We included five categories of type of PECS training rather than

the four specified in the analysis plan. We undertook this change so that we could obtain separate estimates for the effects of informal or in-house training and no training. Collapsing the categories into one as originally planned risked underestimating the impact of in-house training given that the resulting estimate would be confounded with data from participants that had received no training at all. The change allowed us to estimate the effects of these training histories separately. While we report the revised analysis here, we performed our original preregistered analysis using four categories and found effects consistent with our predictions and the revised analyses.

General modelling approach

To generate the logistic regression models, we used a Bayesian framework. In a Bayesian approach, prior information about the parameters in the model (e.g., priors) are specified before the observed data is incorporated. Combining these the prior parameter distributions with the observed data generates a 'posterior distribution' estimate of the parameter values. Statistical inferences can then be made by examining the central tendency and spread of the posterior distributions. One of the benefits of specifying priors in a model is that it allows the exclusion of unreasonable values before the model sees the data (McElreath, 2020). Accordingly, we specified mildly informative, regularizing priors that reflected the fact that we did not have a substantive prediction or hypothesis with respect to the prior parameter values. To incorporate the predictor and covariates in the model, we employed an index variable approach in which parameter estimates were obtained for each level of the predictor (e.g., training) (McElreath, 2020). To represent the central tendency and spread of the posterior distributions we calculated the posterior mean coefficient estimates on the log odds scale along with their corresponding 95% credible intervals

(CI). We then computed posterior contrasts between the levels of the predictor (Training type) along with corresponding 95% CIs. To generate the contrast estimates, or 'marginal effects', we generated simulations in which the covariates in the models were fixed at particular values. This simulation-based approach is recommended with generalized linear multilevel models involving multiple covariates, as the model coefficients can be challenging to interpret directly (Gelman & Hill, 2007; McElreath, 2020). We report the posterior estimates for each level of training as it was the exposure effect of interest. The coefficients corresponding to the covariates in the models (qualifications, role, onsite resources) are provided in full in the supplementary materials; however, we caution against direct interpretation of the "control" variables as they represent unbiased causal estimates (e.g., the so-called Table 2 Fallacy; Westreich & Greenland, 2013). All the models were fit using the Stan computational framework (http://mc-stan.org) via the *brms* package (Bürkner, 2017) which was accessed through the statistical computing software R (R Core Team, 2021). See supplementary materials for full details of the model specification.

Results

Section One- Demographic Characteristics

Of the 283 responders, 43% (*n*= 122) had a graduate-level qualification (e.g., Masters or equivalent), 27% (*n*= 75) were educated to Bachelor's degree-level, and 30% (*n*=86) had a High (Secondary) School diploma or equivalent. In terms of experience and training in PECS, around half of responders had completed the official Pyramid PECS training, either at the basic (Level 1; 24%, *n*=68), or advanced (Level 2; 17%, *n*=48) level. Of the remaining responders, 7%, (*n*=20) reported having attended a Pyramid training workshop (e.g., Guide to Managing Challenging Behavior). Thirty percent of the sample (*n*=85) reported that they had received no

training in PECS and a further 22% (*n*=62) had received informal training. Fourteen percent (*n*=39) of responders reported using PECS in school settings for less than two years, 54% (*n*=152) between two and ten years, and 32% (*n*=92) had ten or more years of experience with the intervention. The full demographic characteristics of the sample are presented in Table 1.

Section Two- Knowledge of PECS

Participants scored a mean of 8.78 (*SD*= 2.53, *range* =0-13) correct responses on the *Knowledge of PECS* section of the questionnaire (see Figure 2A). Analysis of responses showed a high degree of variation in correct responding across the individual statements. Table 2 depicts the percentage of correct, incorrect and don't know responses for each statement (INSERT TABLE 2 HERE). Three statements were responded to correctly by less than half of participants: 'Before starting PECS, a learner should understand that PECS symbols correspond to real items (i.e., picture of an apple equals a real apple)' (39%, *n*=111), 'The learner's pictures and/or communication book can be used as a visual schedule (i.e., to show sequence of upcoming activities)' (47%, *n*=134), and 'Recording learner performance during teaching sessions is an essential component of PECS' (46%, *n*=131). Of the remaining statements, those which had the fewest correct responses were: 1) 'Before starting PECS, a learner must be able to match pictures with one another (i.e., match a picture of a blue car with a picture of a blue car' (60%, *n*=169), and (2) 'An instructor should provide verbal instructions to prompt the PECS user to exchange a picture (e.g., "find the picture", etc.)' (65% correct, *n*=126).

Three statements were responded to correctly by more than 80% of participants: (1)'PECS should only be used by learners in structured training sessions'(86%, *n*=243), (2) 'A learner using PECS should be required to make eye contact with the instructor during an exchange (87%, *n*=247), and (3) 'PECS teaching sessions

with a learner should be conducted in a variety of locations (e.g., classroom, playground, lunch room etc.)' (94%, *n*=265).

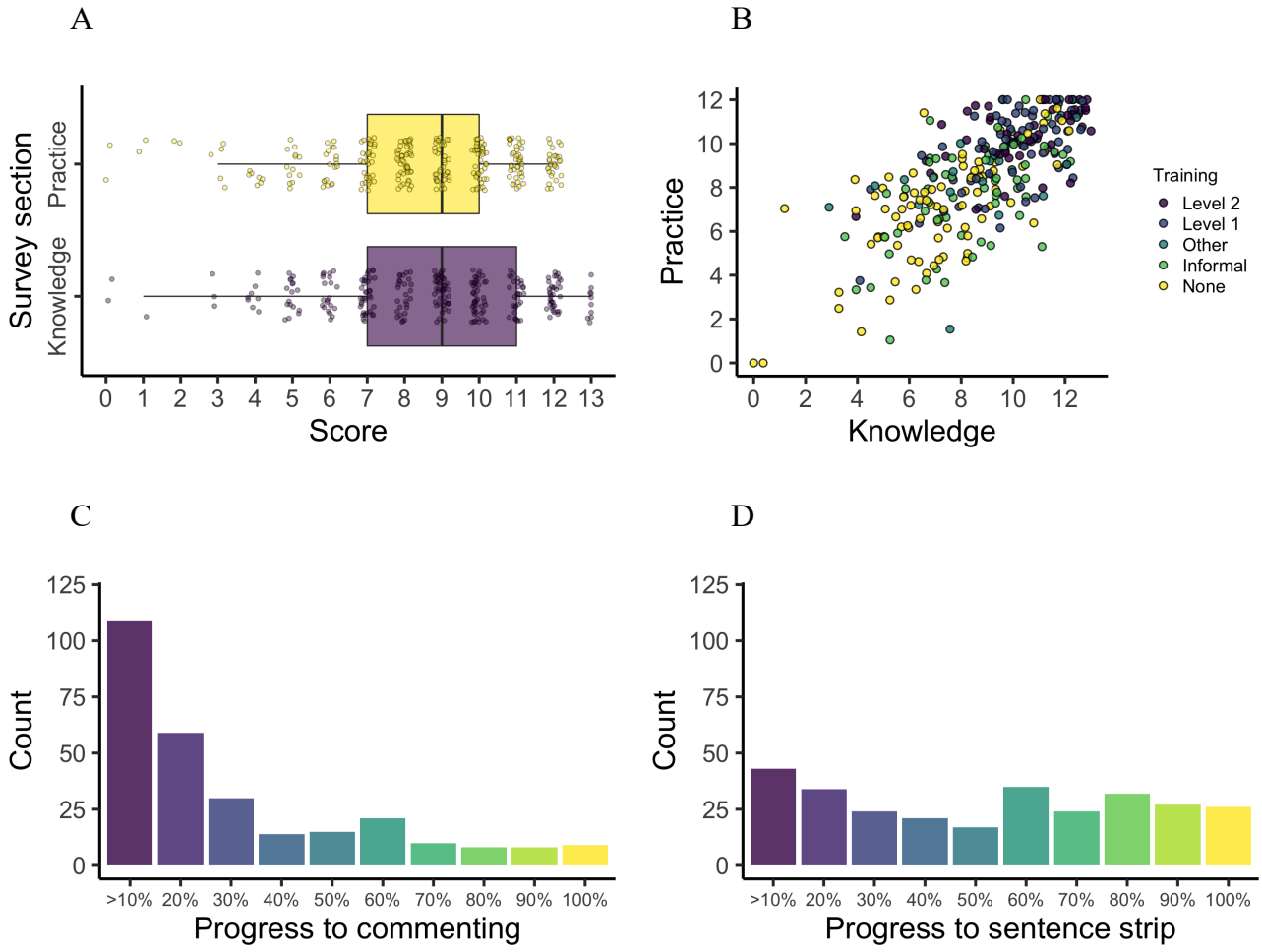

Figure 2. 2A: Raw scores for Knowledge and Implementation sections of the survey. 2B: Scatterplot showing the correlation between Knowledge and Practice raw scores as a function of training type. 2C: Number of individuals reporting the proportion of PECS users that progress to the commenting phase of PECS (Phase VI). 2D: The number of individuals reporting the proportion of PECS users progressing to the sentence strip phase of PECS (Phase IV)

Table 2. *Knowledge about PECS*

Statements	Answer	Correct (%)	Incorrect (%)	Don't know (%)
Introducing PECS to a new learner requires two instructors	True	200(71)	52(18)	31(11)
Before starting PECS, a learner should understand that PECS symbols correspond to real items (i.e., picture of an apple equals a real apple)	False	111(39)	159(56)	13(5)
PECS should only be used by learners in structured training sessions	False	243(86)	20(7)	20(7)
Before starting PECS, a learner must be able to match pictures with one another (i.e., match a picture of a blue car with a picture of a blue car)	False	169(60)	65(23)	49(17)
PECS teaching sessions with a learner should be conducted in a variety of locations (e.g., classroom, playground, lunchroom, etc.)	True	265(94)	6(2)	12(4)
When honoring a request, ideally the reinforcer/reward should be delivered to the learner within half a second	True	186(66)	52(18)	45(16)
Recording learner performance during teaching sessions is an essential component of PECS	True	131(46)	91(32)	61(22)
Instructors should always insist on speech when learners are communicating with PECS	False	235(83)	32(11)	16(6)
An instructor should provide verbal instructions to prompt the PECS user to exchange a picture (e.g., "find the picture", etc.)	False	126(65)	42(22)	25(13)
A learner using PECS should be required to make eye contact with the instructor during an exchange	False	247(87)	16(6)	20(7)
If a learner drops a picture during an exchange, he/she should (1) be directed to pick up the picture; and (2) be prompted to complete the exchange	True	199(70)	39(14)	45(16)
If a learner loses interest in a reinforcer/reward, the instructor should prompt the user to exchange the picture anyway	False	202(71)	36(13)	45(16)
The learner's pictures and/or communication book can be used as a visual schedule (i.e., to show sequence of upcoming activities)	False	134(47)	113(40)	36(13)

Section Three- Implementation of PECS

Participants obtained a mean of 8.56 correct responses (*SD*= 2.47, *range*= 0-12) on the *Implementation of PECS* section of the questionnaire (see Figure 2A).

Table 3 details the percentage of responses that indicated correct adherence to the intervention protocol (INSERT TABLE 3 HERE). Only one statement indicated correct adherence by less than 50% of participants: 'If an item is temporarily unavailable, the corresponding picture is removed from the learner's communication book'(37%, *n*= 104). The statements indicating the weakest adherence were: 1)**'**Verbal instructions are used to help learners select and exchange pictures (e.g., "Pick up the picture")' (51%, *n*=143), (2) 'A learner's pictures or communication book is used as a visual schedule (i.e., a sequence of upcoming activities)' (54%, *n*=154), and (3) 'A reinforcer assessment and/or preference assessment is conducted prior to, or during, PECS teaching sessions with a learner' (61%, *n*=172).

Three statements produced responses indicating adherence by more than 90% of participants. These were:(1)'Learners have the opportunity to communicate using PECS in more than one location each day (e.g., classroom, playground)' (92%, *n*=260), (2) 'Each learner has their own personalized communication book' (95%, *n*=270), and (3) 'Learners have the opportunity to communicate with more than one communicative partner throughout the day' (95%, *n*=269). Figure 2B shows a scatterplot of the distribution of raw implementation scores against raw knowledge scores.

Table 3. *Implementation of PECS*

Statements	Answer	Correct (%)	Incorrect (%)	Not sure (%)
A reinforcer assessment and/or preference assessment is conducted prior to, or during, PECS teaching sessions with a learner	True	172(61)	44(16)	67(24)
If an item is temporarily unavailable, the corresponding picture is removed from the learner's communication book	False	104(37)	160(57)	19(7)
Two instructors/teachers (per PECS learner) are involved in the initial phases of PECS (i.e., Phases I and II)	True	176(62)	64(23)	43(15)
Each and every learner request is honored during the initial phases of PECS (i.e., Phases I and II)	True	214(76)	32(11)	37(13)
Verbal instructions are used to help learners select and exchange pictures (e.g., “Pick up the picture”)	False	143(51)	119(42)	21(7)
A learner's pictures or communication book is used as a visual schedule (i.e., a sequence of upcoming activities)	False	154(54)	98(35)	31(11)
Each learner has their own personalized communication (PECS) book	True	270(95)	10(4)	3(1)
Each PECS learner has unrestricted access to their communication book/pictures throughout the day	True	250(88)	22(8)	11(4)
Learners have the opportunity to communicate with more than one communicative partner throughout the day	True	269(95)	4(1)	10(4)
Learners have the opportunity to communicate using the PECS in more than one location each day (e.g., classroom, playground)	True	260(92)	4(1)	10(4)
PECS learner performance is recorded (i.e., data is collected)	True	177(63)	67(24)	39(14)
If a PECS learner is not making progress, the teaching procedures are reviewed and adapted in a timely manner	True	235(83)	21(7)	27(10)

Section Four

The majority of respondents (62%, *n*=176) indicated that they had access to a PECS intervention manual: at home (4%), at work (36%) or both at work and at home (22%). One hundred and thirty two participants (47%) indicated that the last learner

they worked with had used PECS at home; however, 114 (40%) indicated they didn't and a further 37 (13%) did not know. Figures 2C and 2D show participant responses to the questions about their experiences of the proportion of learners that have progressed to using the sentence strip (C) and commenting (D). When we asked about responsibility for oversight and supervision of PECS, 50% (n=141) of participants trained others to implement PECS at least some of the time, 57% sometimes oversaw others in PECS implementation, and 60% were sometimes involved in planning implementation (e.g., deciding on targets, making adjustments). Figure 3 shows the number of responses by category for each of the three questions. For the purposes of the statistical models, this resulted in a distribution of participants into the 'role' categories (see Methods) as follows: All: 38%, Most: 20%, Some: 13%, and None 29%. In response to the question, "How supportive is the setting in which you implement PECS (e.g., training, resources, supervision)", participants responded as follows: Very supportive: 37%, somewhat supportive: 44%, somewhat unsupportive: 15%, very unsupportive: 4%.

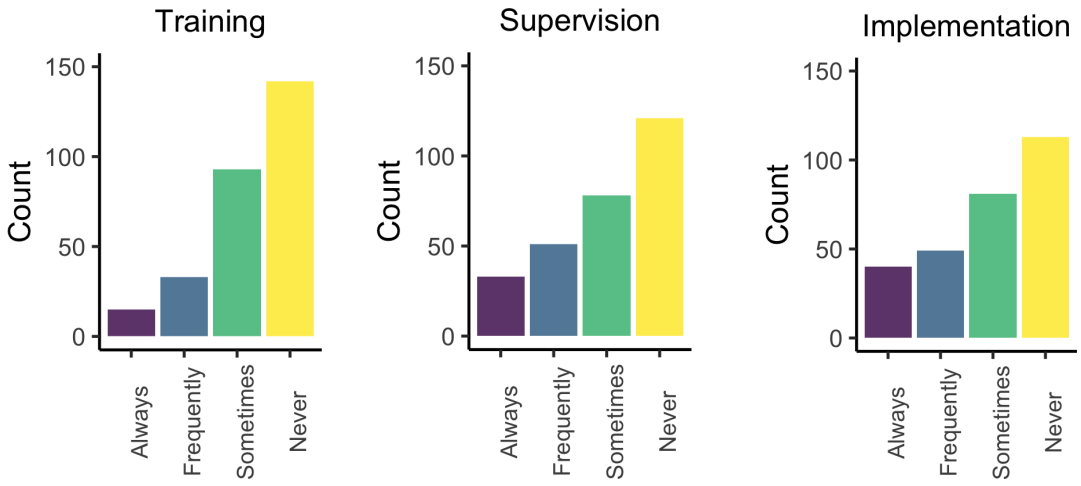

Figure 3. Number of participants responsible for training others, supervising others and overseeing implementation

Section Five: Resources, Progress and Barriers

Table 4 shows participant responses to all questions and statements from Section 5 in percentage of responses made to each statement included in Section 4 and Section 5 of the survey.

Table 4. *Contextual factors and attitudes towards PECS*

Statements	Strongly Disagree (%)	Disagree (%)	Neither Agree or Disagree	Agree (%)	Strongly Agree (%)
I have found PECS to be an effective strategy in teaching learners to request items/activities	1(<1)	4(1)	19(7)	132(47)	127(45)
I have been trained adequately to implement PECS	34(12)	63(22)	58(20)	79(28)	49(17)
The PECS intervention is straightforward to implement	0	30(11)	73(26)	145(51)	35(12)
PECS is not a practical intervention to use in the school setting	76(27)	131(46)	52(18)	22(8)	2(1)
We collect ongoing data on learner performance when implementing the PECS intervention	18(6)	50(18)	73(26)	111(39)	31(11)
I have access to all the PECS related equipment (PECS book, pictures, reinforcers) that I need to successfully implement PECS	18(6)	60(21)	43(15)	60(21)	60(21)
I have access to a PECS manual at my workplace	46(16)	59(21)	33(12)	87(31)	58(20)
I have the time I need to successfully implement PECS	22(8)	100(35)	64(23)	76(27)	21(7)
I feel we have enough staff to successfully implement PECS	38(13)	110(39)	52(18)	63(22)	20(7)
I feel sufficiently supported in my workplace to implement PECS effectively	17(6)	65(23)	75(27)	92(33)	34(12)

Statistical models

To aid the interpretation of the model coefficients we computed conditional effects on the outcome scale by simulating the effect of changing training levels while

fixing the covariate(s) in the model at particular values. This allowed us the estimate contrasts for each level of PECS Training. For Models 3 and 4, supervisory role was fixed at 'None' and setting the supportiveness rating was fixed at 'somewhat supportive' of PECS.

Knowledge of PECS.

Figure 4 shows each of the conditional effect for each possible Training-type contrast for both models. The posterior distributions depicted in this figure give point estimates and 95% credibility intervals which can be interpreted as the most plausible differences in the mean probability of obtaining a correct answer on a given question.

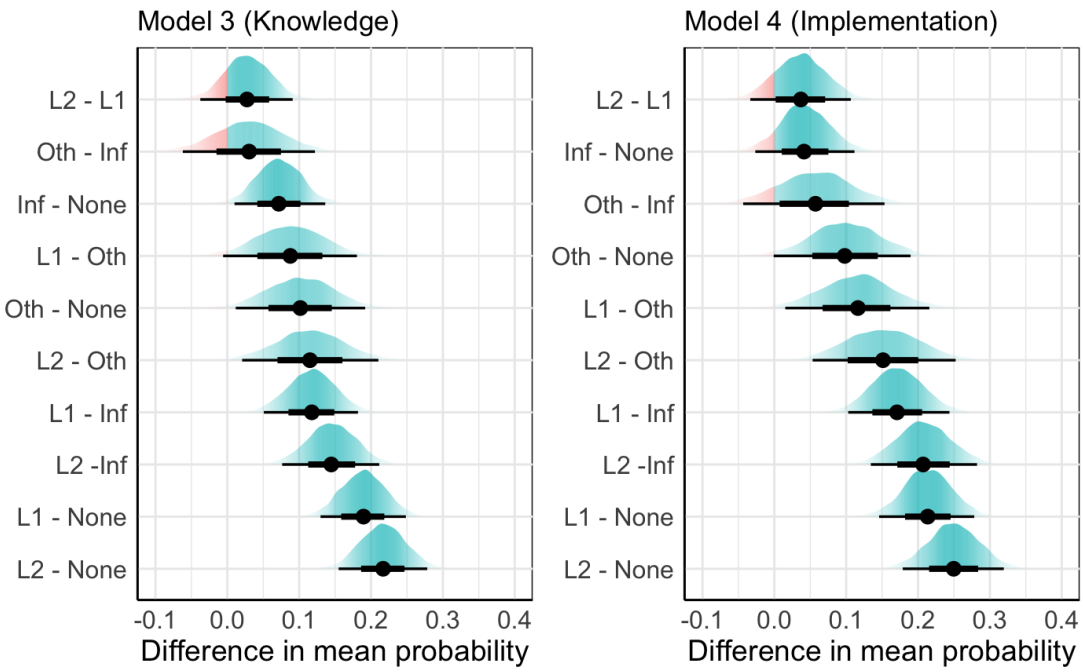

Figure 4. Conditional effects of training type for the Knowledge (Model 3) and Implementation (Model 4) scores. These posterior contrasts represent the most plausible differences in probability between each type of training, controlling for the role and the level of support available within a setting. The conditional effect simulations have been calculated holding the covariates *Role* and *Support* at the levels of "No supervisory role" and "Somewhat supportive", respectively. Note: L2 = Level 2, L1= Level 1, Inf = Informal, Oth = Other, None = No training.

Model 3. Controlling for role and supportive context we estimated a benefit of Level 2 training of 21.8% (95% CI: 15.2, 28), 14.6% (95% CI:7.6, 21.4) and 11.7 % (95% CI: 2.7, 21) greater probability of a correct response when compared to no training, informal training, or 'other' training respectively. Similarly, Level 1 training was associated with a 19% (95% CI: 12.7, 25.1), 11.7% (95% CI:5.1, 18.4) and 8.9 % (95% CI: 0, 17.8) greater probability of a correct response relative to no training, informal training, or 'other' training respectively. There was less evidence for a benefit of Level 2 relative to Level 1 training as measured by the survey; Level 2 was associated with marginally higher rate of success on the measure (2.8%) but the 95% credible interval of the posterior distribution values ranged from -3.8% to 9.1%.

Implementation of PECS.

Model 4. Stratifying on role and supportive context we estimated a benefit of Level 2 training of 23.9% (95% CI: 17, 30.3), 19.7% (95% CI: 12.3, 26.8) and 14.3 % (95% CI: 4.5, 24.2) greater probability of a correct response when compared to no training, informal training, or 'other' training respectively. Level 1 training predicted a 20.6% (95% CI: 14.2, 26.8), 16.5% (95% CI: 9.5, 23.4) and 11 % (95% CI: 1.4, 20.9) greater probability of a correct response relative to no training, informal training, or 'other' training respectively. Consistent with the knowledge section of the survey, when controlling for role and supportive context, there was less evidence of the benefits of Level 2 relative to Level 1 training; Level 2 was associated with marginally higher mean difference in probability of a correct response (3.3%) but the 95% credible interval of the posterior distribution values ranged from -3.5% to 9.8%.

Discussion

In the present study, we sought to understand UK-based education professionals' knowledge of and adherence with the PECS intervention. We explored

factors that were associated with knowledge and implementation as well as participant perspectives of PECS, including supports and perceived barriers to its implementation. To summarize, we found large variations in participants' knowledge of and adherence to the PECS recommendations. Participants correctly identified 67% of the knowledge statements, and 73% of the statements related to implementation. Our preregistered analyses indicated that formal PECS training was reliably associated with higher scores on both domains of the survey when stratifying by role and supportive context. While PECS was rated by the vast majority to be an effective and practical way of teaching communication skills, a large proportion of participants identified that they didn't always have sufficient time or personnel to implement PECS effectively. Finally, the responses we obtained indicated that the purpose of PECS is not always fully understood and there are some specific aspects of PECS knowledge and implementation that could be more effectively supported.

The areas of knowledge and implementation that participants scored with high accuracy tended to be questions about the contexts in which PECS should be, and is, taught. For example, the vast majority correctly identified that PECS instruction should not be restricted to structured teaching sessions and specific locations. Similarly, nearly all participants reported that learners should have unrestricted access to PECS and provided the opportunity to communicate using PECS with multiple communicative partners. Such high agreement with these treatment recommendations is encouraging given that one of the goals of PECS is generalization to contexts and people beyond the intervention setting.

Participants reported moderately high adherence to using multiple teachers during instructional sessions. Nearly two thirds of participants indicated that PECS was taught using multiple trainers when beginning teaching. A second implementer is

considered a necessary part of Phase I of PECS to ensure that errors are minimized, and that the communicative partner, whose role it is to receive the picture, is not (inadvertently) prompting the learner. The finding that two implementers are frequently involved is promising, particularly given that insufficient staffing levels was also highlighted as a barrier by around half of participants. Moreover, there is some evidence that this recommendation might not always be consistently applied. For example, Jurgens et al. (2012) explored PECS implementation by analysing a sample of YouTube® videos, and found that of eligible instances, the recommendation for two implementers was not adhered to on 67% of occasions. Further research would help identify the extent to which the requirement for two implementers represents a practical challenge for special educational settings.

In general, participants tended to score less accurately on questionnaire items that involved within-trial components (e.g., error correction procedures, verbal prompting). We also found that a surprisingly high number of participants misinterpreted the purpose of PECS. For example, less than half of participants identified that the learner's pictures or communication book should not be used as a visual schedule (i.e., arranging the pictures to correspond with the sequence of upcoming activities) by the implementer to communicate with the learner. This finding is consistent with a common misinterpretation, noted by Bondy (2012), that PECS is simply the "use of pictures", or the use of picture schedules. It is possible using PECS materials as a visual schedule might have deleterious effects on a learner's use of PECS. Deviating from the intervention protocol in the manner described above could plausibly undermine the learner's understanding of what PECS is for; that is, a communication book of their own to express their needs and wishes. Clearly, these data highlight some areas that future training should also seek to

address, particularly given the high number of participants that reported using the PECS materials in this manner.

Another prevalent misconception was the idea that learners should understand the connection between the pictures and real items before beginning PECS (61% of participants responded incorrectly). PECS is designed to be introduced to children that have yet to master matching pictures to the items they represent. Indeed, learners work towards picture-to-item correspondence (or discrimination) as part of the intervention (Phase III; Frost & Bondy, 2002). Our findings are concerning because they suggest that some children might be deemed as ineligible for PECS because of an erroneous assumption about what prerequisite skills are necessary. Again, future research should seek to confirm whether this misconception is widely held, and the extent to which it impacts clinical decision-making.

The data also highlight a pressing need for improved training for staff implementing PECS in school contexts. Almost a third of participants (i.e., 30%) indicated that they had received no training at all in PECS, and a further 22% reported received only informal (e.g., in-house) training. This is an important consideration given our finding that participants that had not received the recommended basic (Level 1) or advanced (Level 2) PECS training scored lower on both the measures of knowledge and implementation of PECS than those who had completed this training. The study also provides new insight into the roles, and training and experience level of those tasked with the implementation of PECS in schools. The data suggest that teachers and teaching support staff (e.g., teaching assistants, learning support assistants) are the professionals most likely to be responsible for implementing PECS within special school settings. The vast majority of completed surveys were by participants in one of these roles. On the assumption that these data are representative,

this could be useful for understanding how to improve school-based implementation of PECS in a UK context by ensuring that training and additional support is appropriately targeted.

We hypothesised that PECS training experience would predict both greater knowledge of and fidelity in implementation of PECS. According to the assumptions of our models, type of PECS training predicted higher scores in the knowledge and implementation sections of the questionnaire. While the design of the study does not allow us to make strong causal inferences, the suggestion that training experience has a protective effect on PECS knowledge and implementation is consistent with findings reported in a recent review of the literature. Specifically, McCoy and McNaughton (2019) investigated the effects of teacher training on PECS implementation in educational settings and concluded that instruction incorporating components of behavioural skills training (BST) improved the quality of PECS teaching undertaken by educational professionals. The present study is compatible with the hypothesis that formal training in PECS may have some sustained, albeit modest, benefits. In summary, our findings are broadly consistent with the idea that practitioners should undertake formal training in PECS. Future research might seek to directly examine the effects of training on long term improvements in PECS implementation, and also whether recency of training predicts performance on the measures we employed here.

Finally, nearly all participants reported that they found PECS to be an effective intervention (92%), and the vast majority rated it to be practical (73%) and straightforward to implement (63%). Ostensibly, these data suggest that PECS is highly valued in school settings by the majority of staff responsible for its implementation. This is consistent with the findings by Alsayedhassan et al., (2019)

who found that teachers using PECS reported that the intervention was both easy to use and effective for teaching communication skills in young children with autism. However, the present findings need to be interpreted with caution. Our findings suggest that at least some of the participants may have been unclear about the overall purpose of PECS. As discussed previously, less than half of the responders correctly identified that PECS should not be used as a visual schedule. It is therefore possible that responder judgements about effectiveness, practicality, and other features of the intervention may be distorted to some degree by a misunderstanding about what PECS is designed to achieve.

There were a number of areas of PECS implementation that responders consistently reported could be more effectively supported. Around a third of participants indicated they had sufficient time and personnel to implement PECS. This finding could reflect the requirement for two prompters at various points in the intervention, or simply indicate a more general lack of time and staffing resources for the purposes of implementing individualized interventions. Clearly, the data do suggest that the provision of additional personnel would be a valued step. Less than half of participants reported being aware that PECS was also used by the learner in the home setting. This was a surprising and concerning finding given that PECS is intended to be used as a primary mode of communication, to be implemented across all settings (Bondy, Horton & Frost, 2020). To fully realize the potential of PECS, we recommend that staff in educational settings be supported to work closely with family members outside of the school setting to ensure the transfer of skills to home. The importance of implementing PECS at home with caregivers is difficult to overstate. Not only does training across environments facilitate generalisation, but it also ensures that there is consistency in expectations from the perspective of the learner

(e.g., which communication system is being used). This is likely to be important in reducing the frustration resulting from a failure to be understood (Bondy, Horton & Frost, 2020). These considerations are particularly pertinent given that the COVID-19 pandemic has resulted in many autistic learners spending extended periods at home amidst significant uncertainty.

Around two thirds of participants reported the intervention was easy to implement. This was somewhat unexpected given that, as described earlier, the PECS protocol is relatively complex. Again, it is possible that this finding reflects a lack of understanding regarding what the procedures entail. This interpretation seems plausible given the high number of people that had not undertaken any formal training in PECS, along with other misinterpretations discussed above.

Limitations and Future Research

While the present study offers some new insights into the real-world application of PECS in special educational settings in the United Kingdom, it has some limitations that should be considered when interpreting the results. While we developed the knowledge and implementation measures using the published intervention manual and in consultation with clinicians with expertise in PECS, the instruments were not formally validated nor were any validated assessments administered alongside the survey. We are not aware of any existing measures which assess knowledge or implementation adherence of PECS, beyond the guidance presented in the manual. Future research might seek to formally validate the knowledge and implementation measures reported here. The present study is also limited in that the measures rely on participants' recollections of how they have implemented the intervention in the past. Future studies evaluating practitioners'

adherence to the protocol should be conducted in-vivo to mitigate the sources of error introduced by retrospective self-report.

It is also possible that the convenience sampling strategy that we employed may have generated sources of selection and/or response bias. For example, participants with less knowledge, experience, or interest in PECS (or competence in delivering it) may have been less likely to undertake the survey. Moreover, our use of a mixed-format approach involving an internet-based version of the survey may have restricted at least some of the sample to those with internet access. Given some of these issues, we cannot be completely confident that the responses we obtained were fully representative of the experiences, expertise and attitudes of all professionals working with PECS in schools in the UK. Additionally, although were careful to specify our causal framework (e.g., the DAG), and to do so in a way which informed our data collection and analysis plan, it is possible that we have omitted unobserved confounds. We encourage the perspective that our estimates are potentially biased by such confounding. Given these concerns, the present work might be best interpreted as a preliminary or pilot study which awaits confirmation from a larger evaluation using more systematic sampling strategy or consideration of additional causal variables.

Finally, the present study is also limited to the extent that we did not examine the association between fidelity of PECS and treatment outcomes (e.g., improvements in communication). Interventions that are implemented with poor fidelity may be at risk of producing inferior outcomes relative to the research studies establishing their efficacy (McCall, 2009; Perepletchikova, 2011). Studies from multiple domains provide support for this *fidelity-outcome* hypothesis (Bond et al., 2011; Bond & Salyers, 2004; Burns et al., 2007; Oxman et al., 2006), including some that have

evaluated behavioural interventions for learners with ID (Arkoosh et al., 2007; DiGennaro et al., 2007; Rhymer et al., 2002; Wilder et al., 2006). While we might expect that implementation fidelity is an important moderator of outcomes in the context of PECS, to our knowledge there are no published evaluations examining its impact. Future research exploring this association will help us to further understand the utility of the findings we have reported here.

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